3 Driven machines

Introduction

Centrifugal pumps

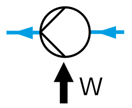
Axial-flow pumps

Positive displacement pumps

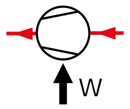
Fans and compressors

Driven machines

Whenever a machine adds energy to a fluid, it is called a driven machine. In order to operate, driven machines require mechanical energy or work **W**. We distinguish between different types of driven machines, depending on the working medium:



Pumps
(incompressible fluid)



Fan or compressor
(compressible fluid)

Moreover, driven machines are distinguished depending on their mode of operation, the direction of flow of the fluid, or their design. Like the driving machines in chapter 2, driven machines are categorised into turbomachines and positive displacement machines.

Driven machines
Energy is added to the fluid

Turbomachines
Transfer of energy between the fluid and the machine by means of flow forces

- rotodynamic pumps
- fans and compressors

Positive displacement machines
Transfer of energy between the fluid and the machine by means of a variable volume, generated by a displacement device

- positive displacement pumps
- piston compressors

Real industrial applications...

A centrifugal pump at a power plant

Positive displacement pump

...and the corresponding GUNT device

HM 150.16 Series and parallel configuration of pumps (easy-to-handle experimental unit)

HM 362 Comparison of pumps (complex trainer)

HM 365.21 Screw pump

The table below is an excerpt from a typical curriculum on fluid machinery at a technical university. As with the categorisation of fluid energy machines, the curriculum can be adjusted depending on focus. The GUNT devices cover almost every aspect of the curriculum.

Driven machines	GUNT products
Pumps	
Centrifugal pumps	HM 150.04, HM 150.16, HM 283, HM 284, HM 299, HM 300, HM 305, HM 332, HM 362, HM 365.11, HM 365.12, HM 365.13, HM 365.14, HM 365.15, HM 450C
Positive displacement pumps	HM 285, HM 286, HM 362, HM 365.16, HM 365.17, HM 365.18, HM 365.19, HM 365.20, HM 365.21, HM 365.22, HM 365.23, HM 365.24
Special types of positive displacement pump	HM 365.21 – HM 365.24
Rotary piston pumps	HM 286, HM 365.16, HM 365.18, HM 365.22, HM 365.24
Water jet pumps	accessories in experimental units from catalogues 4 and 5
Compressors	
Piston compressors	ET 513, HM 299, further experimental units in catalogue 3
Rotary compressors	HM 299
Radial compressors	HM 292
Fans	
Axial fans	HM 215, HM 282
Radial fans	HM 210, HM 280

HM 292 Experiments with a radial compressor

Industrial radial compressor

Basic knowledge

Centrifugal pumps

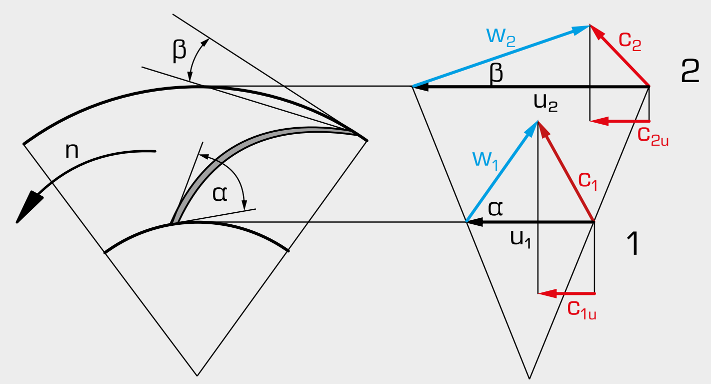
Fundamental principles of centrifugal pumps

In centrifugal pumps the energy is transferred hydrodynamically. This is in contrast to the hydrostatic transfer of energy in positive displacement pumps. In the hydrodynamic transfer of energy the fluid is accelerated by the impeller of the centrifugal pump. Therefore, the impeller of the centrifugal pump has to move with high velocity and thus a high rotational speed. The work Y_i transferred to the fluid is calculated from the velocities at the impeller.

$$Y_i = (c_{2u} \cdot u_2 - c_{1u} \cdot u_1)$$

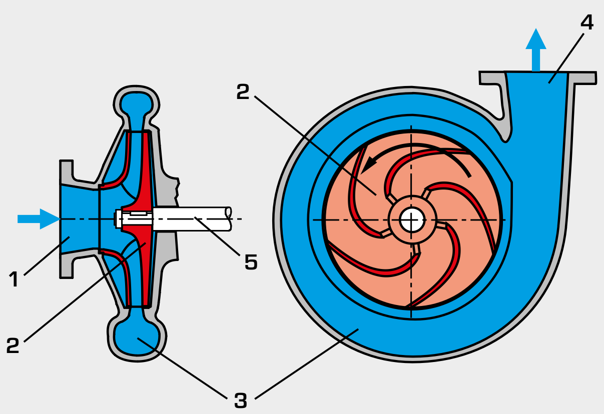
The specific work Y_i is independent of the fluid properties (density, viscosity). The flow rate **Q** and the density **ϱ** of the fluid together give the power P_i transferred from the impeller to the fluid.

$$P_i = ϱ \cdot Q (c_{2u} \cdot u_2 - c_{1u} \cdot u_1)$$



The velocities at the impeller inlet (1) and at the impeller outlet (2) can be clearly represented in velocity triangles.

1 entry of the flow, **2** outlet of the flow,
u peripheral speed, **w** relative speed of the fluid in the impeller,
c absolute velocity of the fluid,
c_{1u}/c_{2u} circumferential component of the absolute velocity,
a, b angle between the velocities, **Q** flow rate,
ϱ density, **n** rotational speed



The main components of a centrifugal pump

1 inlet, **2** impeller, **3** spiral housing, **4** outlet , **5** impeller shaft

Advantages of centrifugal pumps

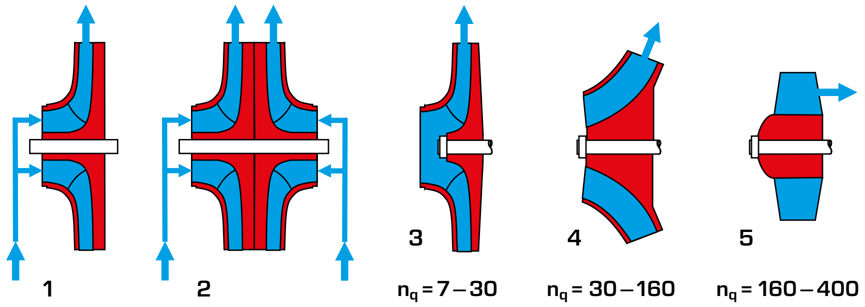
- simple design, few moving parts, long service life
- flow rate easily adjustable via valve at the outlet of the pump or via rotational speed
- high speed, direct drive via electric motor or turbine possible
- built-in pressure relief, no safety valve needed
- quiet running thanks to good mass balancing and lack of oscillating masses
- continuous, pulsation-free delivery
- solids may be carried along with the flow
- suitable for large powers
- high power concentration and smaller space

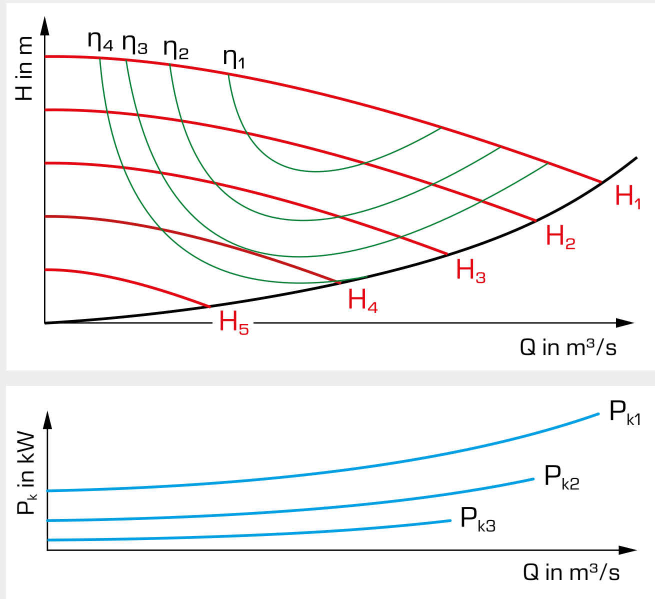
Disadvantages of centrifugal pumps

- not self-priming (special types such as side channel pumps may also be self-priming)
- risk of cavitation with warm water or low intake pressures
- flow rate is dependent on the delivery pressure
- several stages necessary at high delivery pressures

Design features of centrifugal pumps

- number of stages: single-stage, multi-stage
- open/closed impeller
- **1** single-suction/**2** double-suction impeller
- flow through the impeller **3** radial, **4** diagonal, **5** axial





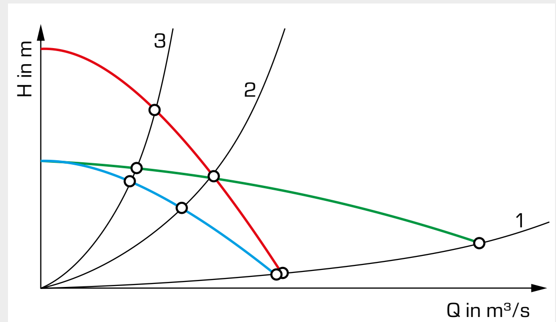
$H_1...H_5$ pump characteristics depending on the speed,
$η_1...η_5$ efficiency depending on the speed,
system characteristic;
$P_{k1}...P_{k3}$ coupling power depending on the speed

$$n_q = n \cdot \frac{Q^{1/2}}{H^{3/4}}$$

The similarity of different pumps is described by the dimensionless characteristic of the specific speed n_q.

Operating behaviour and operating points of centrifugal pumps

At the operating point the delivery pressure generated by the pump is in equilibrium with the resistance of the pipe network at a certain flow rate. The operating point is where the pump characteristic intersects the resistance characteristic of the pipe network.



Pump characteristics

single pump,
two pumps connected in series,
two pumps connected in parallel;

Pipe network characteristics

1 system with low resistance,
2 system with medium resistance,
3 system with large resistance

Characteristic zone of centrifugal pumps

The characteristic values of a centrifugal pump are plotted in a characteristic zone over the flow rate **Q**. The main characteristic is the head **H** or the delivery pressure **p**.

The lines of equal efficiency **η** are also entered in the characteristic zone.

Another important representation is the plot of the coupling power P_K and the **NPSH** over the flow **Q**.

Important physical laws in centrifugal pumps:

- the flow rate **Q** is linearly dependent on the speed **n**. — $Q = f(n)$
- the head **H** is dependent on the square of the speed **n**. — $H = f(n^2)$
- the power P_K is dependent on the third power of the speed **n**. — $P_K = f(n^3)$

HM 150.04
Centrifugal pump

The illustration shows HM 150.04 together with HM 150.

Description

- **characteristic curve of a centrifugal pump**
- **variable speed via frequency converter**

Centrifugal pumps are turbomachines that are used for conveying fluids. The HM 150.04 unit can be used to study a centrifugal pump and to record a typical pump characteristic curve.

The experimental unit includes a self-priming centrifugal pump, a ball valve on the outlet side and manometers on the inlet and outlet side. It is driven by an asynchronous motor. The speed is infinitely adjustable by using a frequency converter. A ball valve is used to adjust the head.

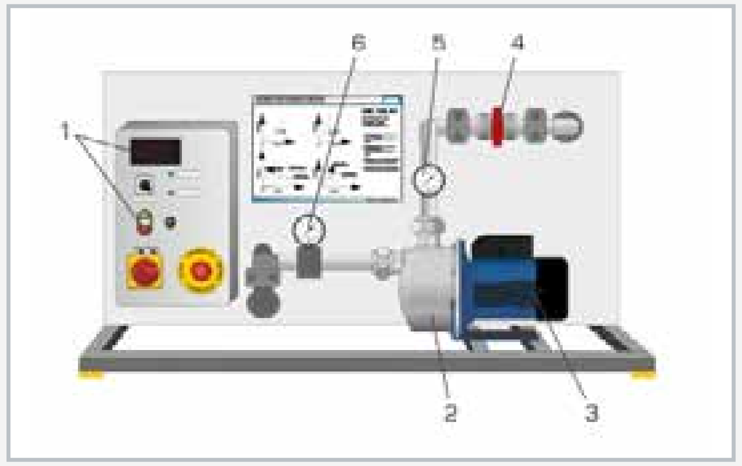
In experiments, the operating behaviour of the pump as a function of the flow rate is studied and displayed in characteristic curves. The motor's speed and electrical power are displayed digitally. Pressures on the inlet and outlet side are displayed on two manometers.

The experimental unit is positioned easily and securely on the work surface of the HM 150 base module. The pump draws in water from the tank on the base module HM 150. The flow rate is determined volumetrically by flowing back into the measuring tank on HM 150.

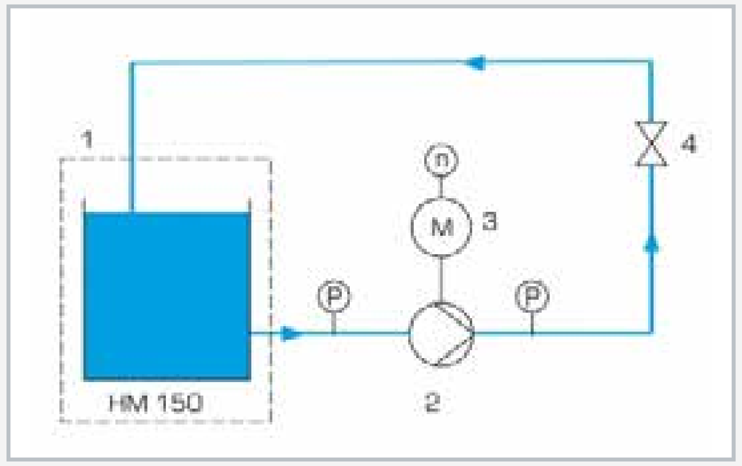
Learning objectives/experiments

- recording the pump characteristic curve at a constant pump speed
  - measuring the inlet and outlet pressure
  - determining the flow rate
- recording the pump characteristics for different speeds
- power and efficiency curves
  - measuring the electrical drive power
  - determining the hydraulic power
  - calculating the efficiency

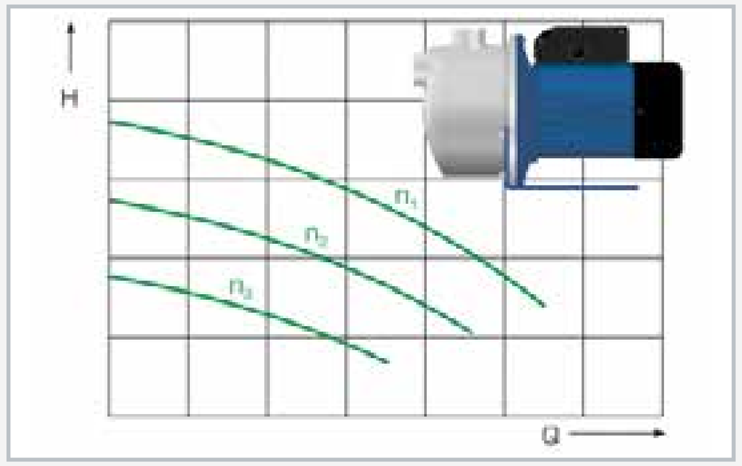
HM 150.04
Centrifugal pump



1 display and controls, 2 centrifugal pump, 3 motor, 4 ball valve for adjusting the head, 5 outlet side manometer, 6 inlet side manometer



1 water supply via HM 150, 2 centrifugal pump, 3 motor, 4 ball valve for adjusting the head; P pressure, n speed



Pump characteristic curves at different speeds:
H head, Q flow rate, n speed

Specification

[1] investigation of a centrifugal pump
[2] drive with variable speed via frequency converter
[3] ball valve to adjust the head
[4] manometers on the inlet and outlet side of the pump
[5] digital display of speed and power
[6] flow rate determined by base module HM 150
[7] water supply using base module HM 150

Technical data

Centrifugal pump, self-priming
- max. flow rate: 3000L/h
- max. head: 36,9m

Asynchronous motor
- nominal power: 370W

Measuring ranges
- pressure (outlet side): -1...5bar
- pressure (inlet side): -1...1,5bar
- speed: 0...3000min^{-1}
- power: 0...1000W

Measuring ranges
- pressure (outlet): -1...5bar
- pressure (inlet): -1...1,5bar
- speed: 0...3000min^{-1}
- power: 0...1000W

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1100x640x600mm
Weight: approx. 46kg

Required for operation

HM 150 (closed water circuit)

Scope of delivery

1 experimental unit
1 set of instructional material

HM 150.16

Series and parallel configuration of pumps

Description

- **series and parallel configuration of pumps**
- **determining pump characteristic curves**

In complex systems, pumps can be connected in series or in parallel. In series operation the heads are added together and in parallel operation, the flow rates of the pumps are added. Series and parallel configuration of pumps behave similar to series and parallel configuration of electric resistances in electric circuits. The pump correlates with the electric resistance, the flow correlates with the electric current and the head with the voltage.

With HM 150.16 pumps are studied individually, in series and in parallel configuration.

The experimental unit contains two identical centrifugal pumps and an intake tank with overflow. The overflow ensures a constant suction head in the tank, regardless of the water supply. Ball valves in the pipes allow easy switching between series and parallel operation.

Pressures at inlet and outlet of the two pumps are displayed on manometers.

The experimental unit is positioned easily and securely on the work surface of the HM 150 base module. The water is supplied and the flow rate measured by HM 150. Alternatively, the experimental unit can be operated by the laboratory supply.

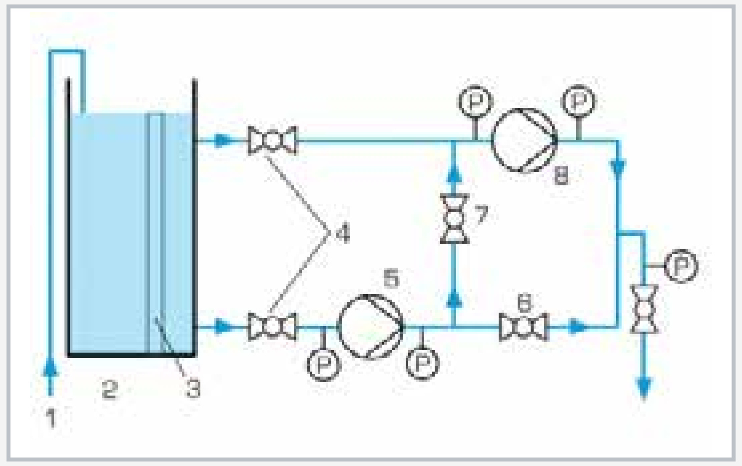
Learning objectives/experiments

- investigation of pumps in series and parallel configuration
  - determining the head
  - recording the pump characteristics
  - determining the hydraulic power
  - determining the operating point

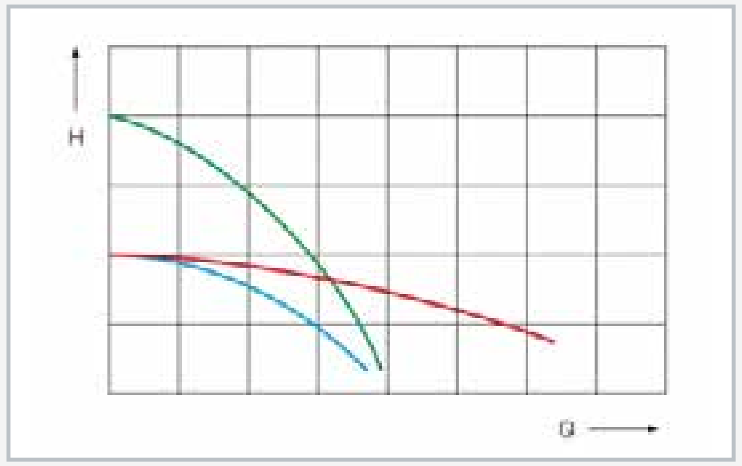
HM 150.16

Series and parallel configuration of pumps

1 tank, 2 overflow, 3 water connection, 4 ball valve, 5 pump, 6 pump switch, 7 drain, 8 manometer



1 water connection, 2 tank, 3 overflow, 4 ball valve, 5 pump 1, 6 and 7 ball valves for switching the pumps between series and parallel operation, 8 pump 2; P pressure



Characteristic curves: blue: one pump in operation, red: parallel configuration of pumps, green: series configuration of pumps; H head, Q flow rate

Specification

[1] investigation of series and parallel configuration of pumps
[2] two identical centrifugal pumps
[3] transparent tank as intake tank
[4] overflow in the tank ensures constant suction head
[5] ball valves used to switch between series and parallel operation
[6] manometers at inlet and outlet of each pump
[7] flow rate determined by base module HM 150
[8] water supply via HM 150 or via laboratory supply

Technical data

2x centrifugal pump
- power consumption: 370W
- max. flow rate: 21L/min
- max. head: 12m

Tank: 13L
Pipes and pipe connections: PVC

Measuring ranges
- pressure (inlet): 2x -1...1,5bar
- pressure (outlet): 3x 0...2,5bar

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1110x650x500mm
Weight: approx. 62kg

Required for operation

HM 150 (closed water circuit) or water connection, drain

Scope of delivery

1 experimental unit
1 set of instructional material

HM 450C
Characteristic variables of hydraulic turbomachines

The illustration shows HM 450C together with the two turbines HM 450.01 (left) and HM 450.02 (right).

Description

- **characteristic variables of water turbines and centrifugal pumps**
- **pelton turbine HM 450.01 and Francis turbine HM 450.02 extend the scope of experiments**
- **pumped storage plant**

Turbomachines such as pumps and turbines are energy converters. Turbines convert flow energy into mechanical energy and pumps convert mechanical energy into flow energy.

HM 450C can be used to investigate a centrifugal pump. Experiments can be performed on two key water turbine designs: Pelton and Francis turbine, available as accessories HM 450.01 and HM 450.02.

The closed water circuit comprises a tank, a standard centrifugal pump with variable speed and a flow control valve to adjust the back pressure.

The speed is detected contact-free by means of an inductive displacement sensor on the motor shaft. To determine the drive power, the drive motor is mounted on swivel bearings and equipped with a force sensor to measure the drive torque. Pressures at the inlet and outlet of the pump are measured. The flow rate is measured by means of an electromagnetic flow meter. The measured values are displayed digitally and processed further on a PC. The PC is used to calculate the power output data of the examined turbomachine and to represent them in characteristics.

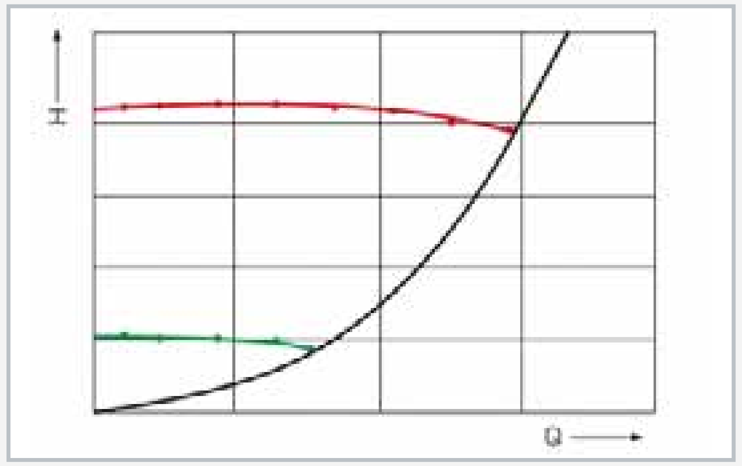
One of the turbines HM 450.01 or HM 450.02 can also be placed on top of the storage tank. The centrifugal pump supplies the turbine with water. The measured values of the turbine are transfered via cable to HM 450C. A special feature of HM 450C is the ability to operate pump and turbine at the same time. Relevant measured values are recorded contemporaneously at both turbomachines. Thus the trainer can be used as a pumped storage plant.

Learning objectives/experiments

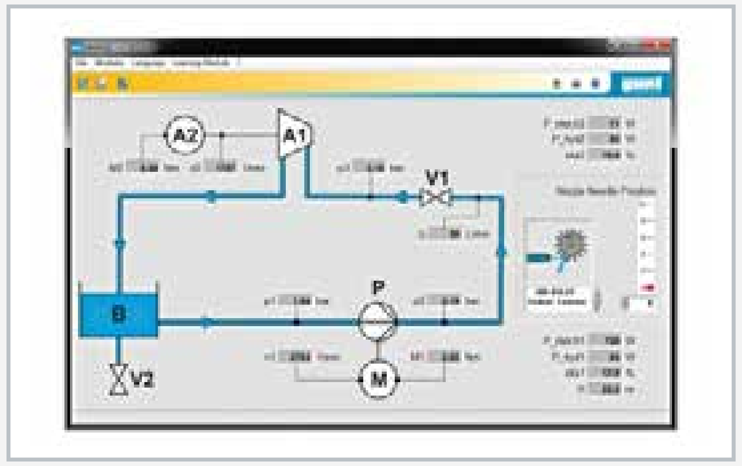
- centrifugal pump
  - measuring inlet and outlet pressures of the pump
  - determining delivery height
  - determining hydraulic output
  - determining mechanical output
  - recording characteristics at various speeds
  - determining the efficiency
- with accessories Pelton turbine HM 450.01 or Francis turbine HM 450.02
  - measuring torque and speed
  - determining efficiency of the turbine
  - recording characteristics
  - demonstration of a pumped storage plant

HM 450C
Characteristic variables of hydraulic turbomachines

1 electromagnetic flow meter, 2 flow control valve, 3 storage tank, 4 ressure sensor at pump inlet, 5 centrifugal pump, 6 drive motor including measurement of torque, 7 pressure sensor at pump outlet, 8 switch cabinet with displays and controls



Pump characteristics: H head, Q flow rate; red: characteristics at n=2900min^{-1}, green: characteristics at n=1450min^{-1}, black: system characteristic



Software screenshot: Francis turbine process schematic

Specification

[1] determining characteristic variables of a centrifugal pump
[2] determining characteristic variables of water turbines together with the accessories HM 450.01 and HM 450.02
[3] experiments on a pump in a closed water circuit with storage tank and flow control valve to adjust the back pressure
[4] experiments on turbines: closed water circuit for supplying turbines
[5] pipes and fittings made of PVC
[6] 3-phase AC motor for pump with variable speed via frequency converter
[7] non-contact speed measurement at the turbine shaft and force sensor at the brake for measuring the torque
[8] digital displays for pressures, flow rate, speed and torque
[9] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Standard centrifugal pump
- max. head: 23,9m
- max. flow rate: 31m^3/h

Drive motor with variable speed
- power output: 2,2kW
- speed range: 0...3000min^{-1}

Storage tank: 250L

Measuring ranges
- pressure: 2x 0...4bar abs.
- flow rate: 0...40m^3/h
- torque: 0...20Nm
- speed: 2x 0...4000min^{-1}

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
230V, 60Hz, 3 phases
UL/CSA optional
LxWxH: 1900x790x1900mm
Weight: approx. 243kg

Required for operation

PC with Windows recommended

Scope of delivery

1 trainer
1 GUNT software CD + USB cable
1 set of instructional material

HM 283
Experiments with a centrifugal pump

Description

- **determination of characteristic pump variables**
- **closed water circuit**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

Centrifugal pumps are turbomachines which are used to transport fluids. The rotation of the pump impeller generates centrifugal forces. These forces are used to deliver the water.

The experimental unit provides the basic experiments to get to know the operating behaviour and the important characteristic variables of centrifugal pumps.

HM 283 features a closed water circuit with water tank and a centrifugal pump with variable speed via frequency converter. The pump housing is transparent. This enables to observe the pump impeller in operation and the occurrence of cavitation.

Valves in the inlet and outlet of the pump allow the setting of different pressure conditions.

The experimental unit is fitted with sensors for pressure, temperature and flow rate. The microprocessor-based measuring technique is well protected in the housing. The measured values are transmitted directly to a PC via USB where they can be analysed using the software included.

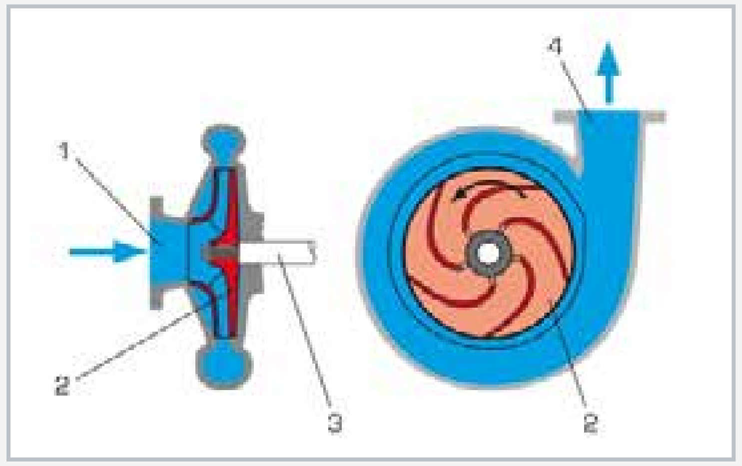
All the advantages of software-supported experiments with operation and evaluation are offered by the GUNT software and the microprocessor.

Learning objectives/experiments

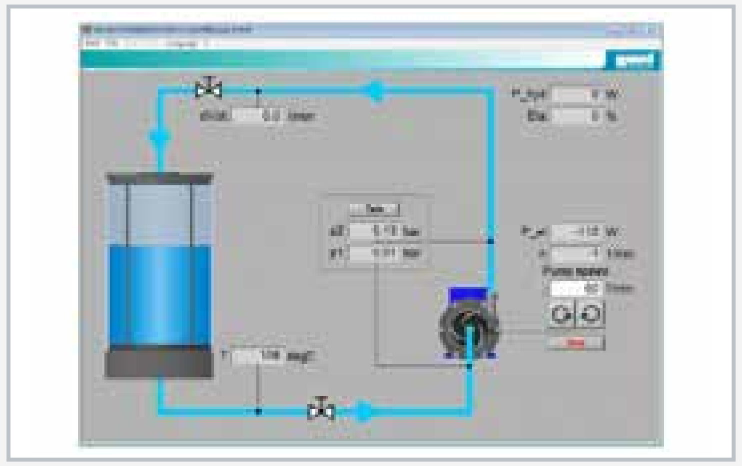
- principle of operation of a centrifugal pump
- recording of pump characteristics
- effect of speed on head
- effect of speed on flow rate
- determination of pump efficiency
- cavitation effects
- effect of incorrect direction of rotation

HM 283
Experiments with a centrifugal pump

1 water tank, 2 temperature sensor, 3 valve at intlet, 4 pressure sensor at inlet, 5 pump, 6 pressure sensor at outlet, 7 motor, 8 flow meter, 9 valve at outlet



Principle of operation of a centrifugal pump
1 water inlet, 2 pump impeller, 3 pump shaft, 4 water outlet



Operating interface of the powerful software

Specification

[1] functioning and operating behaviour of a centrifugal pump
[2] closed water circuit contains centrifugal pump with drive motor and a transparent water tank
[3] transparent housing for observing the pump impeller
[4] variable speed via frequency converter
[5] adjustment of pressure conditions at inlet and outlet side of the pump by valves
[6] sensors for pressure at inlet and outlet side of the pump, temperature and flow rate
[7] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[8] display and evaluation of the measured values as well as operation of the unit via software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Centrifugal pump with drive motor
- power consumption: 370W
- speed: 0...3000min^{-1}
- max. flow rate: approx. 40L/min
- max. head: approx. 10m

Water tank: approx. 15L

Measuring ranges
- pressure (inlet): ±1bar
- pressure (outlet): 0...5bar
- flow rate: 3,5...50L/min
- temperature: 0...130°C

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 660x590x720mm
Weight: approx. 46kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 set of instructional material

HM 284
Series and parallel configuration of pumps

Description

- **characteristic behaviour of pumps during single pump operation, series or parallel configuration**
- **closed water circuit**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

In complex systems, pumps can be connected in series or in parallel. In serial operation the heads of the pumps are added and in parallel operation the flow rates (capacities) of the pumps are added.

The experimental unit provides the determination of the characteristic behavior for single operation and interaction of two pumps.

HM 284 features a closed water circuit with a water tank and two centrifugal pumps with drive motors. The speed of one motor is variably adjustable by a frequency converter. The other pump is fitted with a motor with fixed speed, this pump can be added to the system.

The impellers of both pumps are mounted in transparent housings and can be observed during operation. Valves enable to easily switch change between single pump, series or parallel pump operation. The system behaviour is analyzed with the aid of a valve at the outlet of the pump adjusting the flow resistance.

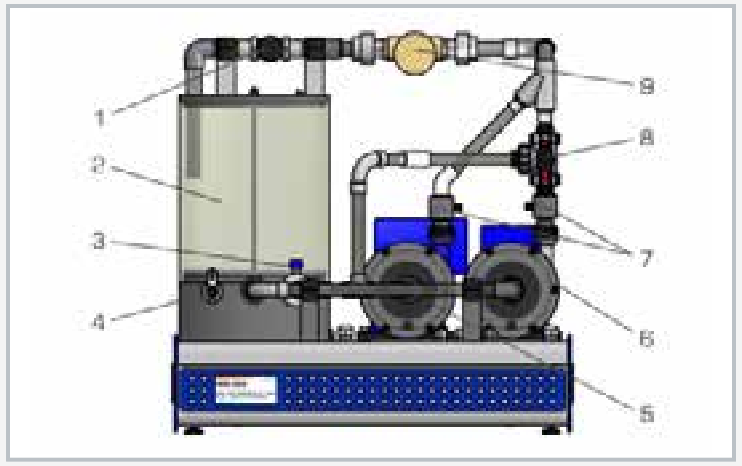
The experimental unit is fitted with sensors for pressure and flow rate. The microprocessor-based measuring technique is well protected in the housing. The measured values are transmitted directly to a PC via USB where they can be analysed using the software included.

All the advantages of software-supported experiments with operation and evaluation are offered by the GUNT software and the microprocessor.

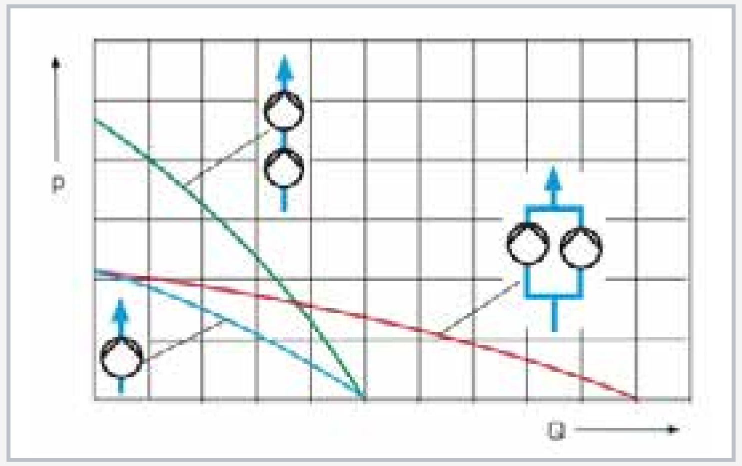
Learning objectives/experiments

- operating behaviour of centrifugal pumps
  - single pump
  - series configuration
  - parallel configuration
- recording of pump curves
- determination of pump efficiencies
- recording of system characteristic

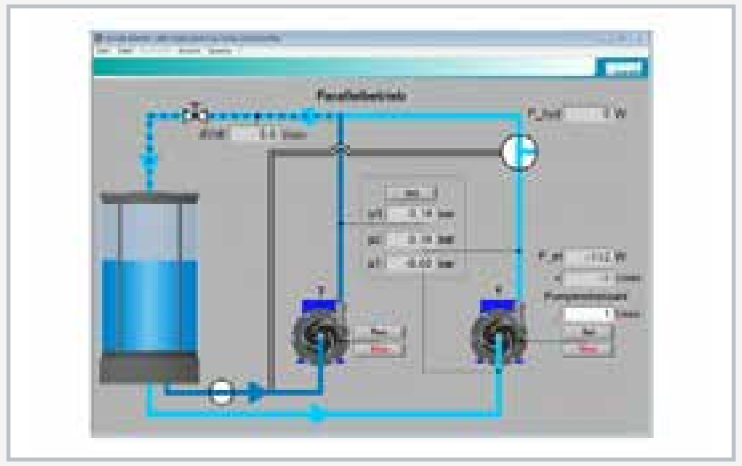
HM 284
Series and parallel configuration of pumps



1 valve for adjusting the flow rate, 2 water tank, 3 valve for configurating parallel/series operation, 4 water drain, 5 pump with fixed speed, 6 pump with variable speed, 7 pressure sensor at outlet, 8 three-way valve for parallel/series operation, 9 flow meter



Characteristic curves at different operating modes
blue: single pump operation, red: parallel configuration of pumps, green: series configuration of pumps; p pressure, Q flow rate



Operating interface of the powerful software

Specification

[1] investigation and operating behaviour of pumps in various operating modes
[2] single pump, series or parallel pump operation, configurable via valves
[3] closed water circuit contains centrifugal pumps with drive motor and a transparent water tank
[4] one pump with variable speed and one pump with fixed speed
[5] adjustment of flow resistance by a valve at outlet of the pump
[6] sensors for pressure at inlet and outlet of the pumps and flow rate
[7] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[8] display and evaluation of the measured values as well as operation of the unit via software
[9] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Centrifugal pumps with motors
- power consumption: 370W each

Pump with variable speed: 0...3300min^{-1}
- max. flow rate: 40L/min
- max. head: 10m

Pump with fixed speed: approx. 2800min^{-1}
- max. flow rate: 40L/min
- max. head: 10m

Water tank: approx. 15L

Measuring ranges
- pressure (inlet): ±1bar
- pressure (outlet): 2x 0...5bar
- flow rate: 10...140L/min

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 670x600x670mm
Weight: approx. 62kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 set of instructional material

HM 300
Hydraulic circuit with centrifugal pump

Description

- **measurement of pressure conditions in valves and fittings and a pump**
- **measurement of the flow rate**
- **clearly arranged pump circuit**

Hydraulic circuits are designed according to their task and their area of application. Designing hydraulic circuits requires knowledge of flow behaviour and pressure losses in valves and fittings, as well as characteristics of the pump. A hydraulic circuit can be compared to an electrical circuit. This analogy can be made evident in the HM 300 experimental unit.

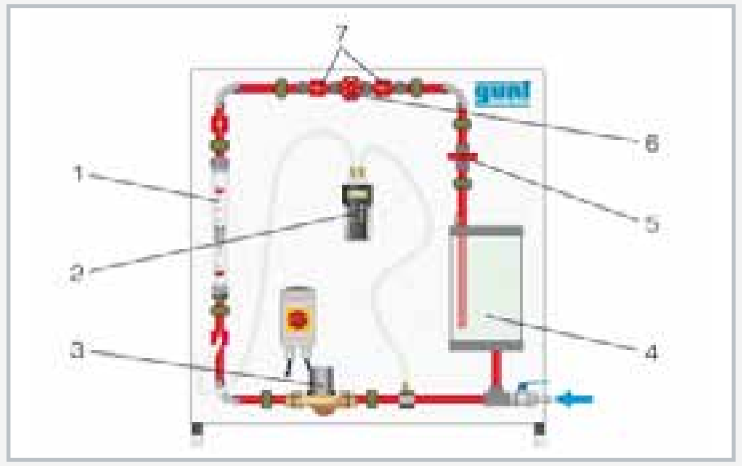
The HM 300 experimental unit includes a centrifugal pump, a rotameter, a diaphragm valve, a water tank and various other valves and fittings. After filling the system once the experimental unit can be operated independently from the water supply.

The flow is adjusted by valves and read off a rotameter. The pressure measuring points in the pipe system are designed as annular chambers. This creates a largely interference-free pressure measurement. Also supplied is an electronic pressure meter for differential pressure measurement. The pressure measurement points are connected in pairs to the pressure meter and the respective differential pressure read off the display.

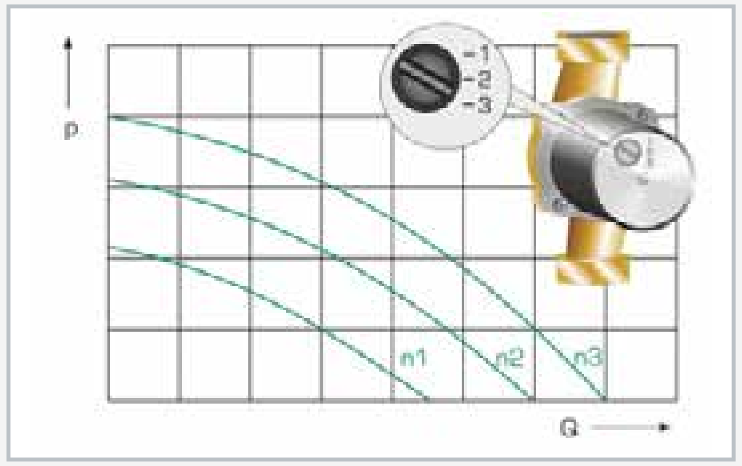
Learning objectives/experiments

- recording the pump characteristic
- pressure losses at various valves and fittings depending on the flow
- determination of the operating point in a hydrostatic circuit

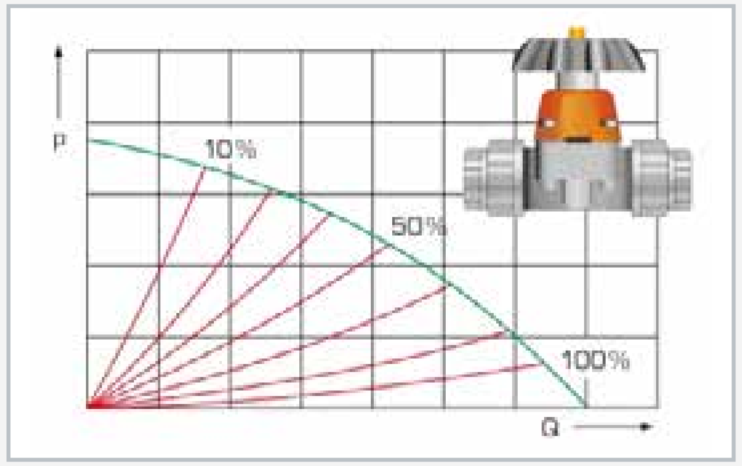
HM 300
Hydraulic circuit with centrifugal pump



1 flow meter, 2 pressure meter, 3 pump, 4 tank, 5 valve for throttling, 6 diaphragm valve, 7 pressure measuring points



Characteristics of the pump at different speeds: n speed, p pressure, Q flow rate



Characteristics of the valve at different degrees of openness up to 100%: p pressure, Q flow rate

Specification

[1] pressure conditions at various measuring objects
[2] measuring objects: pump, flow meter, diaphragm valve
[3] centrifugal pump with 3 different speeds
[4] closed water circuit
[5] flow can be adjusted via valves
[6] flow measurement using rotameter
[7] annular chambers allow easy measurement of pressure
[8] differential pressure measurement using electronic pressure meter

Technical data

Tank
- volume: 8,5L

Pump:
- max. power consumption: 70W
- max. flow rate: $5m^3/h$
- max. head: 6m
- three switching stages for speed selection

Measuring ranges
- flow rate: 150...1600L/h
- differential pressure: ±350mbar

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1000x610x1100mm
Weight: approx. 55kg

Scope of delivery

1 experimental unit
1 pressure meter
1 set of instructional material

HM 305
Centrifugal pump trainer

The illustration shows a similar unit.

Description

- **principle of operation of a centrifugal pump**
- **closed water circuit**
- **centrifugal pump, standard design**

Centrifugal pumps are turbomachines that are used for conveying fluids. In centrifugal pumps, the head depends on the flow rate. This dependency is understood to be the operating behaviour of the pump and is represented in the characteristic diagram of the pump.

The trainer HM 305 is intended for experiments on the fundamental behaviour of a hydraulic circuit. HM 305 is suitable for both training in vocational colleges and for laboratory experiments in higher education.

The equipment of the trainer includes a closed water circuit and a powerful, standard centrifugal pump. Standard pumps are built according to industrial standards. The standard defines rating schemes and key dimensions so that standard pumps from different manufacturers can be exchanged without replacing the piping and ground plate.

The centrifugal pump is powered by a three-phase motor. The speed can be adjusted to the desired value with the frequency converter. An inductive, non-contact position encoder on the engine shaft records the speed. The drive motor is mounted in a pendulum bearing such that the drive torque can be measured with a force sensor and the mechanical drive power can be determined.

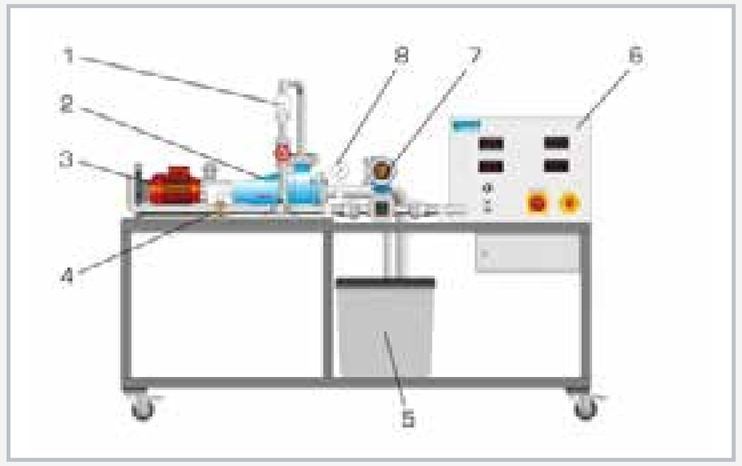
Manometers display the pressure on the pump's inlet and outlet. The flow rate is measured with an electromagnetic flow rate sensor. The flow rate can also be determined by means of a differential pressure measurement on an orifice plate flow meter.

The speed, torque, and electrical power consumption of the pump and the flow rate are shown on a digital display on the switch cabinet.

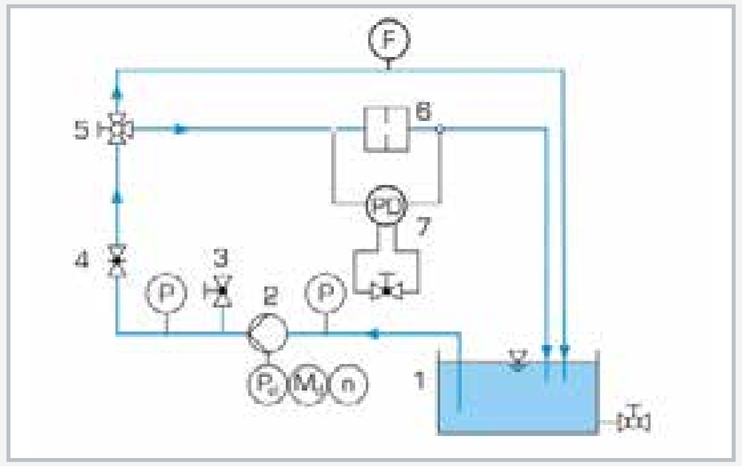
Learning objectives/experiments

- recording of pump characteristics
- recording of system characteristics
- determination of the flow rate by means of an electromagnetic flow rate sensor or an orifice plate flow meter and a differential pressure measurement
- calculation of efficiencies

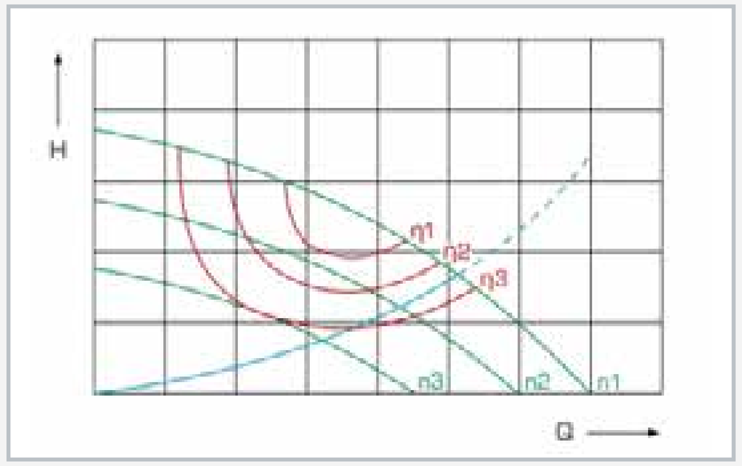
HM 305
Centrifugal pump trainer



1 outlet manometer, 2 centrifugal pump, 3 drive motor, 4 orifice plate flow meter, 5 tank, 6 switch cabinet with display and control elements, 7 electromagnetic flow meter, 8 inlet manometer



1 tank, 2 pump, 3 water connection for filling, 4 gate valve, 5 3-way valve, 6 orifice plate flow meter, 7 differential pressure sensor with bleed valve
P pressure, F flow rate, P_{el} power, n speed, M_d torque



Characteristic diagram of the centrifugal pump
green: pump characteristics for different speeds, blue: system characteristics, red: characteristics of constant efficiencies
H head, Q flow, n speed

Specification

[1] examination of a standard centrifugal pump
[2] closed water circuit
[3] three-phase motor to power the pump with variable speed via a frequency converter
[4] drive motor with pendulum bearing
[5] non-contact speed measurement at the engine shaft and force sensor for measuring the drive power
[6] determination of the flow rate by using an electromagnetic flow rate sensor, or an orifice plate flow meter and a differential pressure measurement
[7] manometer at the inlet and outlet of the centrifugal pump
[8] digital displays for torque, speed, electrical power consumption and flow

Technical data

Centrifugal pump
- max. flow rate: approx. 15m^3/h
- max. head: approx. 16m

Drive motor with variable speed
- power output: 1,1kW
- speed range: 0...2400min^{-1}

Tank
- volume: 96L

Measuring ranges
- pressure: 1x -0,6...0bar, 1x 0...2,5bar
- flow rate: 5...600L/min
- speed: 0...5000min^{-1}
- torque: 0...10Nm
- power consumption: 0...2,2kW

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
230V, 60Hz, 3 phases
LxWxH: 2000x750x1480mm
Weight: approx. 215kg

Scope of delivery

1 trainer
1 set of accessories
1 set of instructional material

HM 332

Pump characteristics for parallel and series configuration

Description

- **operation of centrifugal pumps in parallel and series configuration**
- **identification of pump and system characteristics**

In practice, several pumps are often installed either in parallel or in series configuration for economic reasons. In in parallel configuration the pumps operate in a common pipe. This requires that the pumps used in each case can achieve the same head. Parallel configurations offer the advantage that when demand is low only one pump works and other pumps are switched on as the flow rate increases. In series configuration pumps with equal flow rates are arranged in a row. This arrangement allows the bridging of large heads and is often more cost-effective than the use of a single pump with large head.

The HM 332 trainer studies the cooperation of two centrifugal pumps and illustrates the differences in parallel and series configuration. The metrology components used are common in industry and therefore closely related to practice.

The trainer has a closed water circuit and is equipped with two identical pumps that are driven by speed-controlled motors. The rotational speed of the motors for the centrifugal pumps can be adjusted via frequency converters. All motors are mounted on swivel bearings so that the drive torque can be measured via a force sensor, allowing the mechanical drive power to be determined.

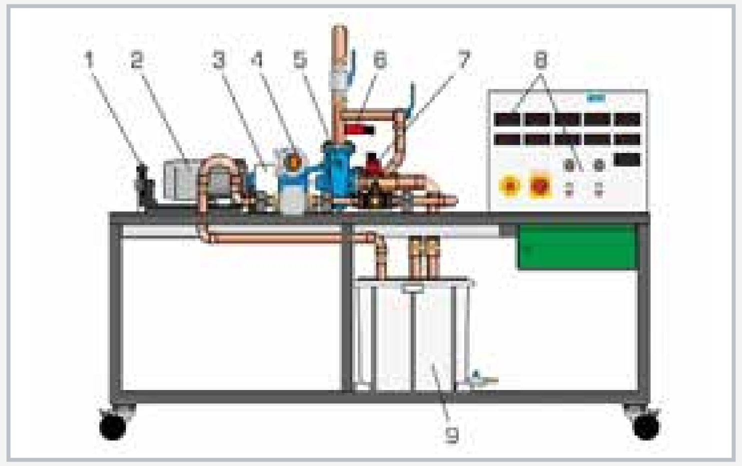
Sensors detect the pressures at inlet and outlet of the pumps. The flow rate is measured by an electromagnetic flow meter. Relevant measured values are read from digital displays and can be transmitted simultaneously via USB directly to a PC where they can be analysed using the software included. The performance data of the pump and losses in the pipe are calculated in the software and shown in the form of characteristics. Characteristic parameters of pumps are determined from the measured values. Furthermore, students are familiarised with the operating behaviour of centrifugal pumps and can practise the correct way to start up and shut down such a pump system.

Learning objectives/experiments

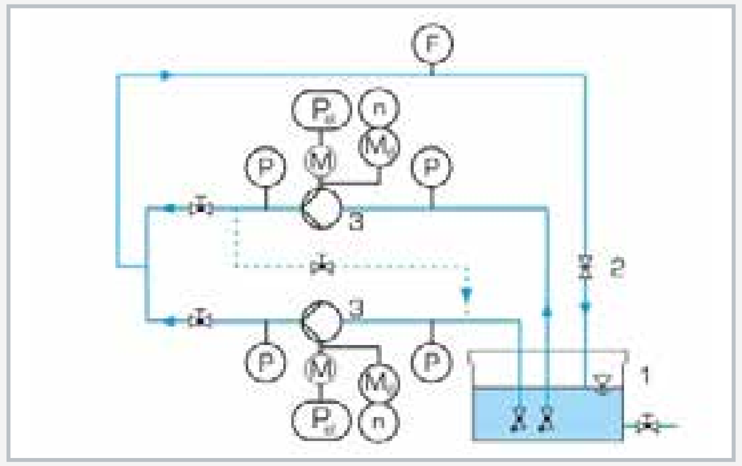
- investigate behaviour of centrifugal pumps in operation
- recording pump characteristics
- recording system characteristics
- determining efficiency
- investigation of series and parallel configuration of pumps
- starting up and shutting down pump systems

HM 332

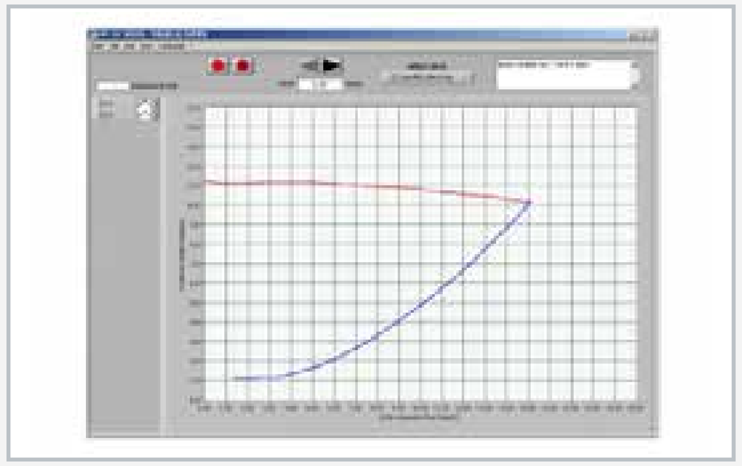
Pump characteristics for parallel and series configuration



1 force sensor, 2 drive motor, 3 speed sensor, 4 electromagnetic flow meter, 5 pump, 6 pressure sensor at outlet, 7 pressure sensor at inlet, 8 displays and controls, 9 supply tank



Parallel configuration of pumps: 1 supply tank, 2 valve for adjusting the flow rate, 3 pump with drive motor; P pressure, F flow rate, n speed, M_d torque, P_{el} power



Software screenshot: red: pump characteristic, blue: system characteristic with parallel configuration of pumps

Specification

[1] trainer with 2 centrifugal pumps which are operated in series or parallel configuration
[2] closed water circuit
[3] drive motors with adjustable speed
[4] motor with pendulum bearing, torque measurement via lever arm and force sensor
[5] inductive speed sensor on the motor
[6] electromagnetic flow meter
[7] digital displays for power consumption, torque, speed, pressure and flow rate
[8] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

2 pumps

- max. flow rate: 18,5m^3/h
- max. head: 19,6m

2 drive motors

- power output: 1,1kW
- speed range: 0...3000min^{-1}

Supply tank: 96L

Measuring ranges

- pressure (inlet):
  - pump 1: -1...0,6bar
  - pump 2: -1...3bar
- pressure (outlet):
  - pump 1: 0...2,5bar
  - pump 2: 0...6bar
- flow rate: 0...480L/min
- speed: 2x 0...3000min^{-1}
- torque: 2x 0...10Nm
- power: 2x 0...2,2kW

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 230V, 60Hz, 3 phases
UL/CSA optional
LxWxH: 2000x750x1700mm
Weight: approx. 310kg

Required for operation

PC with Windows recommended

Scope of delivery

1 trainer
1 GUNT software CD + USB cable
1 set of instructional material

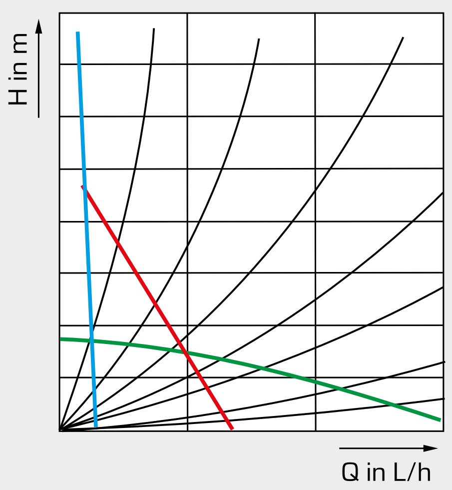
HM 362 Comparison of pumps

In order to properly use a pump, it is important to know the pump's operating behaviour. The HM 362 trainer offers students the opportunity to compare the operating behaviour of three different types of pumps. The trainer includes two centrifugal pumps, a piston pump as positive displacement pump and a self-priming side channel pump. The side channel pump primarily works as a centrifugal pump and, depending on the fill level, may also act as a positive displacement pump. This means a special feature of the side channel pump is the ability to convey gases.

Investigations on series and parallel configurations can be conducted with the two identical centrifugal pumps.

The trainer provides a ready-prepared place for experiments with its own pump. This space is fitted with a variable speed three-phase motor, whose direction of rotation is reversible.

The measurements are supported and visualised by the GUNT data acquisition software.



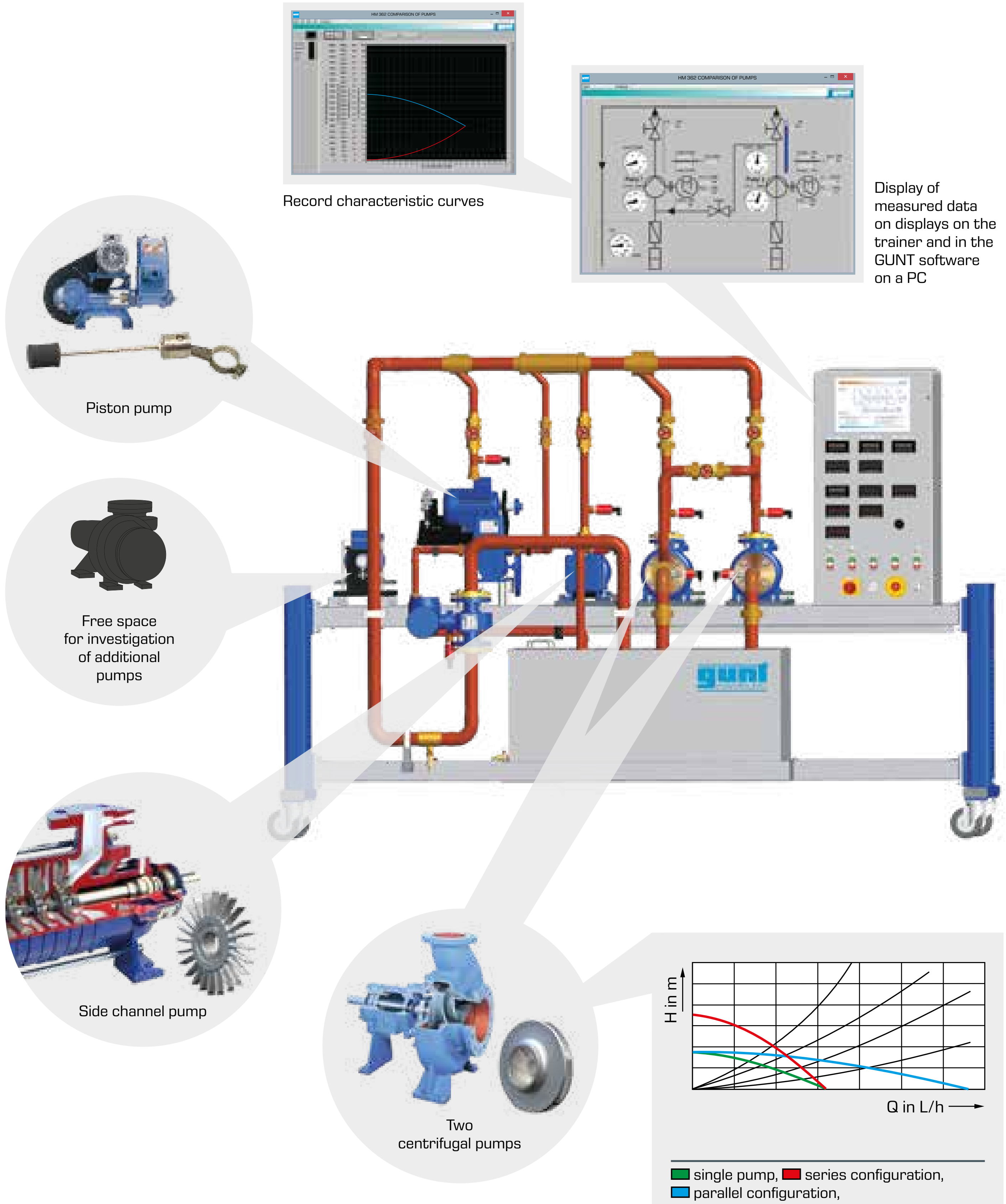
Compare operating behaviour of different types of pumps

centrifugal pump, side channel pump, piston pump, system characteristics; **Q** flow, **H** head

Each pump testing station has a measuring device for detecting the drive torque

Each pump has an inlet and outlet above pressure sensors

Sensors for flow measurement



single pump, series configuration, parallel configuration, system characteristics; **Q** flow, **H** head

HM 362
Comparison of pumps

Description

- **investigation of the operating behaviour of centrifugal, piston and side-channel pumps**
- **all pumps driven separately by three-phase AC motors**
- **centrifugal pumps can be operated in series or parallel configuration**

The experiments familiarise students with various pump types, such as centrifugal and positive-displacement pumps.

The HM 362 trainer includes two centrifugal pumps, one piston pump as a positive-displacement pump and a self-priming side-channel pump. The side-channel pump works primarily as a centrifugal pump and, depending on liquid level, can also act as a positive-displacement pump. This means, as a special feature, the side-channel pump also permits gases to be pumped.

The pump being investigated pumps water in a closed circuit. In the process, the performance data of the pump and pressure losses in the pipeline are recorded. The centrifugal pumps can also be operated in parallel or in series configuration. Each pump is driven by a separate three-phase AC motor. The speed of the motors for the centrifugal pumps is variably adjustable by a frequency converter. All motors are mounted on swivel bearings, so the torque can be measured by way of a force sensor, enabling the mechanical drive power output to be determined.

One free position is likewise equipped with a reversible three-phase AC motor with variable speed. This position can be used for mounting of any pump.

Experiments demonstrate the basic operating behaviour of various pump types.

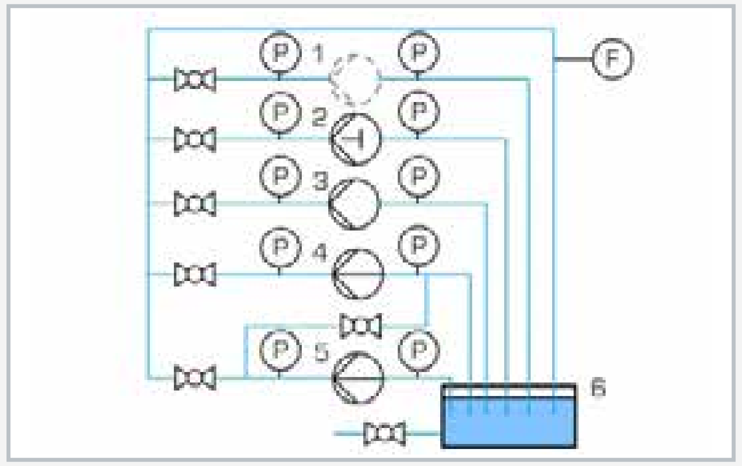
Relevant measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included. The performance data of the pump and losses in the pipeline are calculated by the software and represented by characteristic curves. The operating point of the pump can be determined from these characteristics.

Learning objectives/experiments

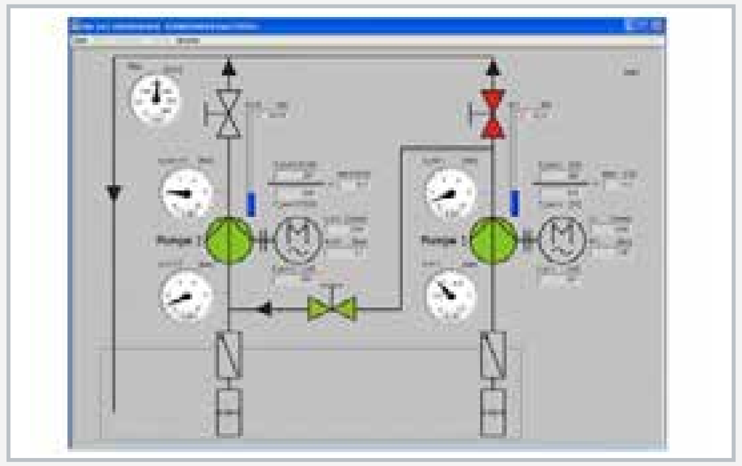
- investigation and comparison of the operating behaviour of various pump types:
  - centrifugal pumps
  - piston pump (positive-displacement pump)
  - side-channel pump
- recording a pump characteristic curve
- recording a system characteristic curve
- determining efficiency
- investigation and comparison of parallel and series configuration of centrifugal pumps
- comparison of pump types

HM 362
Comparison of pumps

1 flow control valve (at outlet), 2 connection for additional pump, 3 piston pump motor, 4 motor for additional pump, 5 piston pump, 6 flow rate sensor, 7 storage tank, 8 switch cabinet with displays and controls, 9 centrifugal pump, 10 side-channel pump, 11 pressure sensor



Process schematic of the trainer
1 free place for additional pump (provided by user), 2 piston pump, 3 side-channel pump, 4+5 centrifugal pump, 6 storage tank; F flow rate, P pressure



Software screenshot: series configuration of centrifugal pumps

Specification

[1] experiments relating to key issues in pump engineering
[2] comparison of various pump types: centrifugal pump, piston pump, side-channel pump
[3] operation of centrifugal pumps in parallel or series configuration
[4] free position for additional pump
[5] three-phase AC motors for centrifugal pumps and additional motor with variable speed by frequency converter
[6] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Centrifugal pump 2x
- max. flow rate (Q): 300L/min
- max. head (H): 16,9m
- nominal speed: 2900min^{-1}

Three-phase AC motor 2x, for centrifugal pump
- power output: 1,1kW

Side-channel pump, self-priming, one-stage
- Q: 83,3L/min, H: 50m
- nominal speed: 1450min^{-1}

Three-phase AC motor for side-channel pump
- power output: 1,1kW

Piston pump
- Q: 17L/min, H: 60m
- nominal speed: 405min^{-1}

Three-phase AC motor for piston pump
- power output: 0,55kW

Three-phase AC motor, additional motor, reversible
- power output: 0,75kW
- speed range: 750...3000min^{-1}

Measuring ranges
- flow rate: 0...500L/min
- pressure (inlet): -1...1,5bar
- pressure (outlet): 0...10bar
- torque: 0...15Nm
- speed: 0...3000min^{-1}
- pump electrical power consumption: 0...2kW

400V, 50Hz, 3 phases
400V, 60Hz, 3 phases
230V, 60Hz, 3 phases
LxWxH: 2860x1200x1960mm
Weight: approx. 430kg

Required for operation

PC with Windows recommended

Scope of delivery

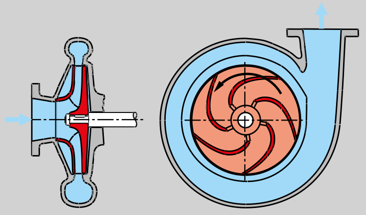
trainer, 1 GUNT software CD + USB cable, 1 set of instructional material

GUNT-FEMLine
Water pump training part 1 roto dynamic pumps

Water pumps are driven machines. They can be designed as positive displacement pumps or rotodynamic pumps. The selection of the correct pump type is crucial when designing industrial systems or installing a pump. This is why it is important that future engineers understand the characteristics of pumps and interpret diagrams to be able to distinguish between the different types of pumps.

1st part | Rotodynamic pumps as water pumps:

The centrifugal pump is the most common water pump. It belongs to the group of rotodynamic pumps. The water pump training from GUNT offers four different types of centrifugal pumps, based on which students can learn about the mode operation and the differences of these types:



Standard design centrifugal pump

Standard pumps are pumps that are designed in accordance with international standards. The standard defines rating schemes and key dimensions so that standard pumps from different manufacturers can be exchanged without replacing the piping and ground plate.

HM 365.11
Centrifugal pump, standard design

Centrifugal self-priming pump

Self-priming pumps are able to suck in and transport air and water. In contrast to a simple centrifugal pump, they can also be started if there is air in the intake line. This is possible because of an additional side-channel suction stage that removes the air from the intake line and creates the negative pressure that is needed to suck in the fluid.

HM 365.12
Centrifugal pump, self-priming

4-stage centrifugal pump

In centrifugal pumps with multiple stages, several impellers are arranged in series. This allows the pump to overcome large differences in head.

HM 365.13
Centrifugal pump, multistage

Different circuit configurations for centrifugal pumps

In complex systems, pumps can be connected in series or in parallel. In series operation the head is the sum of the individual heads; in parallel operation the flow rates of the individual pumps are combined.

HM 365.14
Centrifugal pumps,
series and parallel connected

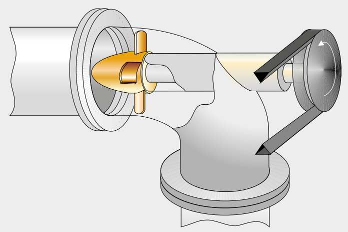
Side channel pump

Side channel pumps form a category between positive displacement pumps and rotodynamic pumps. During the suction phase the side channel pump operates according to the positive displacement principle. As soon as the suction process is over, the side channel pump starts working like a centrifugal pump. The centrifugal force of the rotating impeller separates the fluid and gas. Side channel pumps are therefore self-priming pumps.

HM 365.15
Side channel pump

Axial-flow pump

Axial-flow pumps are also known as propeller pumps. Axial-flow pumps come with fixed blades and with variable blades. The flow passes through the impeller in axial direction. In axial-flow pumps, the pressure is not built up by the effect of centrifugal force but, like the aerodynamic principle, by the propeller blade. Propeller pumps are not self-priming pumps. They are used when high flow rates and a small head are needed. The typical areas of application for propeller pumps are drainage systems, wastewater treatment plants and cooling water supply systems.



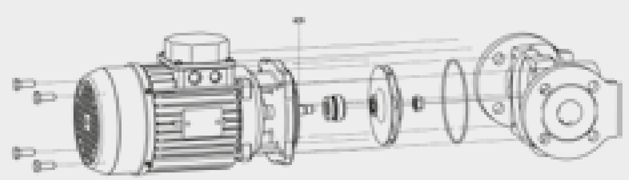
HM 365.45
Axial-flow pump

Sectional models and assembly training

To complete the water pump training, GUNT offers **sectional models and assembly and maintenance training** for different pumps. Please refer to catalogue 4 for more information on these devices.

HM 700.17 Cutaway model: centrifugal pump

MT 181 Assembly & maintenance exercise: multistage centrifugal pump



MT 185 Assembly & maintenance exercise: in-line centrifugal pump exploded drawing of an inline centrifugal pump

HM 365
Universal drive and brake unit

Learning objectives/experiments

- asynchronous motor as a drive or brake unit in connection with one of the accessories
  - torque measurement
  - speed measurement

Description

- **base module of the GUNT-FEM-Line**
- **asynchronous motor with frequency converter and precise adjustment of the drive and brake torque**
- **connection of HM 365 and the driving or driven machine with a V-belt drive**
- **setting up a complete test stand with various accessories**

HM 365 is the base module of the GUNT-FEMLine, on which students can carry out experiments on fluid machinery. This equipment series covers five training courses on water and oil pumps, turbines, and systems engineering and engine technologies.

The complete experimental setup includes the base module HM 365, the fluid energy machine to be investigated and, where needed, a supply unit or a test stand. The fluid energy machine under investigation is connected to the HM 365 base module via a belt drive. Fasteners connect the HM 365 and the trainer to the accessories.

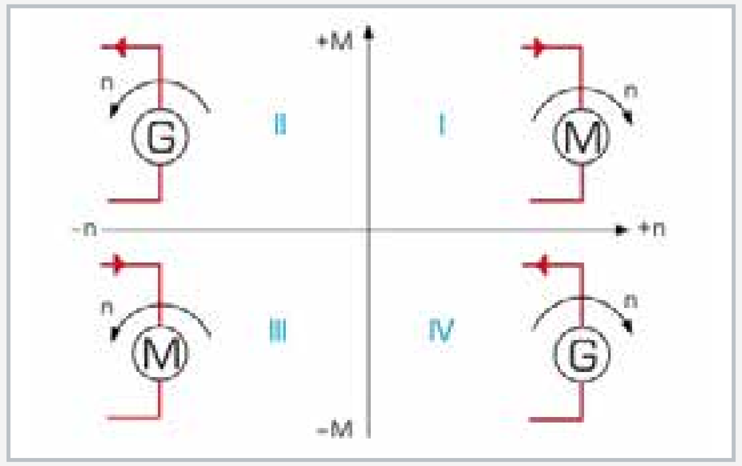
The main function of HM 365 is to provide the drive or brake power necessary to study the selected driving or driven machine. This power is generated by an air-cooled asynchronous motor with a frequency converter. The asynchronous motor operates as a generator or a motor, as required. As a generator, it acts as a brake on the fluid energy machine, in this case motors or turbines, and diverts the energy. As a motor, it powers the fluid energy machine under investigation, e.g. pumps or compressors.

The energy that is created during the braking process in generator mode is converted into heat at a load resistor. The drive and/or brake torque can be adjusted precisely. It is measured with a force sensor. For this purpose, the asynchronous motor is suspended as a pendulum. The motor can be moved to tension the V-belt.

HM 365 is fitted with digital displays for speed and torque. Data between the base module and the accessories are exchanged through a data cable. The measured values can be transmitted simultaneously via USB directly to a PC. Each of the individual accessories is delivered with specific evaluation software.

HM 365
Universal drive and brake unit

1 display and control elements, 2 spindle tensioning device for V-belt, 3 load resistor, 4 fastener, 5 clamping lever for tensioning device, 6 transparent maintenance flap, 7 protective hood for V-belt



Representation of 4-quadrant operation in speed/torque diagram: I motor operation, clockwise rotation (drive), II generator operation, anticlockwise rotation (brake), III motor operation, anticlockwise rotation (drive), IV generator operation, clockwise rotation (brake); red line: energy flow, M torque, n speed

Example of a complete experimental setup: HM 365.45 axial-flow pump, connected to HM 365 universal drive and brake unit

Specification

[1] drive and brake unit used for studying different driving or driven machines
[2] asynchronous motor with frequency converter allows 4-quadrant operation: generator or motor mode
[3] asynchronous motor with pendulum suspension, torque measurement via lever arm and force sensor
[4] optical sensor for recording the speed
[5] data exchange between base module and accessories through data cable
[6] measured values for speed and torque are digitally displayed on the device

Technical data

Asynchronous motor with frequency converter
- power: 2200W
- max. speed: approx. 3000min^{-1}
- max. torque: approx. 12Nm

V-belt operation
- length of V-belt: 1157mm, 1180mm, 1250mm
- type of V-belt: SPA
- diameter of V-belt pulley: 125mm

Resistive load: 72Ω, 2400W

Measuring ranges
- torque: ±15Nm
- speed: 0...5000min^{-1}

400V, 50Hz, 3 phases
400V, 60Hz, 3 phases
230V, 60Hz, 3 phases
UL/CSA optional
LxWxH: 1000x800x1250mm
Weight: approx. 125kg

Scope of delivery

1 base module
1 set of accessories
1 manual

HM 365.10
Supply unit for water pumps

Learning objectives/experiments

- in combination with HM 365 and a pump of the series HM 365.11 – HM 365.19
  - recording of pump characteristics
  - determination of the power requirement of the pump
  - determination of the hydraulic power of the pump
  - determination of the pump efficiency
  - determination of the system characteristics and the pump's operating point
  - checking of the required NPSH value of the rotodynamic pumps

Description

- **closed water circuit to supply the water pumps**
- **GUNT Software for data recording and visualisation**
- **part of the GUNT-FEMLine**

Pumps belong to the group of driven machines. Their task is to transport incompressible fluids. Pumps are categorised into rotodynamic pumps and positive displacement pumps, depending on their principle of operation.

Rotodynamic pumps transfer energy to the fluid with the help of blades arranged on an impeller. The blades are shaped in a way that the flow around them causes a pressure difference between the inlet and outlet side.

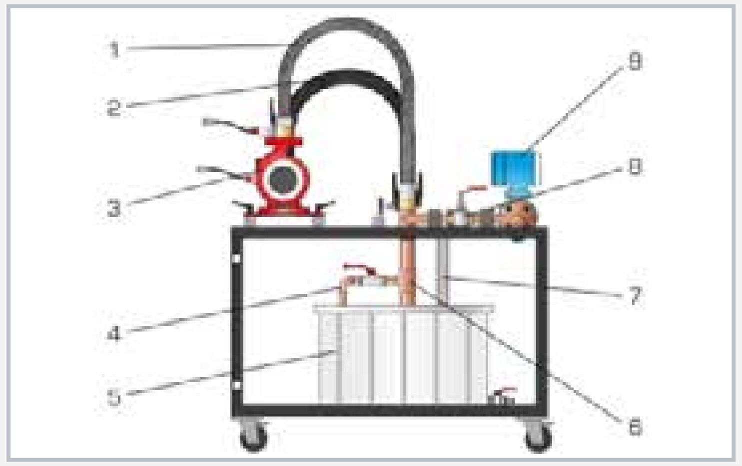
Positive displacement pumps move the pumping medium by changing the volume and by opening and closing inlets and outlets correspondingly. Depending on the design of the displacement device the volume changes through oscillating or rotating movements. Rotodynamic pumps, such as centrifugal pumps, are of advantage where large flow rates are required, while positive displacement pumps, such as piston pumps, are better suited for smaller flow rates with a high head.

The supply unit HM 365.10 supplies the working medium water for several centrifugal pumps and positive displacement pumps (HM 365.11 to HM 365.19). The pumps are powered in conjunction with the HM 365 Universal Drive and Brake Unit.

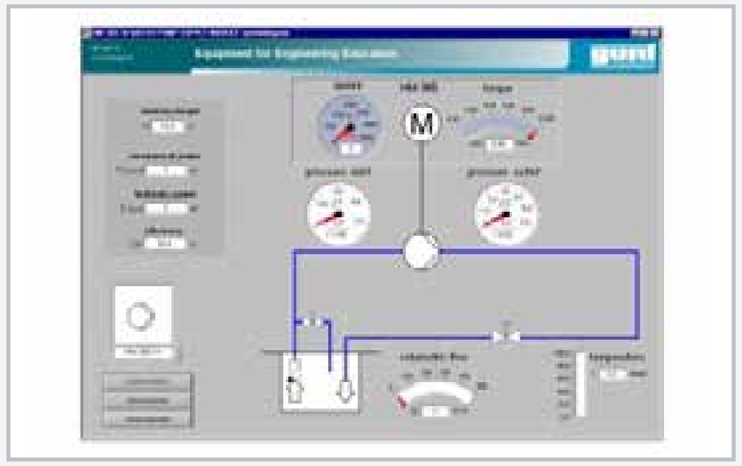
The trainer works independently of the water supply network, using a closed circuit with a storage tank. The individual pumps are placed on the work surface and connected by means of hoses with quick-release couplings, and attached with clamping levers. The pump is connected to the drive unit, which provides it with power via a V-belt.

The flow rate is measured with an electromagnetic flow rate sensor. A temperature sensor records the temperature in the piping system. Each pump is equipped with pressure sensors for measuring the pressure. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

HM 365.10
Supply unit for water pumps



1 outlet, 2 inlet, 3 accessories: pump (HM 365.11 – HM 365.19), 4 drain line, 5 storage tank, 6 intake pipe, 7 reflux, 8 flow control valve, 9 flow meter



Software screenshot: process schematic

Functional experimental setup: HM 365 drive unit (left), HM 365.10 with pump to be examined (right)

Specification

[1] supply unit for operation of different water pumps HM 365.11 to HM 365.19
[2] closed water circuit
[3] connection of pumps via flexible hoses with quick-release couplings
[4] pressure sensors at the inlet and outlet included in the scope of delivery of the pumps
[5] measurement of the water temperature in the pipeline system with PT100
[6] flow measurement with electromagnetic flow meter
[7] digital display of flow, pressure and temperature
[8] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Storage tank: 96L

Measuring ranges

- pressure (inlet): ±1bar
- pressure (outlet): 0...6bar
- temperature: 0...100°C
- flow rate: 0...480L/min

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1200x850x1150mm
Weight: approx. 140kg

Required for operation

PC with Windows recommended

Scope of delivery

1 supply unit
1 display and control unit
1 set of hoses
1 GUNT software CD + USB cable
1 set of instructional material

HM 365.11
Centrifugal pump, standard design

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics
  - determination of the power requirement and the hydraulic power
  - determination of the pump efficiency
  - determination of the system characteristics and the operating point of the pump
  - checking of the necessary NPSH value of the pump

Specification

[1] examination of a standard centrifugal pump
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Standard centrifugal pump
- max. flow rate: $24m^3/h$
- max. head: 22m
- nominal speed: approx. $2900min^{-1}$

LxWxH: 640x300x420mm
Weight: approx. 42kg

Scope of delivery

1 centrifugal pump

Description

- **operating behaviour of a standard centrifugal pump**
- **part of the GUNT-FEMLine**

Standard pumps are pumps that are designed in accordance with international standards. The standard defines rating schemes and key dimensions so that standard pumps from different manufacturers can be exchanged without replacing the piping and ground plate.

HM 365.11 is a standard, non-self-priming pump that is delivered ready for installation, mounted on a plate. The centrifugal pump is installed in the supply unit HM 365.10 with just a few simple steps and connected via hoses and attached with clamping levers. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressures at the inlet and outlet of the centrifugal pump are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

HM 365.12
Centrifugal pump, self-priming

The illustration shows a similar unit.

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics
  - determination of the power requirement and the hydraulic power
  - determination of the pump efficiency
  - determination of the system characteristics and the operating point of the pump
  - checking of the necessary NPSH value of the pump

Specification

[1] investigation of a self-priming centrifugal pump
[2] operation with HM 365.10 Supply unit for water pumps
[3] powered by HM 365 Universal drive and brake unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Self-priming centrifugal pump
- max. flow rate: $18m^3/h$
- max. head: 18m
- nominal speed: $2900min^{-1}$

LxWxH: 640x300x420mm
Weight: approx. 44kg

Scope of delivery

1 centrifugal pump

Description

- **operating behaviour of a self-priming centrifugal pump**
- **part of the GUNT-FEMLine**

Self-priming pumps are able to suck in and transport air and water. In contrast to a simple centrifugal pump, they can also be started if there is air in the intake line. This is possible because of an additional side-channel suction stage that removes the air from the intake line and creates the negative pressure that is needed to suck in the fluid.

HM 365.12 is a self-priming pump that is delivered ready for installation, mounted on a plate. The centrifugal pump is installed in the supply unit HM 365.10 with just a few simple steps and connected via hoses with quick-release couplings and attached with clamping levers. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressures at the inlet and outlet of the centrifugal pump are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC where they can be analysed using the included software.

HM 365.13
Centrifugal pump, multistage

Description

■ **operating behaviour of a multistage centrifugal pump**
■ **part of the GUNT-FEMLine**

In centrifugal pumps with multiple stages several impellers are arranged in series. This allows the pump to overcome large differences in head.

HM 365.13 is a centrifugal pump with four stages that is delivered ready for installation, mounted on a plate. The centrifugal pump is installed in the supply unit HM 365.10 with just a few simple steps and connected via hoses with quick-release couplings and attached with clamping levers. For power supply, the pump is connected to the drive unit HM 365 with a V-belt. The pump speed is reduced by the transmission ratio of the belt.

The pressures at the inlet and outlet of the centrifugal pump are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics
  - determination of the power requirement and the hydraulic power
  - determination of the pump efficiency
  - determination of the system characteristics and the operating point of the pump
  - checking of the necessary NPSH value of the pump

Specification

[1] investigation of a centrifugal pump with 4 stages
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Centrifugal pump with 4 stages
- max. flow rate: 17m^3/h
- max. head: 27m
- nominal speed: 1450min^{-1}
- transmission ratio: 1:1,6

LxWxH: 560x300x440mm
Weight: approx. 64kg

Scope of delivery

1 centrifugal pump

HM 365.14
Centrifugal pumps, series and parallel connected

Description

■ **Operating behaviour of two pumps in series or parallel connection**
■ **Part of the GUNT-FEMLine**

In complex systems, pumps can be connected in series or in parallel. In series operation, the heads are added, and in parallel operation the flow rates of the pumps are added. The series and parallel configuration of pumps is very well suited to understand the similarities with an electric circuit.

HM 365.14 is equipped with two standard centrifugal pumps that are delivered ready for installation, mounted on a plate. The centrifugal pumps are installed in the supply unit HM 365.10 with just a few simple steps, connected via hoses with quick-release couplings, and attached with clamping levers. To power the pumps, they are connected to the drive unit HM 365 with a V-belt.

The pressures at the inlet and outlet of the centrifugal pumps are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

Learning objectives/experiments

- recording of pump characteristics
- determination of the power requirement and the hydraulic power in series or parallel connection
- determination of the pump efficiency
- determination of the system characteristics and the operating point for both cases

Specification

[1] examination of standard centrifugal pumps
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] driven via HM 365
[5] pressure sensors at the inlet and outlet of the pumps
[6] pressure display on the display unit of HM 365.10

Technical data

Standard centrifugal pump
- max. flow rate: 24m^3/h
- max. head: 22m
- nominal speed: 2900min^{-1}

LxWxH: 540x840x510mm
Weight: approx. ca. 97kg

Scope of delivery

2 centrifugal pumps

HM 365.15
Side channel pump

The illustration shows a similar unit.

Description

- **operating behaviour of a side channel pump**
- **part of the GUNT-FEMLine**

Side channel pumps form a category between positive displacement pumps and rotodynamic pumps. During the suction phase the side channel pump operates according to the positive displacement principle. As soon as the suction process is over, the side channel pump starts working like a centrifugal pump. The centrifugal force of the rotating impeller separates the fluid and gas. Side channel pumps are self-priming pumps.

HM 365.15 is a self-priming, single-stage side channel pump that is delivered ready for installation, mounted on a plate. The pump is installed in the HM 365.10 supply unit with just a few simple steps, connected via hoses with quick-release couplings, and attached with clamping levers. For power supply, the pump is connected to the drive unit HM 365 with a V-belt. The pump speed is reduced by the transmission ratio of the belt.

The pressures at the inlet and outlet of the side channel pump are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics, system characteristics, operating point
  - power requirement, hydraulic power, pump efficiency, NPSH value

Specification

[1] investigation of a self-priming, single-stage side channel pump
[2] operation with HM 365.10 Supply unit for water pumps
[3] powered by HM 365 Universal drive and brake unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Side channel pump, single-stage, self-priming
- max. flow rate: $5m^3/h$
- max. head: 48m
- nominal speed: $1450min^{-1}$
- transmission ratio: 1:2

LxWxH: 400x310x460mm
Weight: approx. 24kg

Scope of delivery

1 side channel pump

First-rate handbooks

GUNT's policy is simple: high quality hardware and clearly developed accompanying instructional material ensure successful teaching and learning about an experimental unit.

The core of the accompanying material are detailed reference experiments that we have carried out. The description of the experiment contains the actual experimental setup right through to the interpretation of the results and findings. A group of experienced engineers develops and maintains the instructional material.

Nevertheless, we are here to help should any questions remain unanswered, either by phone or – if necessary – on site.

HM 365.45
Axial-flow pump

The illustration shows a similar unit.

Learning objectives/experiments

- in combination with HM 365
  - determination of the pressure/volume characteristics
  - determination of the power requirement of the pump
  - determination of the hydraulic power
  - determination of the efficiency
  - determination of the head
  - determination of the system characteristics

Description

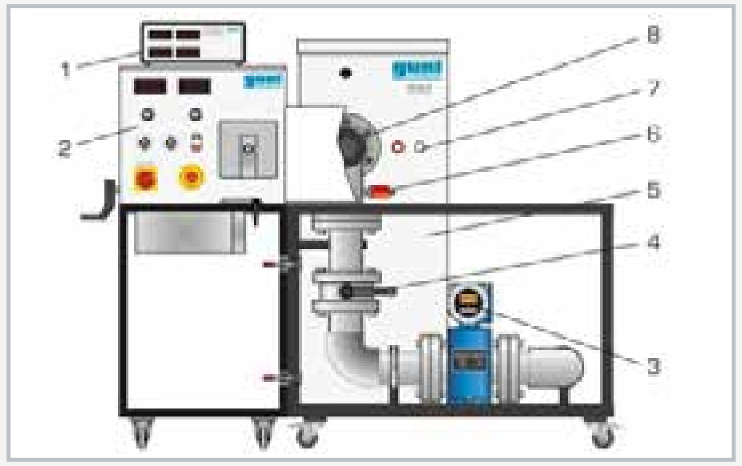
- **operating behaviour of an axial-flow pump**
- **part of the GUNT-FEMLine**

In an axial-flow pump the pumping medium flows through the impeller (here a propeller) in the axial direction. In axial-flow pumps, the pressure build-up is not achieved by the centrifugal force but, like the aerodynamic principle, by the propeller blade. Therefore these pumps are also known as propeller pumps. They are not self-priming and the propeller must always be covered by the pumping medium. Axial propeller pumps are used when high flow rates and a small head are needed. The typical areas of application for propeller pumps are drainage systems, wastewater treatment plants and cooling water supply systems.

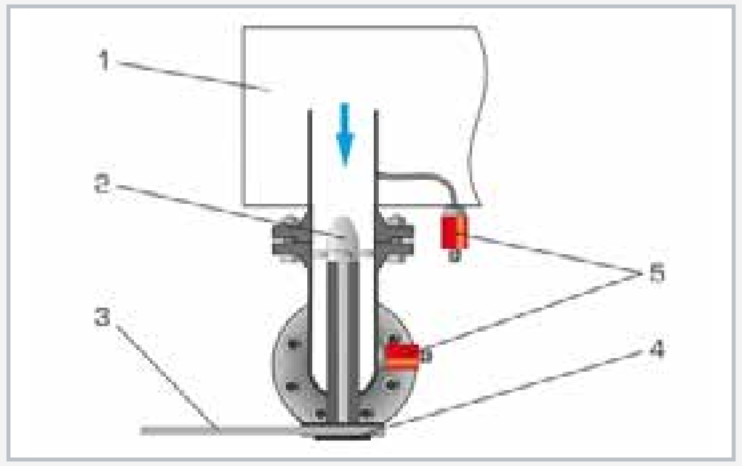
The HM 365.45 trainer includes an axial propeller pump, a tank and pipelines with generously designed pipe cross-sections. The pump is powered in conjunction with the HM 365 Universal Drive and Brake Unit. The closed water circuit means that the trainer can be used independently of the water system.

The trainer is equipped with measuring elements for the pressures at the inlet and outlet of the pump. A temperature sensor measures the water temperature. The flow rate is measured with an electromagnetic flow meter. The measured values are read from digital displays and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the software included.

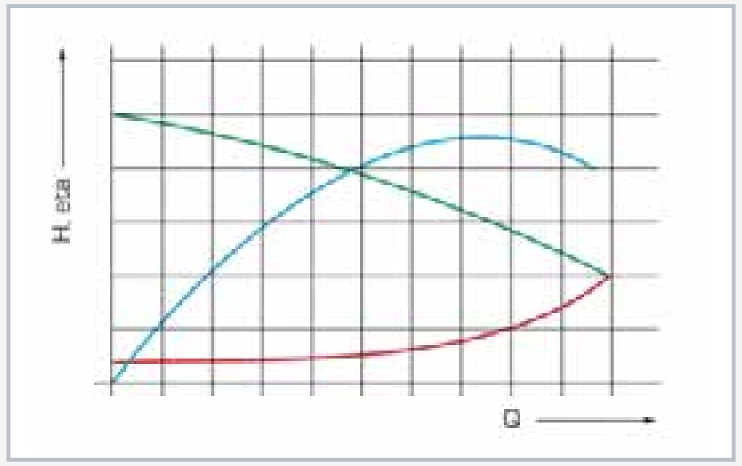
HM 365.45
Axial-flow pump



1 measuring amplifier, 2 drive unit HM 365, 3 flow meter, 4 valve, 5 water tank, 6 pressure sensor, 7 temperature sensor, 8 V-belt pulley of the axial-flow pump



1 tank, 2 pump impeller, 3 drive belt, 4 V-belt pulley, 5 pressure sensors



Pump characteristics: Q flow rate; red: system characteristics, green: pump head H, blue: pump efficiency eta

Specification

[1] investigation of an axial-flow pump
[2] closed water circuit
[3] powered by HM 365 Universal drive and brake unit
[4] water tank with sight glass
[5] determination of the flow rate with the electromagnetic flow rate sensor
[6] digital display of flow rate, pressure and temperature
[7] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Pump
- output: 1000W at 1000min^{-1}
- max. flow rate: 700L/min
- max. head: 1,75m

Tank: 160L

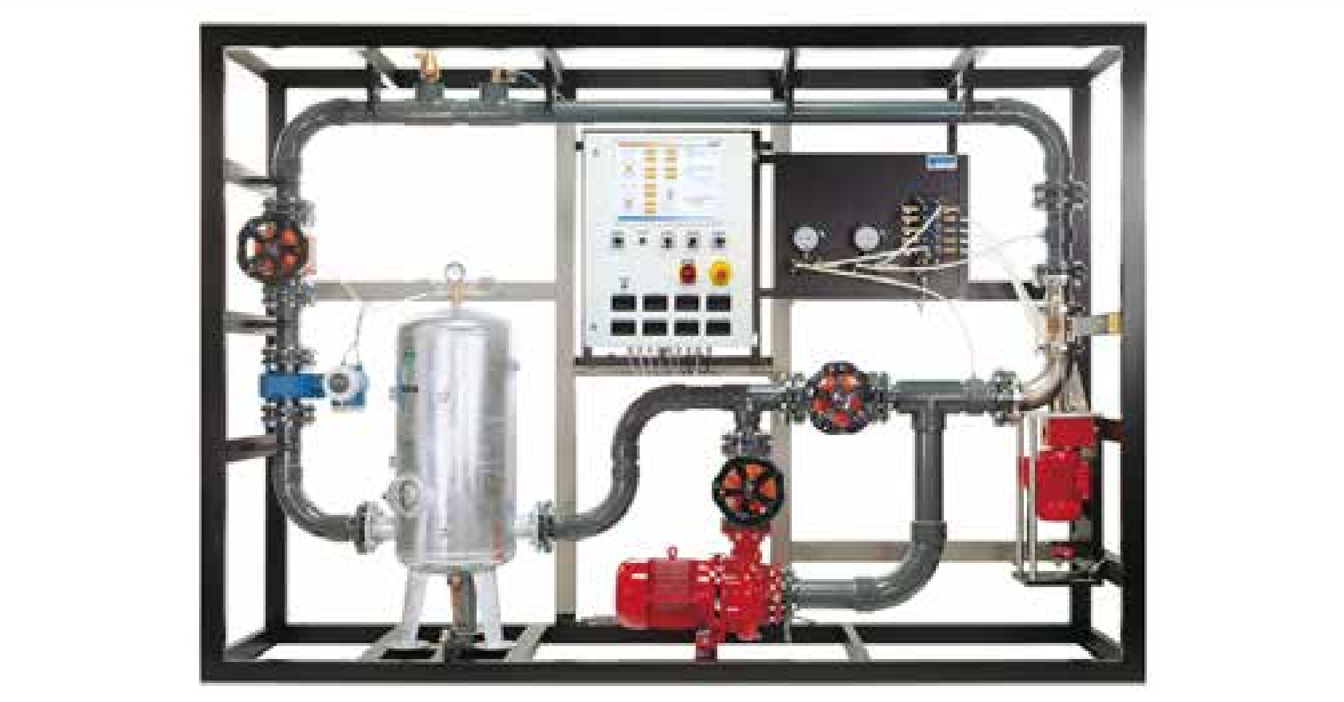
Measuring ranges
- flow rate: 0...1200L/min
- temperature: 0...100°C
- pressure (inlet): ±1bar
- pressure (outlet): 0...0,6bar

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 1110x800x1380mm
Weight: approx. 154kg

Scope of delivery

1 trainer
1 measuring amplifier
1 GUNT software CD + USB cable
1 set of instructional material

HM 405
Axial-flow turbomachines



Description

- **investigation of a single-stage axial turbomachine**
- **can be operated as pump or turbine by changing rotor, impeller and stator, guide vane system**
- **probe to determine flow conditions at inlet and outlet of rotor, impeller and stator, guide vane system**
- **transparent working area**

The core piece of the experimental plant is the axial turbomachine with attached asynchronous motor. It can be operated either as a pump or turbine. To this end, different rotors, impellers and stators, guide vane systems are used. Included in the scope of delivery are four rotors, impellers and four stators, guide vane systems supplied with different blade, vane angles. The experimental plant contains a closed water circuit with expansion tank and centrifugal pump. The compressed-air powered expansion tank allows the turbomachine to be converted without loss of water.

The asynchronous motor functions during turbine operation as a generator, and during pump operation as a drive. A powerful pump generates flow and pressure during turbine operation. The power that is generated by the turbine is fed into this pump.

The transparent housing allows a full view of the rotor, impeller and stator, guide vane system and flow processes. The 3-hole probe can be used to measure the direction and velocity in the flow field directly upstream of, between, and downstream of rotor, impeller and stator, guide vane system. These values are used to record the velocity triangles for the blade, vane shapes.

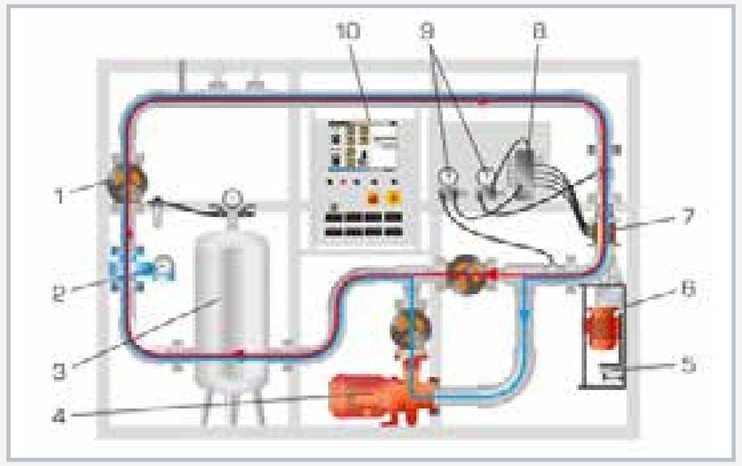
Operation under different pressure levels is possible in order to study cavitation.

The speed is detected contact-free by means of an inductive displacement sensor on the motor shaft. To determine the drive power, the asynchronous motor is mounted on swivel bearings and equipped with a force sensor to measure the drive torque. Manometers measure the pressures at inlet and outlet. Pressure sensors measure the differential pressures at rotor, impeller and stator, guide vane system. The flow rate is measured by an electromagnetic flow meter. The measured values are read from digital displays.

Learning objectives/experiments

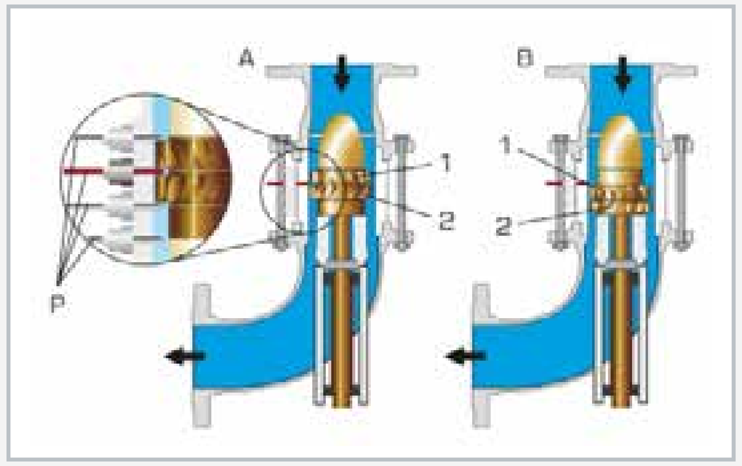
- recording characteristic curves
- determining dimensionless characteristics
- velocity triangles and pressure curves
- investigation of energy conversion within the turbomachine
- how blade, vane shape affects power and efficiency
- determining the outlet angular momentum and its effect on the power
- cavitation effects

HM 405
Axial-flow turbomachines



1 valve for adjusting the flow, 2 flow meter, 3 expansion tank with air cushion, 4 centrifugal pump for turbine mode, 5 force sensor for measuring the torque, 6 asynchronous motor, 7 axial-flow turbomachine, 8 differential pressure sensor, 9 manometer, 10 switch cabinet; red: pump mode, blue: turbine mode

The illustration shows cavitation effects in the working area of the axial flow turbomachine



A: axial flow turbomachine as a turbine, 1 stator, 2 rotor;
B: axial flow turbomachine as a pump, 1 impeller, 2 guide vane system;
P pressure sensor

Specification

[1] investigation of an axial flow turbomachine
[2] closed water circuit with expansion tank and centrifugal pump
[3] turbomachine may be operated as a turbine and as a pump
[4] two sets of impellers and guide vane systems for pump mode and two sets of rotors and stators for turbine mode with different inlet and outlet angles
[5] asynchronous motor with 4-quadrant operation via frequency converter
[6] recovery of the brake energy
[7] motor with pendulum bearing, torque measurement via lever arm and force sensor
[8] inductive speed sensor on the motor
[9] manometers for measuring the inlet and outlet pressures
[10] measuring probe and differential pressure sensor for recording the pressure curve in the turbomachine
[11] electromagnetic flow meter
[12] display of power consumption, torque, speed, pressure, differential pressure and flow rate

Technical data

Centrifugal pump
- power: 5,5kW
- max. flow rate: 150m^3/h
- max. head: 10m

Asynchronous motor
- power: 1,5kW
- torque: 0...5Nm
- speed: 0...3000min^{-1}

Expansion tank: 150L

Measuring ranges
- pressure (manometer): 2x -1...5bar
- differential pressure: 5x 0...500mbar
- flow rate: 0...100m^3/h
- speed: 0...3000min^{-1}
- torque: 0...9,81Nm

400V, 50Hz, 3 phases
LxWxH: 3300x750x2300mm
Weight: approx. 620kg

Required for operation

compressed air connection: 3...10bar

Scope of delivery

1 experimental plant
4 rotors
4 distributors / guide vanes
1 set of accessories
1 set of instructional material

Basic knowledge

Positive displacement pumps

Fundamental principles of positive displacement pumps

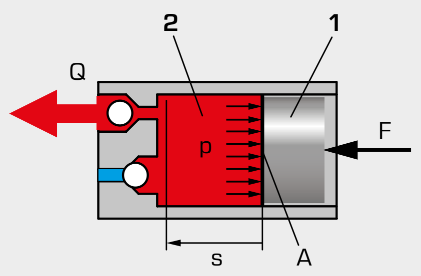
In positive displacement pumps the energy is transferred to the fluid hydrostatically. In the hydrostatic transfer of energy a displacement body reduces a working chamber filled with fluid and pumps the fluid into the pipe. In this case, the displacement body applies a pressure to the fluid. When the working chamber expands it is refilled with fluid from the pipe.

The work done W_s results from the product of the displacement force **F** and displacement distance s. This equation can also be written as the product of displaced volume V_s and delivery pressure **p**.

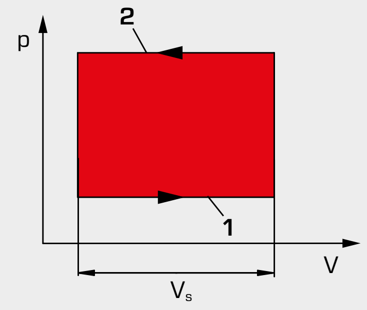
$$W_S = F \cdot s = A \cdot p \cdot s = V_S \cdot p$$

The power **P** transferred to the fluid is calculated from the flow rate **Q** and delivery pressure **p**.

$$P = Q \cdot p$$



1 displacement body, **2** working chamber;
Q flow rate, **F** displacing force, **A** area, **p** delivery pressure,
s displacement distance



Representation of the pump process of a positive displacement pump in the p,V diagram.

During suction **1** the volume increases at low pressure.
Pushing out **2** occurs as the volume reduces at high pressure.
The enclosed area corresponds to the work done on the fluid.

Advantages of positive displacement pumps

- flow rate only slightly dependent on the head; thus well suited for dosing and injection pumps
- suitable for high pressures; only one stage required
- very good suction capacity, even with gas content
- suitable for high viscosity (pastes)
- flow rate can be adjusted very precisely and reproducibly via stroke and stroke rate
- cyclical delivery possible
- well suited for low drive speeds
- direct pneumatic, hydraulic or electromagnetic drive possible with oscillating pumps

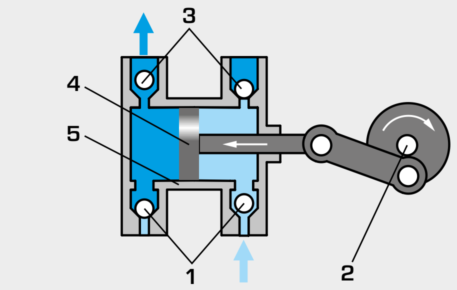
Disadvantages of positive displacement pumps

- principle of operation does not include a pressure restriction, therefore safety or pressure relief valves are necessary
- in oscillating positive displacement pumps vibration-free operation is only possible with complex mass balancing
- oscillating positive displacement pumps less suitable for high speeds
- in oscillating positive displacement pumps, pulsating flow is necessary, as is a pulsation dampener
- in some more complicated designs, fault-prone construction with valves
- larger number of wear parts than centrifugal pumps

Types of positive displacement pumps

In positive displacement pumps a distinction is made between **oscillating** and **rotary pumps**.

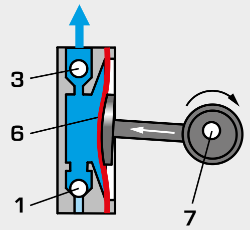
Examples of oscillating positive displacement pumps



Piston pump

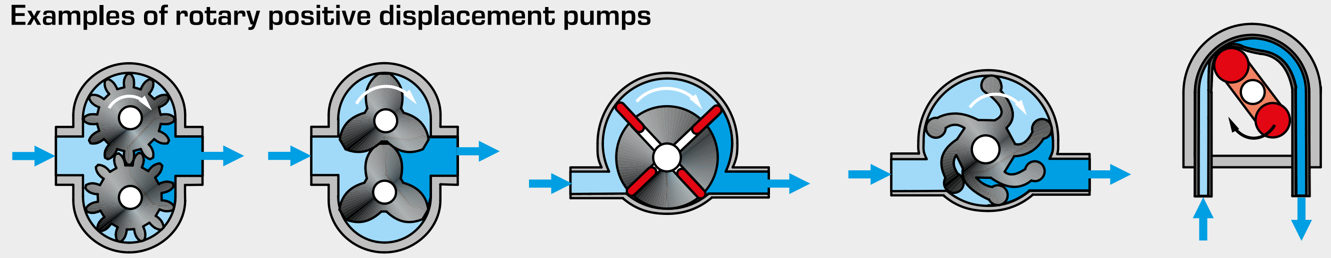
Structure of oscillating positive displacement pumps

1 suction valve,
2 crank mechanism,
3 pressure valve,
4 piston,
5 cylinder,
6 diaphragm,
7 eccentric mechanism



Diaphragm pump

Examples of rotary positive displacement pumps



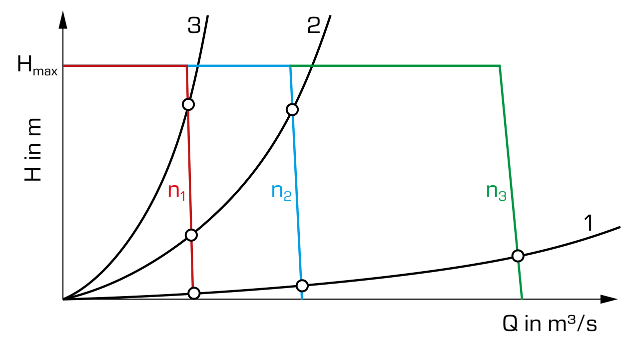
Gear pump | Rotary piston pump | Vane pump | Impeller pump | Peristaltic pump

Since rotary positive displacement pumps usually have large working chambers that are filled and emptied in overlap, these pumps deliver more evenly than oscillating positive displacement pumps with only smaller working chambers. The rotating displacement bodies mean the pumps have good mass balancing and low vibrations even when running at higher speeds.

For applications where a pulsed delivery is desired, such as in fuel injection pumps for engines, only oscillating positive displacement pumps are suitable. Oscillating positive displacement pumps generally have a more complicated design because the rotating drive must be converted into an oscillating stroke movement. This is done via a crank, eccentric or cam mechanism. In addition, at least one pressure control valve is necessary to prevent backflow of the fluid.

Operating behaviour and operating points of a positive displacement pump

Positive displacement pumps have very steep characteristics. The flow rate **Q** is almost independent of the head **H**. The maximum head $\mathbf{H_{max}}$ is usually limited by a pressure relief valve or safety valve. Therefore, the flow rate is almost independent of the system characteristic. In contrast to centrifugal pumps, the flow rate cannot be regulated by increasing the system resistance. This is realised by a change in the rotational speed ($\mathbf{n_1}$-$\mathbf{n_3}$) or the displaced volume. The black curves represent the system characteristics at different speeds **1...3**.



HM 285
Experiments with a piston pump

Description

- **illustrative model of a typical positive displacement pump**
- **closed water circuit**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

Piston pumps belong to the group of positive displacement pumps. They transport the medium by a reciprocating motion of a piston in the pump working space, called stroke. The stroke creates a suction hence vacuum effect used to deliver the water. Piston pumps are used when high pressures are to be generated. The flow rate of piston pumps is independent of the head and is determined only by speed. Its good suction performance is outstanding.

The experimental unit provides the basic experiments to get to know the operating behaviour and the important characteristic variables of piston pumps.

HM 285 features a closed water circuit with water tank, a piston pump with variable speed via a frequency converter and an air vessel.

The piston of the pump is mounted in a transparent housing and can be observed during operation. The cycle that takes place (intake and discharge of water) can be shown clearly in the p-V diagram. The pulsating pressure curve of the pump can be damped with the aid of the air vessel. Flow rate and head are adjusted via a needle valve and overflow valve.

The experimental unit is fitted with sensors for pressure and flow rate. One pressure sensor measures the pressure at the outlet of the pump, another one measures the pressure in the inside of the cylinder. The position of the piston rod is measured by an angle sensor. This allows the determination of the cylinder volume. The microprocessor-based measuring technique is well protected in the housing. The measured values are transmitted directly to a PC via USB where they can be analysed using the software included.

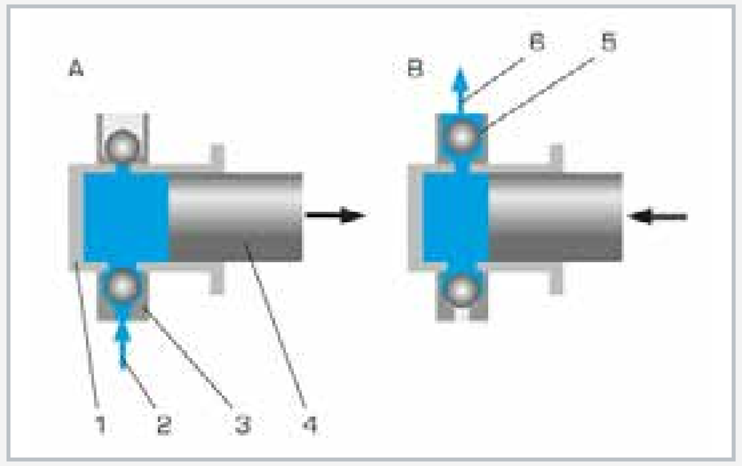
All the advantages of software-supported experiments with operation and evaluation are offered by the GUNT software and the microprocessor.

Learning objectives/experiments

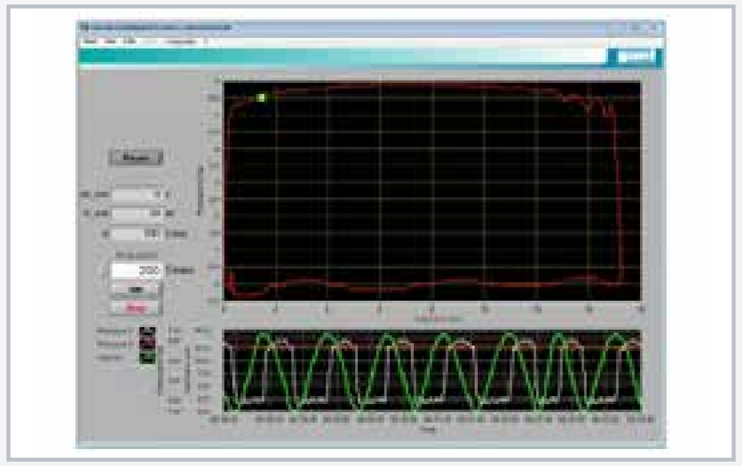
- principle of operation of a piston pump
- recording of pump characteristics
- pressure curves of delivery pressure and cylinder pressure
- influence of pulsation damping
- p-V diagram
- determination of efficiencies

HM 285
Experiments with a piston pump

1 overflow valve, 2 pressure sensor at outlet, 3 water tank, 4 air vessel, 5 piston pump, 6 motor, 7 flow meter, 8 needle valve for adjusting the flow rate



Principle of operation of a piston pump: A intake, B discharge
1 cylinder, 2 water inlet, 3 valve at inlet, 4 plunger piston, 5 valve at outlet, 6 water outlet



Operating interface of the powerful software

Specification

[1] functioning and operating behaviour of a piston pump
[2] closed water circuit contains piston pump with variable speed via frequency converter, transparent water tank and air vessel
[3] transparent housing for observing the pump piston
[4] needle valve for adjusting the flow rate
[5] overflow valve for adjusting the head
[6] pulsation damping of the head using air vessel with bleed valve
[7] sensors for pressure at outlet and in the cylinder of the pump, flow rate and crank angle
[8] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[9] display and evaluation of the measured values as well as operation of the unit via software
[10] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Piston pump
- speed: 30...180min^{-1}
- max. flow rate: 135L/h
- max. head: 40m

Drive motor
- power: 180W

Gear transmission ratio: i=7,5
Overflow valve: 1...4bar

Measuring ranges
- pressure (cylinder): 0...5bar
- pressure (outlet): 0...5bar
- crank angle: 0...360°
- flow rate: 0,2...6L/min

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 670x590x740mm
Weight: approx. 49kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 set of instructional material

HM 286
Experiments with a gear pump

Description

- **illustrative model of a gear pump**
- **closed oil circuit**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

Gear pumps belong to the group of positive displacement pumps with a continuous flow. Two counter-rotating gears transport the medium. The transported medium is between the housing and the tooth spaces. The pulsation-free flow increases linearly with speed. These pumps are particularly suitable for the generation of medium-high pressure at low flow rates.

The experimental unit provides the basic experiments to get to know the operating behaviour and the most important characteristic variables of gear pumps.

HM 286 features a closed circuit with a tank and a gear pump with variable speed via frequency converter. The pump gears are mounted in a transparent housing and can be observed during operation.

Flow rate and head are adjusted via a needle valve and an overflow valve. Oil is used as the medium.

The experimental unit is fitted with sensors for pressure and temperature. The oval wheel meter is especially used for the accurate flow measurement of viscous liquids. Oval wheel meters operate on the positive displacement principle with two precise oval gear wheels. The microprocessor-based measuring technique is well protected in the housing. The measured values are transmitted directly to a PC via USB where they can be analysed using the software included.

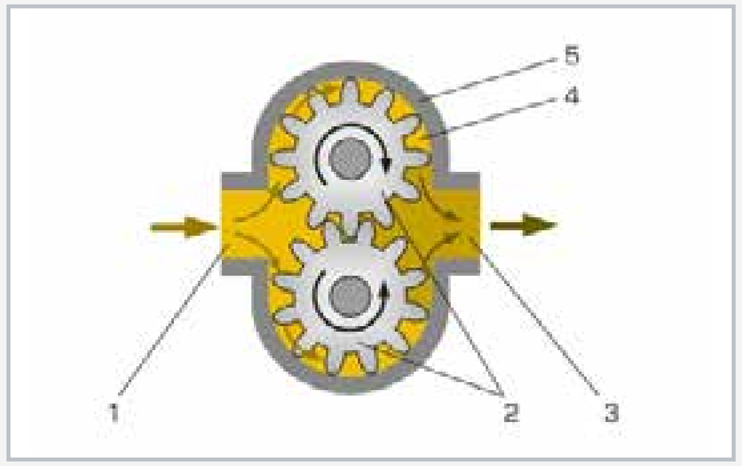
All the advantages of software-supported experiments with operation and evaluation are offered by the GUNT software and the microprocessor.

Learning objectives/experiments

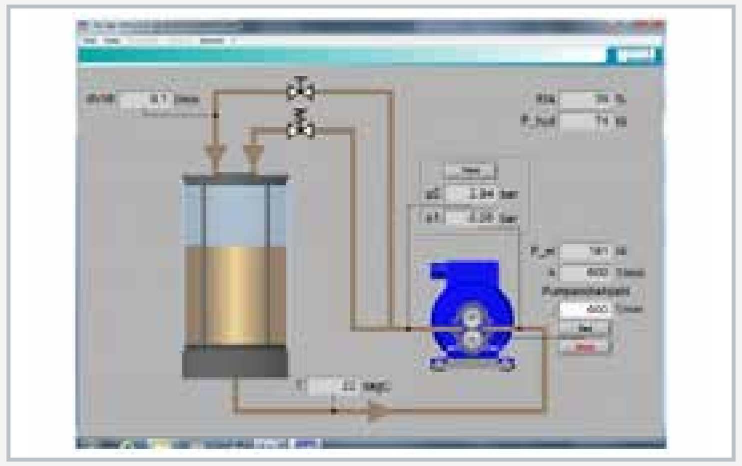
- principle of operation of a gear pump
- recording of pump characteristics
- relationship between head and speed
- effect of pressure limitation
- determination of efficiencies

HM 286
Experiments with a gear pump

1 tank, 2 flow meter (oval wheel meter), 3 needle valve, 4 pressure sensor at outlet, 5 pressure sensor at inlet, 6 gear pump, 7 drive, 8 overflow valve for adjusting the head



Principle of operation of a gear pump
1 oil inlet, 2 gears, 3 oil outlet, 4 tooth spaces as pumping chamber, 5 housing



Operating interface of the powerful software

Specification

[1] functioning and operating behaviour of a gear pump
[2] closed oil circuit contains a gear pump with variable speed via frequency converter and a transparent tank
[3] transparent housing for observing the pump gears
[4] needle valve for adjusting the flow rate
[5] overflow valve for adjusting the head
[6] sensors for temperature and pressure at inlet and outlet of the pump
[7] oval wheel meter as flow sensor
[8] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[9] display and evaluation of the measured values as well as operation of the unit via software
[10] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Gear pump with speed-controlled drive
- power consumption: 370W
- nominal speed: 200...1000min^{-1}
- max. flow rate: approx. 15cm^3 per revolution
- max. head: approx. 100m

Overflow valve: 0...5,5bar

Measuring ranges
- pressure (inlet): ±1bar
- pressure (outlet): 0...5bar
- flow rate: 0...25L/min
- temperature: 0...100°C

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 670x590x750mm
Weight: approx. 50kg

Required for operation

PC with Windows

Scope of delivery

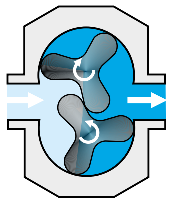
1 experimental unit
1 oil 5L (ISO VG 100)
1 GUNT software CD + USB cable
1 set of instructional material

GUNT-FEMLine
Water pump training part 2 positive displacement pumps

The HM 365.10 Supply unit for water pumps from GUNT is a trainer for studying the properties of different water pumps under realistic operating conditions. Some of the pumps are powerful industrial pumps. Combined with the drive unit HM 365 and the different pump units, the supply unit HM 365.10 is an ideal pump trainer.

HM 365.10
Supply unit for water pumps

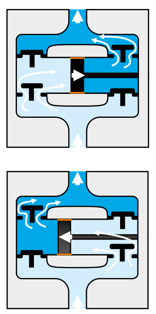
2nd part | Positive displacement pumps as water pumps:



Lobe pump

In a lobe pump two non-contact pistons rotate in two cylindrical chambers. With each revolution, they deliver the same volume. Lobe pumps are used for delivering highly viscous and highly abrasive media.

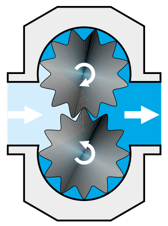
HM 365.16 Lobe pump



Reciprocating piston pump

The most simple type of reciprocating piston pump consists of a piston moving in a cylinder with one inlet and one outlet valve. Depending on the internal cylinder pressure, the valves open the inlet and outlet to the stroke chamber.

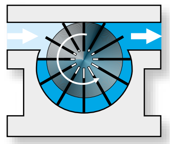
HM 365.17 Reciprocating piston pump



Gear pump

Essentially, gear pumps consist of three components: a housing with an inlet and outlet for the fluid and two gears, one of which powers the other one. Gear pumps differ depending on their internal design. The most common gear pump, the external gear pump, is used here as an example.

HM 365.18 Gear pump



Vane pump

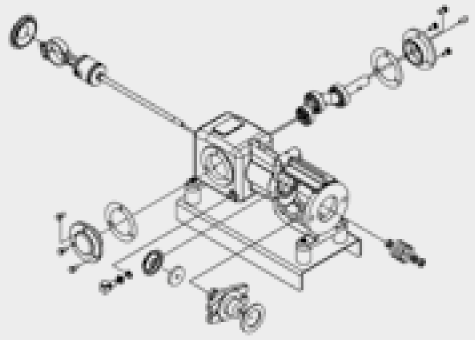
Vane pumps are also known as rotary vane pumps. They can be used for both liquid and gaseous media. There are vane pumps with constant displacement volumes and with adjustable displacement volumes. The pump consists of a housing, in which an eccentric cylindrical rotor rotates. Rotary vanes are spring-mounted to radial guides inside the rotor. During operation, the spring-force ensures that the rotary vanes run along the inner wall of the housing and an enclosed space is formed between them. The pumping medium is transported between the rotary vanes and the housing wall.

HM 365.19 Vane pump

Sectional models and assembly training

To complete the water pump training, GUNT offers **sectional models and assembly and maintenance training** for different positive displacement pumps: Please refer to catalogue 4 for more information on these devices.

HM 700.20 Cutaway model: piston pump



Exploded drawing of the piston pump

MT 184 Assembly & maintenance exercise: piston pump

HM 365.16
Lobe pump

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics, system characteristics, operating point
  - power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of a lobe pump
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Lobe pump
- max. flow rate: 1.8m^3/h
- max. head: 120m
- transmission ratio: 1:2
- nominal speed: 1450min^{-1}

LxWxH: 660x360x310mm
Weight: approx. 25kg

Scope of delivery

1 lobe pump

Description

- **investigation of the pumping behaviour of a lobe pump**
- **part of the GUNT-FEMLine**

In contrast to rotodynamic pumps, a positive displacement pump moves the medium by means of closed conveying chambers. In a lobe pump two non-contact pistons rotate in two cylindrical chambers. With each revolution, they deliver the same volume. Lobe pumps are used for delivering highly viscous and highly abrasive media.

HM 365.16 is a lobe pump that is delivered ready for installation, mounted on a plate. The pump is installed in the HM 365.10 supply unit with just a few simple steps and connected via hoses with quick-release couplings and attached with clamping levers. The pump has an internal bypass that opens if the pressure is too high and releases pressure to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt. The pump speed is reduced by the transmission ratio of the belt.

The pressures at the inlet and outlet of the lobe pump are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

HM 365.17
Reciprocating piston pump

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics, system characteristics and operating point
  - power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of a lobe pump
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

reciprocating piston pump
- maximum flow rate: 1,5m^3/h
- maximum head 60m
- number of strokes: 337min^{-1}
- total transmission ratio: 1:6,88

LxWxH: 690x500x410mm
Weight: approx. 24kg

Scope of delivery

1 reciprocating piston pump

Description

- **investigation of the pumping behaviour of a reciprocating piston pump**
- **part of the GUNT-FEMLine**

Piston pumps are part of the group of positive displacement pumps. The most simple type of reciprocating piston pump consists of a piston that moves in a cylinder with one inlet and one outlet valve. Depending on the internal cylinder pressure, the valves open the inlet and outlet to the stroke chamber.

HM 365.17 is a reciprocating piston pump that is delivered ready for installation, mounted on a plate. The pump is installed in the HM 365.10 supply unit with just a few simple steps, connected via hoses with quick-release couplings, and attached with clamping levers. The pump has an internal bypass that opens if the pressure is too high and releases pressure to the low pressure side. The pump is connected to the HM 365 Universal Drive and Brake Unit with a V-belt. The pump speed is reduced by the transmission ratio of the belt.

The pressures at the inlet and outlet of the reciprocating piston pump are recorded by sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

HM 365.18
Gear pump

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics, system characteristics and operating point
  - power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of a gear pump
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Gear pump
- max. flow rate: 4,2m^3/h
- max. head: 70m
- nominal speed: 1700min^{-1}
- transmission ratio: 1:1,6

LxWxH: 570x300x315mm
Weight: approx. 17kg

Scope of delivery

1 gear pump

Description

- **onvestigation of the pumping behaviour of a gear pump**
- **part of the GUNT-FEMLine**

A gear pump is characterised by a steady flow rate. Its compact structural shape allows for a small housing. We distinguish between external and internal gear pumps. The external gear pump consists of a housing in which two gears rotate in opposite directions, transporting the pumping medium between the gears and the housing.

HM 365.18 is an external gear pump that is delivered ready for installation, mounted on a plate. The pump is installed in the HM 365.10 supply unit with just a few simple steps, connected via hoses with quick-release couplings, and attached with clamping levers. The pump has an internal bypass that opens if the pressure is too high and releases pressure to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt. The pump speed is reduced by the transmission ratio of the belt.

The pressures at the inlet and outlet of the gear pump are recorded with sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

HM 365.19
Vane pump

Learning objectives/experiments

- in combination with HM 365 and HM 365.10
  - recording of pump characteristics, system characteristics and operating point
  - power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of a vane pump
[2] operation with HM 365.10 Supply Unit for Water Pumps
[3] powered by HM 365 Universal Drive and Brake Unit
[4] pressure sensors at the inlet and outlet of the pump
[5] pressure display on the display unit of HM 365.10

Technical data

Vane pump
- max. flow rate: 7,2m^3/h
- max. head: 70m
- nominal speed: 1400min^{-1}
- transmission ratio: 1:1,44

LxWxH: 500x350x300mm
Weight: approx. 18kg

Scope of delivery

1 vane pump

Description

- **investigation of the pumping behaviour of a vane pump**
- **part of the GUNT-FEMLine**

The vane pump is part of the group of positive displacement pumps. It consists of a housing, in which an eccentrically installed cylinder rotates. Rotary vanes are spring-mounted to radial guides inside the rotating cylinder. During operation, the spring-force ensures that the rotary vanes run along the inner wall of the housing, and an enclosed space is formed between them. The pumping medium is transported between the rotary vanes and the housing wall. Vane pumps are used where high delivery pressures are required.

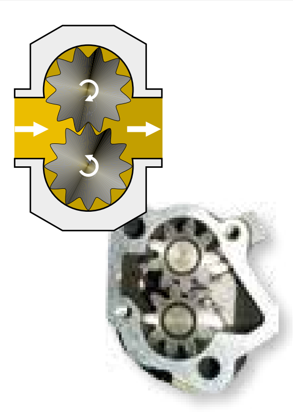
HM 365.19 is a vane pump that is delivered ready for installation, mounted on a plate. The pump is installed in the HM 365.10 supply unit with just a few simple steps, connected via hoses with quick-release couplings, and attached with clamping levers. The pump has an internal bypass that opens if the pressure is too high and releases pressure to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressures at the inlet and outlet of the vane pump are recorded by sensors. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

GUNT-FEMLine
Oil pump training

Oil pumps are driven machines. The selection of the correct oil pump mainly depends on the viscosity or, its inverse, the fluidity of the oil. In refineries centrifugal pumps are used to deliver large volumes of thin or low viscosity oils, such as petroleum. Oils with a higher viscosity are transported with positive displacement pumps. Moreover, oil pumps are used to perform mechanical work and for lubrication and cooling purposes. In hydraulic systems, oil is used to transmit forces. The pumps that are needed for this purpose must be able to achieve high pressures in order to generate large lifting or forming forces. They are, for example, used in lifting platforms or metal presses.

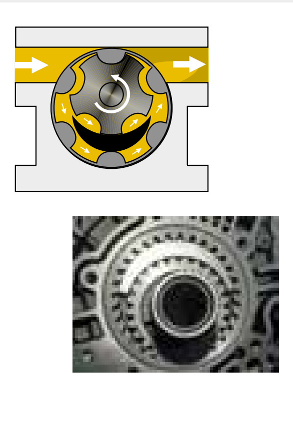
This training course deals with oil pumps that transport oil with the help of enclosed volumes according to the positive displacement principle. Depending on requirements and demand, different oil pump designs are used. The most commonly used oil pumps are **gear pumps**. Essentially, gear pumps consist of the following components: a housing with an inlet and outlet for the oil and two gears, one of which powers the other one. Depending on their internal design, gear pumps are categorised as follows:



External gear pump

In an external gear pump, two gears rotate in opposite directions in a housing. The pumping medium is transported between the gears and the housing. Due to their simple, robust setup these pumps are relatively cost-efficient. External gear pumps are very common in the automobile industry.

HM 365.22
External gear pump



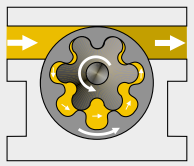
Internal gear pump

Internal gear pumps are also known as crescent pumps. They are characterised by their low pulsation, high efficiency, low level of noise and medium-high operating pressures. An internal gear drives an external toothed ring. Since the driving gear is mounted on an eccentric bearing, clearances result in the gaps between the gear and the toothed ring. These clearances form the delivery volume. A crescent-shaped seal between the gear and the ring forms the enclosed volume that is necessary to reach the required pressure.

HM 365.24
Internal gear pump

Toothed ring pump

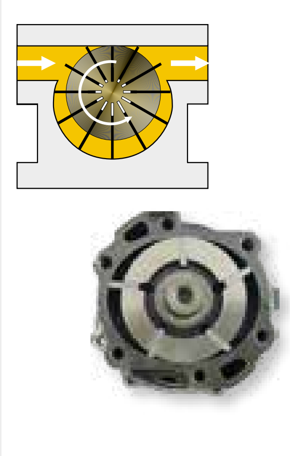
Toothed ring pumps are also known as Eaton pumps or gerotor pumps. The internal gear runs eccentrically along the internal gearing of the toothed ring and powers this ring. The volume of the displacement chamber between the gaps changes, and thereby allows the pumping medium to be transported.



Screw pump

Screw pumps are able to provide continuous delivery of even viscous media without pulsation or turbulence. Their pump housing contains two or more rotors that rotate in opposite directions, with an external screw thread profile. As the threads of the screws engage, the fluid is transported. Depending on the thread pitch, very high pressures can be achieved. Screw pumps run very smoothly, which is why they are often used in lifts and as fuel pumps in oil burners.

HM 365.21
Screw pump



Vane pump

Vane pumps are also known as rotary vane pumps. They can be used for both liquid and gaseous media. In some vane pumps, the displacement volume is adjustable. These pumps consist of a housing, in which an eccentrically installed cylinder rotates (rotor). Rotary vanes are spring-mounted to radial guides inside the rotor. During operation, the spring-force ensures that the rotary vanes run along the inner wall of the housing and an enclosed space is formed between them. The pumping medium is transported between the rotary vanes and the housing wall.

HM 365.23
Vane pump

Sectional models and assembly training

HM 700.22 Cutaway model: gear pump

To complete the oil pump training, GUNT offers **sectional models and assembly and maintenance training** for different positive displacement pumps: Please refer to catalogue 4 for more information on these devices.

MT 186 Assembly & maintenance exercise: gear pump

HM 365.20
Oil pump supply unit

Description

- **closed oil circuit for supplying the oil pumps**
- **GUNT software for data recording and visualisation**
- **part of the GUNT-FEMLine**

Oil pumps are driven machines. Depending on the viscosity of the oil they work either according to the positive displacement principle for for high viscosity oils, or as rotodynamic pumps for low viscosity oils. Oil pumps are used to deliver oil required in machines or plants for the purpose of lubrication or cooling. Another area of application is the use of oil to transfer energy in the field of hydraulics.

The supply unit HM 365.20 provides the working medium oil for several oil pumps (HM 365.21 to HM 365.24). The pumps are powered by the drive unit HM 365.

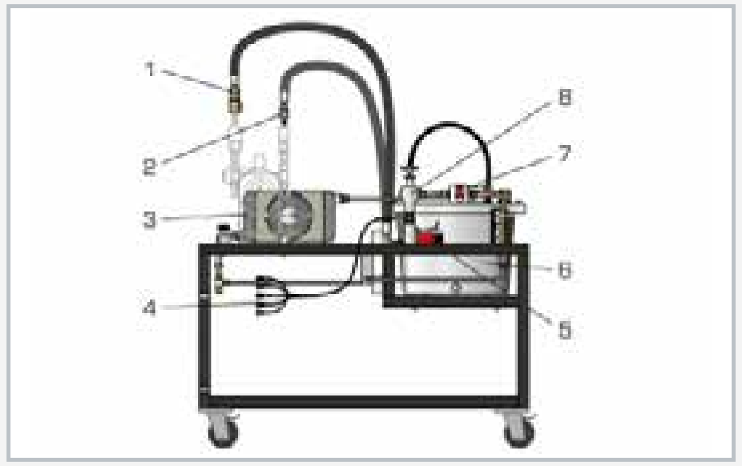
The trainer includes a closed oil circuit with an internal oil tank. The individual pumps are placed on the work surface and connected via hoses. To power the pump, it is connected to the drive unit HM 365 with a V-belt. The supply unit is equipped with a closed-circuit air/oil cooling system that cools the oil.

The flow rate is measured with an oval wheel flow meter. A temperature sensor records the temperature in the piping system. The trainer has pressure sensors to measure the inlet and outlet pressures. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

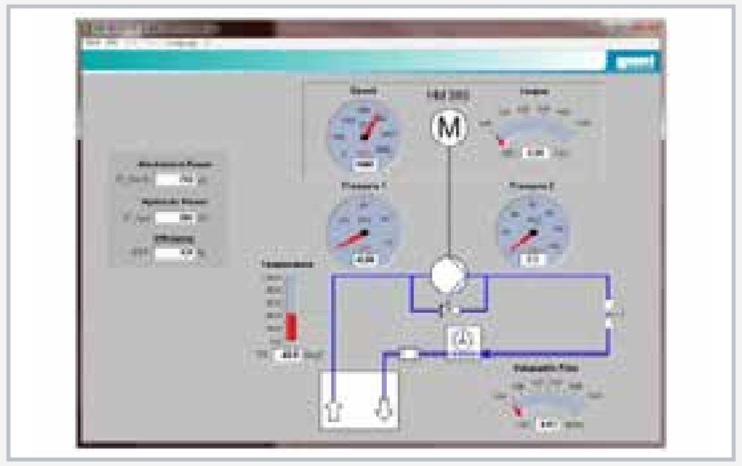
Learning objectives/experiments

- in combination with HM 365 and a pump of the series HM 365.21 – HM 365.24
  - recording of pump characteristics
  - determination of the power requirement of the pump
  - determination of the hydraulic power of the pump
  - determination of the pump efficiency
  - determination of the system characteristics and the operating point of the pump

HM 365.20
Oil pump supply unit



1 inlet, 2 outlet, 3 closed-circuit cooling system (air/oil), 4 connections for display unit, 5 pressure sensor, 6 oil tank, 7 oval wheel flow meter, 8 adjustable pressure valve



GUNT software screenshot: process schematic

Functional experimental setup: drive unit HM 365 (left), HM 365.20 with pump under investigation (right)

Specification

[1] supply unit for operation of different oil pumps HM 365.21 to HM 365.24
[2] closed oil circuit
[3] connection of pumps via hydraulic hoses with quick-release couplings
[4] pressure sensors at the inlet and outlet included in the scope of delivery of the pumps
[5] measurement of the oil temperature in the pipeline system with PT100
[6] closed-circuit cooling via air/oil heat exchanger
[7] flow measurement with oval wheel flow meter
[8] digital display of flow, pressure and temperature
[9] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Oil container: 27L
Oil: HLP-ISO 32
Oil cooling 2...3kW

Measuring ranges
pressure (inlet): ±1bar
pressure (outlet): 0...120bar
temperature: 0...1000°C
flow rate: 0...10L/min

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
LxWxH: 1200x850x1300mm
Weight: approx. 80kg

Required for operation

PC with Windows recommended

Scope of delivery

1 supply unit
1 display unit
1 CD with GUNT software + USB cable
2 hoses with quick-release couplings
1 set of instructional material

HM 365.21
Screw pump

Description

■ **investigation of the pumping behaviour of a screw pump**
■ **part of the GUNT-FEMLine**

Screw pumps are positive displacement pumps. They are able to provide continuous delivery of even viscous media without pulsation or turbulence. Their pump housing contains two or more rotors that rotate in opposite directions with an external screw thread profile. As the threads of the screws engage, the fluid is transported. Depending on the thread pitch, very high pressures can be achieved. Screw pumps run very smoothly, which is why they are often used in lifts and as fuel pumps in oil burners.

HM 365.21 is a screw pump that is delivered ready for installation, mounted on a plate. The pump is installed in the supply unit HM 365.20 with just a few simple steps and connected via hydraulic hoses. A safety valve protects the pump against positive pressure. If the pressure becomes too high, a bypass is opened and the pressure is released to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressure, temperature, and flow sensors are located in the closed oil circuit of supply unit HM 365.20. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

Learning objectives/experiments

■ in combination with HM 365 and HM 365.20
  ▸ recording of pump and system characteristics, operating point
  ▸ power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of a screw pump
[2] operation with HM 365.20 Oil Pump Supply Unit
[3] powered by HM 365 Universal Drive and Brake Unit
[4] Safety valve protects against overpressure in the system
[5] display of temperature, pressures and flow on the display unit of HM 365.20

Technical data

Screw pump
■ flow rate per rotation: 3,1cm^3
■ max. pressure: 40bar
■ safety valve: 40bar
■ permissible inlet pressure: -0,7...3bar
■ max. speed: 3000min^{-1}

LxWxH: 380x250x330mm
Weight: approx. 12kg

Scope of delivery

1 screw pump

HM 365.22
External gear pump

Description

■ **investigation of the pumping behaviour of an external gear pump**
■ **part of the GUNT-FEMLine**

Gear pumps are often used as oil pumps in motor vehicles. In an external gear pump, two gears rotate in opposite directions in a housing. The pumping medium is transported between the gears and the housing.

HM 365.22 is an external gear pump that is delivered ready for installation, mounted on a plate. The pump is installed in the supply unit HM 365.20 with just a few simple steps and connected via hydraulic hoses. A safety valve protects the pump against positive pressure. If the pressure becomes too high, a bypass is opened and the pressure is released to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressure, temperature, and flow sensors are located in the closed oil circuit of supply unit HM 365.20. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

Learning objectives/experiments

■ in combination with HM 365 and HM 365.20
  ▸ recording of pump and system characteristics, operating point
  ▸ power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of an external gear pump
[2] operation with HM 365.20 Oil Pump Supply Unit
[3] powered by HM 365 Universal Drive and Brake Unit
[4] safety valve protects against overpressure in the system
[5] display of temperature, pressures and flow rate on the display unit of HM 365.20

Technical data

External gear pump
■ flow rate per rotation: 2cm^3
■ max. pressure: 210bar
■ safety valve 110bar
■ nominal speed: 3000min^{-1}

LxWxH: 460x250x280mm
Weight: approx. ca. 15kg

Scope of delivery

1 external gear pump

HM 365.23
Vane pump

Learning objectives/experiments

- in combination with HM 365 and HM 365.20
  - recording of pump characteristics, system characteristics and operating point
  - power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of a vane pump
[2] operation with HM 365.20 Oil Pump Supply Unit
[3] powered by HM 365 Universal Drive and Brake Unit
[4] safety valve protects against overpressure in the system
[5] display of temperature, pressures and flow on the display unit of HM 365.20

Technical data

Gear pump
- max. displacement volume: 10cm^3
- max. pressure: 100bar
- safety valve: 110bar
- nominal speed: 900...1500min^{-1}
- transmission ratio: 1:2

LxWxH: 450x300x420mm
Weight: approx. 15kg

Scope of delivery

1 vane pump

Description

- **investigation of the pumping behaviour of a vane pump**
- **part of the GUNT-FEMLine**

Vane pumps are designed with either constant displacement volumes or adjustable displacement volumes. These pumps consist of a housing, in which an eccentrically installed cylinder rotates (rotor). Rotary vanes are spring-mounted to radial guides inside the rotor. During operation, the spring-force ensures that the rotary vanes run along the inner wall of the housing and an enclosed space is formed between them. The pumping medium is transported between the rotary vanes and the housing wall.

HM 365.23 is a vane pump with adjustable displacement volume that is delivered ready for installation, mounted on a plate.

The pump is installed in the supply unit HM 365.20 with just a few simple steps and connected via hydraulic hoses. A safety valve protects the pump against positive pressure. If the pressure becomes too high, a bypass is opened and the pressure is released to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressure, temperature, and flow sensors are located in the closed oil circuit of supply unit HM 365.20. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

HM 365.24
Internal gear pump

Learning objectives/experiments

- in combination with HM 365 and HM 365.20
  - recording of pump characteristics, system characteristics and operating point
  - power requirement, hydraulic power, pump efficiency

Specification

[1] investigation of an internal gear pump
[2] operation with HM 365.20 Oil Pump Supply Unit
[3] powered by HM 365 Universal Drive and Brake Unit
[4] safety valve protects against overpressure in the system
[5] display of temperature, pressures and flow rate on the display unit of HM 365.20

Technical data

Internal gear pump
- flow rate per rotation: 1,7cm^3
- max. pressure: 180bar
- safety valve: 110bar
- nominal speed: 600...3000min^{-1}

LxWxH: 450x250x310mm
Weight: approx. 15kg

Scope of delivery

1 internal gear pump

Description

- **investigation of the pumping behaviour of an internal gear pump**
- **part of the GUNT-FEMLine**

Internal gear pumps, or crescent pumps, are characterised by their low pulsation, high efficiency, low level of noise, and high operating pressures. An internal gear drives an external toothed ring. Since the driving gear is mounted on an eccentric bearing, clearances result in the gaps between the gear and ring. These clearances form the delivery volume. A crescent-shaped seal between the gear and the ring forms the enclosed volume that is necessary to reach the required pressure.

HM 365.24 is an internal gear pump that is delivered ready for installation, mounted on a plate. The pump is installed in the supply unit HM 365.20 with just a few simple steps and connected via hydraulic hoses. A safety valve protects the pump against positive pressure. If the pressure is too high, an internal bypass is opened and the pressure is released to the low pressure side. For power supply, the pump is connected to the drive unit HM 365 with a V-belt.

The pressure, temperature, and flow sensors are located in the closed oil circuit of supply unit HM 365.20. The measured values are read from digital displays on the supply unit and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the included software.

Basic knowledge

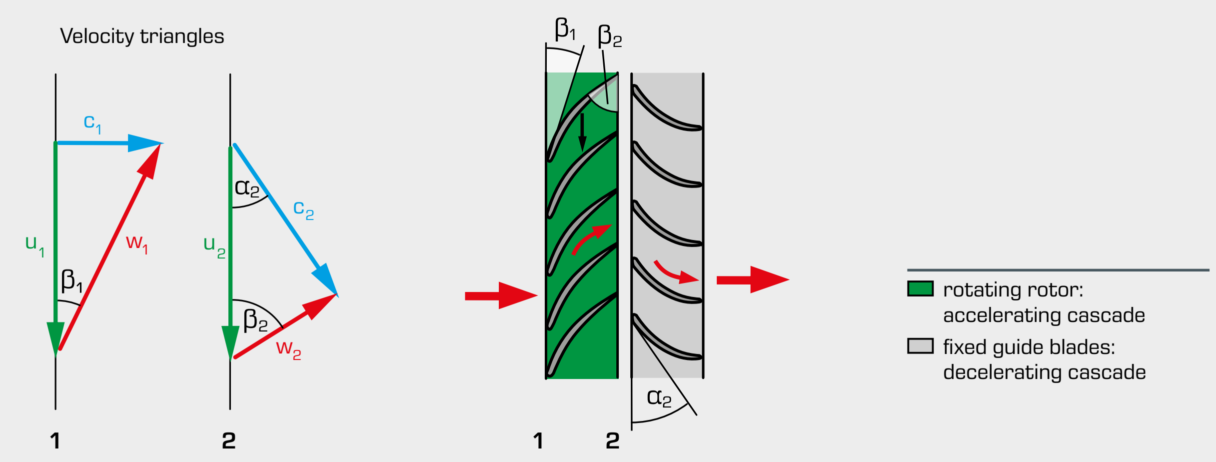
Fans

Fundamental principles of fans

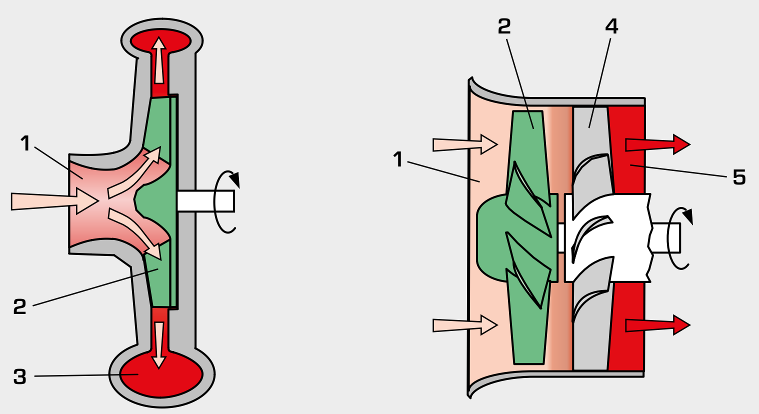
Fans are turbomachines that are used to convey gaseous fluids such as air. A characteristic of fans is the pressure ratio **Π**, which indicates the ratio of the absolute final pressure to the absolute intake pressure. Fans are different from compressors because of their low pressure ratio of max. 2,5. At very low pressures up to about 1,1 they are also known as ventilators.

In a fan the energy is transferred to the fluid via aerodynamic flow forces. In this process the fluid is accelerated by the fan's rotor. Therefore, the rotor of the fan has to move with high velocity and thus a high rotational speed. In this case, it can be said that the higher the pressure ratio, the higher the peripheral speed and rotational speed. The peripheral speed ranges from 15 m/s in small domestic ventilators to more than 600 m/s and speeds of more than 150,000 min^{-1} in turbochargers. While the fluid at low pressures and velocities can still be regarded as incompressible, at higher pressures it must be considered compressible.

Velocities on the cascade using the example of an axial fan



c absolute velocity of the fluid, **w** relative velocity of the fluid, **u** peripheral speed of the rotor;
1 rotor inlet, **2** rotor outlet



1 inlet, **2** rotor, **3** spiral housing, **4** guide blades, **5** outlet

Types

As with other turbomachines, a distinction is made between radial and axial fans depending on the direction of flow.

Characteristics of fans

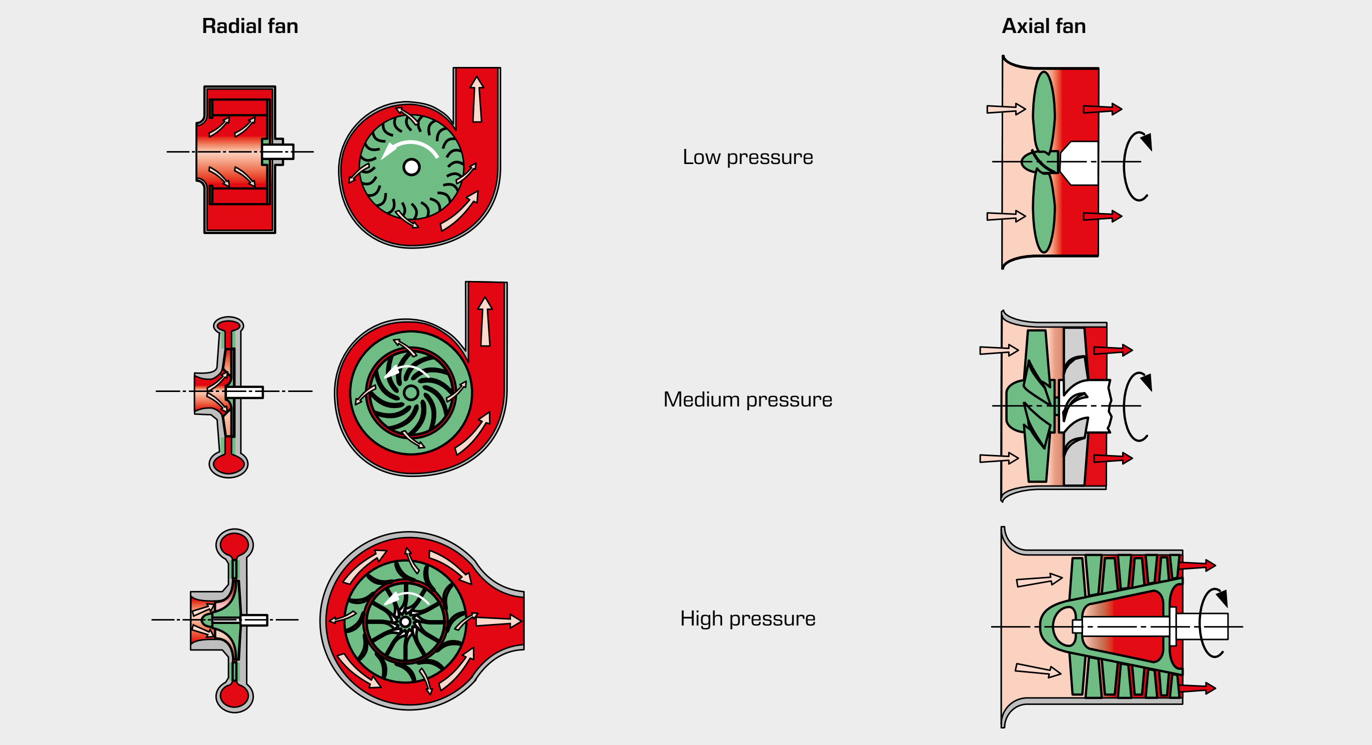
A fan is characterised by the specific speed **σ**. It is formed from the speed **n**, volumetric flow rate **Q** and specific hydraulic energy **Y**.

$$\sigma = n \cdot \frac{2 \cdot \sqrt{\Pi} \cdot \sqrt{Q}}{(2 \cdot Y)^{3/4}}$$

The ideal efficiency of a fan is achieved at a specific speed of **σ** = 0,3 – 0,6.

The specific hydraulic energy **Y** is the difference of the working capability of the fluid between the inlet and outlet of the turbomachine. It is calculated from the product of the head **H** and the gravitational acceleration **g**.

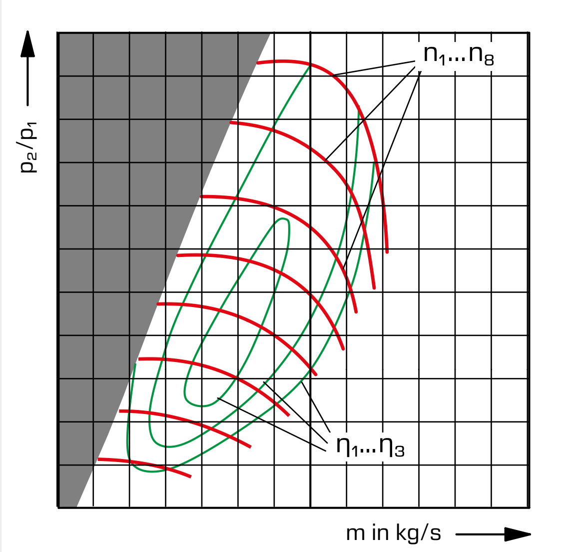
Fan rotor shapes



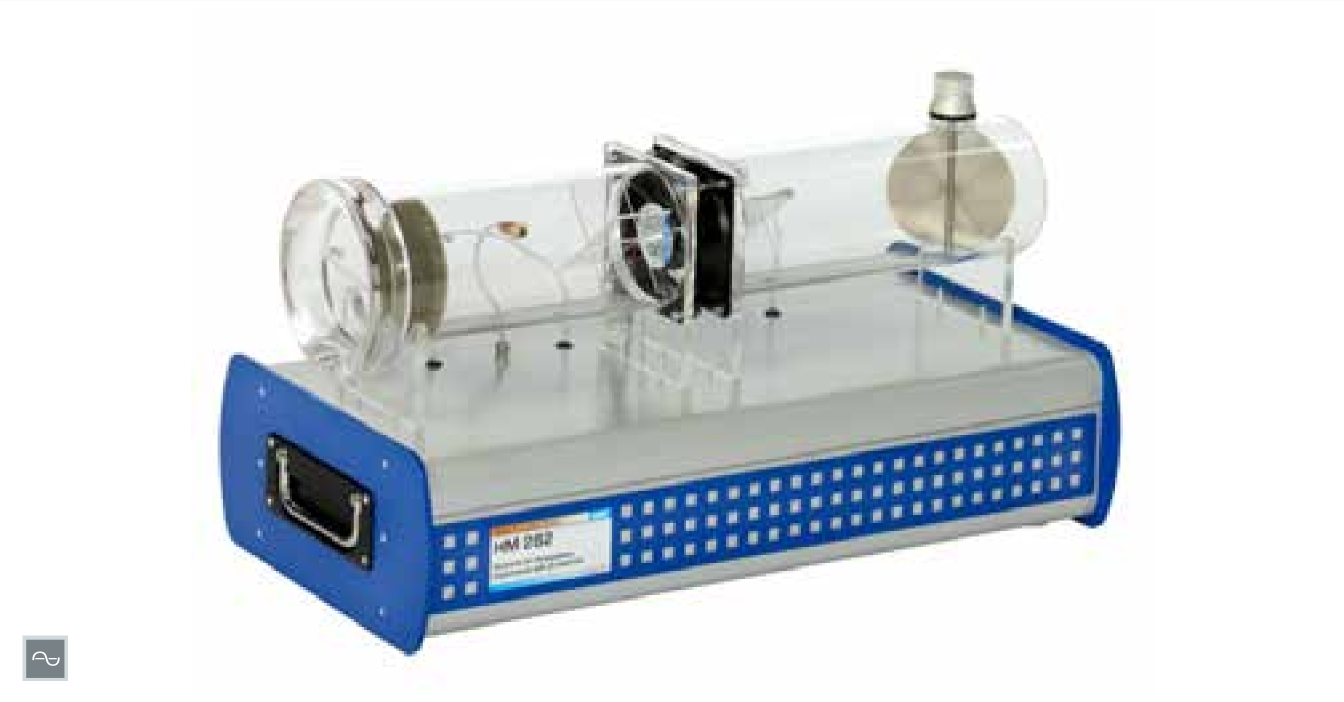
Operating behaviour

The diagram shows the characteristic field of a high-pressure fan. The pressure ratio p_2 / p_1 is plotted against the mass flow rate for different speeds n_1 to n_8 in red. Green lines show the same efficiency η_1 to η_3.

The operating range is restricted at low mass flows via the surge line (grey region). At small mass flows, the flow in the rotor becomes unstable, resulting in flow separation and partial return flows. In axial compressors in particular, this area should be avoided since the blades are placed under high stress.



HM 282
Experiments with an axial fan



Description

- **illustrative model of an axial fan**
- **transparent delivery pipe and intake pipe**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

Axial fans are used to transport gases. The medium to be transported is drawn in axially to the drive shaft of the axial fan by the rotation of the rotor. The medium flows through the rotor and is discharged axially behind the rotor.

The experimental unit provides the basic experiments to get to know the operating behaviour and the important characteristic variables of axial fans.

HM 282 features an axial fan with variable speed via an integrated controller, an intake pipe and a delivery pipe. The transparent intake and delivery pipes are fitted with guide plates for flow guidance.

A flow straightener in the intake pipe serves to calm the air. This enables precise measurements even with heavily reduced operation. The air flow is adjusted by a throttle valve at the end of the delivery pipe.

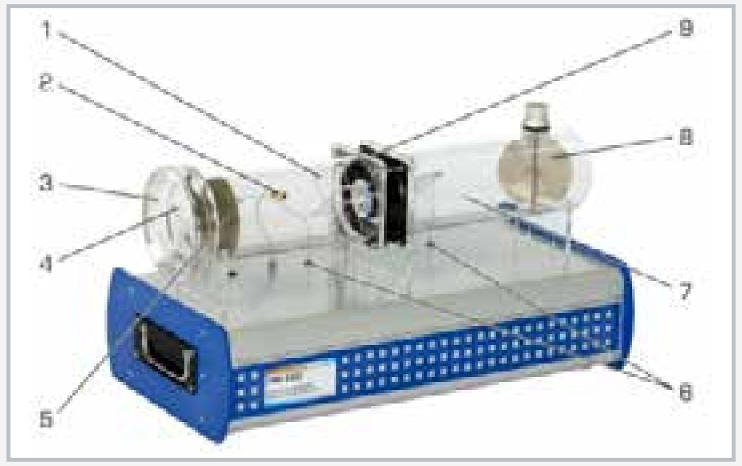
The experimental unit is fitted with sensors for pressure and temperature. The flow rate is determinated via differential pressure measurement on the intake nozzle. The microprocessor-based measuring technique is well protected in the housing. The measured values are transmitted directly to a PC via USB where they can be analysed using the software included.

All the advantages of software-supported experiments with operation and evaluation are offered by the GUNT software and the microprocessor.

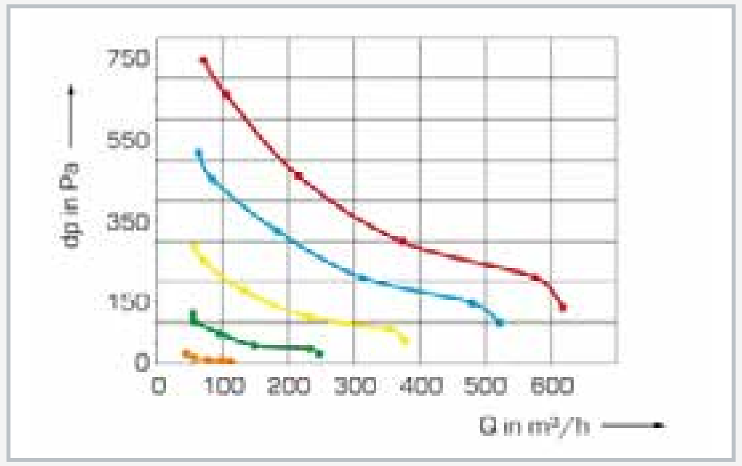
Learning objectives/experiments

- operating behaviour and characteristic variables of an axial fan
- recording the fan characteristic (differential pressure as a function of the flow rate)
- effect of the rotor speed on the pressure
- effect of the rotor speed on the flow rate
- stall
- determination of hydraulical power output and efficiencies

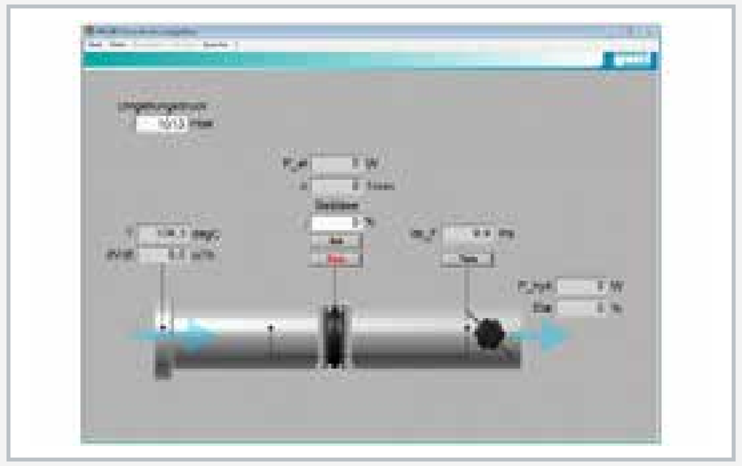
HM 282
Experiments with an axial fan



1 guide plates for flow guidance, 2 measuring point for temperature, 3 intake nozzle at intake pipe, 4 measuring point for pressure (to determine the flow rate), 5 flow straightener, 6 measuring points for pressure, 7 delivery pipe, 8 throttle valve, 9 axial fan



Characteristic curves for an axial fan: differential pressure dependent on the flow rate at different speeds; pd differential pressure, Q flow rate



Operating interface of the powerful software

Specification

[1] functioning and operating behaviour of an axial fan
[2] axial fan with electronically commutated drive motor
[3] variable speed via integrated controller
[4] transparent intake and delivery pipes
[5] throttle valve to adjust the air flow in the delivery pipe
[6] determination of flow rate via intake nozzle
[7] display of differential pressure, flow rate, speed, electrical power consumption and hydraulical power output, temperature and efficiency
[8] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[9] display and evaluation of the measured values as well as operation of the unit via software
[10] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Intake pipe
- inner diameter: 110mm
- length: 275mm

Delivery pipe
- inner diameter: 110mm
- length: 310mm

Axial fan
- power consumption: 90W
- nominal speed: 9500min^{-1}
- max. volumetric flow rate: approx. 600m^3/h
- max. pressure difference: approx. 700Pa

Measuring ranges
- differential pressure: 0...1800Pa
- flow rate: 0...1000m^3/h
- temperature: 0...100°C
- speed: 0...9999min^{-1}
- power consumption: 0...500W

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 670x340x370mm
Weight: approx. 15kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
1 GUNT software CD + USB cable
1 set of instructional material

HM 215
Two-stage axial fan

Axial fans are often used in practice in building services engineering for air conditioning and ventilation systems. In order to increase the supply pressure axial fans can be connected in series. In this case they are known as two-stage fans.

With HM 215 GUNT offers experiments on a two-stage axial fan. In addition, the trainer allows the investigation of a fan in stand-alone operation. Theory and practice can be compared in a simple way.

The device is equipped with sensors for temperature and differential pressure. The flow rate is determined by differential pressure in the inlet nozzle.

Learning objectives

- determining the fan characteristic
- stand-alone or series configuration of axial fans
- determining the energy balance
- determining the pressure and velocity distribution on rotor and guide vane by means of a probe
- effect of rotating blade position

Measuring device with 3-hole probe for determining the differential pressure on rotor and guide vane

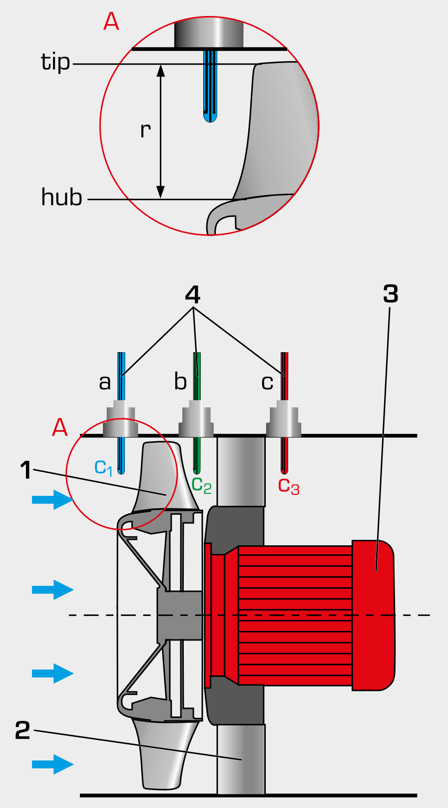
A carefully designed nozzle contour and a flow straightener at the air inlet ensure turbulence-free flow of the blades

The experimental unit is equipped with two high-power axial fans

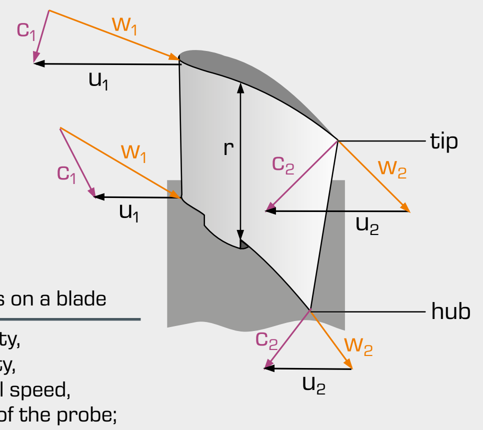
Throttle valve at the end of the measuring section for adjusting the volumetric flow rate

Adjustable blade on the rotor hub

The angle of attack and exit angle, as well as the pressure of the air can be measured with an adjustable measuring probe along the blade radius. Adjusting the blades alters the angle of attack. The GUNT software simplifies measurements with the measuring device and enables the processing and visualisation of measured data.

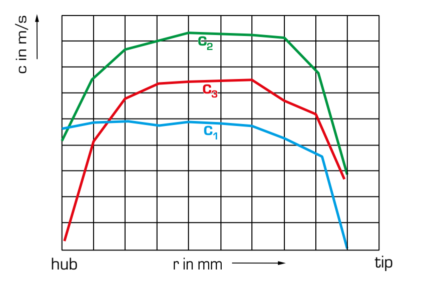


1 adjustable blade on the rotor hub, **2** guide vane, **3** motor, **4** measuring points a-c with 3-hole probe (radial adjustable);



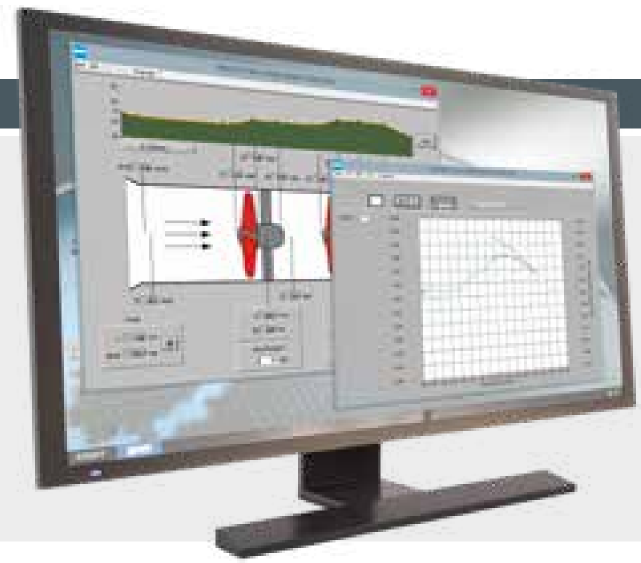
Velocity triangles on a blade

c absolute velocity,
w relative velocity,
u circumferential speed,
r radial position of the probe;



Velocity distribution

pos. a upstream of rotor, c_1,
pos. b downstream of rotor, c_2,
pos. c downstream of guide vane, c_3



Software

The GUNT software clearly displays the measurements on the PC and allows easy analysis of the measuring results. For example, the pressure curve in the measuring section can be clearly shown for different operating states.

HM 215
Two-stage axial fan

Description

- **two axial fans in series configuration or in individual operation**
- **three-hole probe for determining pressure and velocity profile**

Axial fans are connected in series in plants to increase the pressure. In theory, connecting two fans in series doubles the pressure increase.

The HM 215 trainer allows the investigation of a two-stage axial fan. A measuring device is used to determine the pressure and velocity distribution.

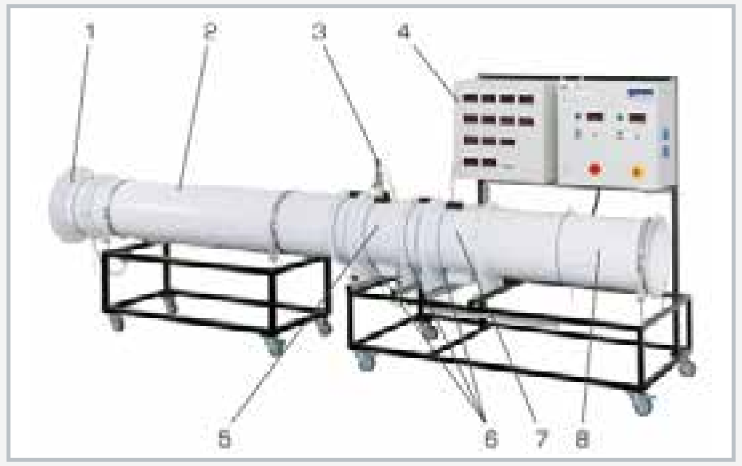
The trainer includes a measuring section with two identical axial fans. The carefully designed nozzle contour and a flow straightener at the air inlet ensure a uniform velocity distribution with little turbulence in the measuring section. The rotors are equipped with individually adjustable blades to change the angle of attack. The fans are equipped with outlet guide vane systems. These guide mechanisms redirect the angular momentum of the outflow in the axial direction and allow an increase in pressure. A pipe bend may optionally be installed to rotate the flow at the outlet of the measuring section. One of the fans can be removed from the measuring section so that the remaining fan can be studied in individual operation.

In the measuring section there are measuring connections to detect the differential pressures and temperatures. The flow rate is measured via an inlet nozzle. The differential pressure and the angle of attack are detected radially at rotors and guide vane systems by means of the 3-hole probe. This enables the display of different pressure and velocity profiles. The measured values are read from digital displays and can at the same time be transmitted via USB directly to a PC where they can be analysed using the software included.

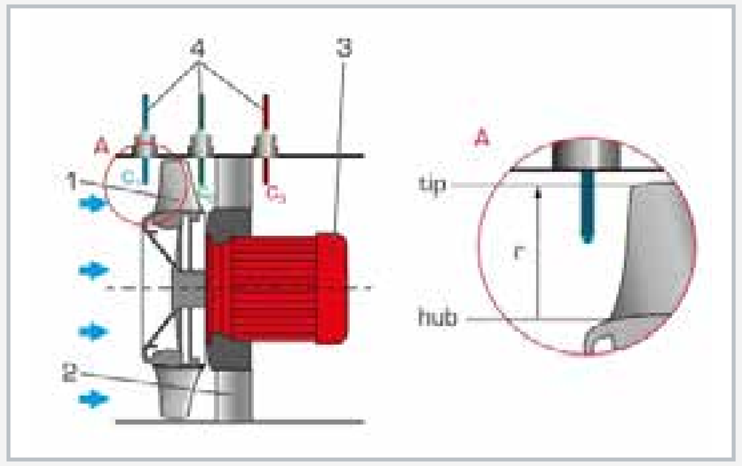
Learning objectives/experiments

- determining the fan characteristic
- series configuration or individual operation of axial fans
- determining the energy balance
- determining the radial pressure and velocity distribution on rotor and guide vane system by means of a probe
- effect of the blade position

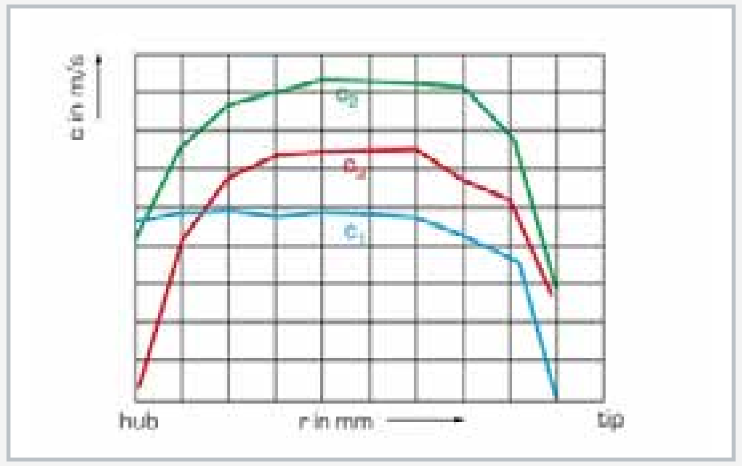
HM 215
Two-stage axial fan



1 nozzle with flow straightener, 2 intake pipe, 3 measuring device, 4 switch box, 5 fan no. 1, 6 pressure measuring points, 7 fan no. 2, 8 throttle valve



Fan with measuring device
1 adjustable blade on the rotor hub, 2 guide vane system, 3 motor, 4 measuring points with 3-probe hole; c_1 to c_3 absolute velocities, r radial position of the probe



Velocity distribution along the blade in radial direction
blue: c_1 upstream of the rotor, green: c_2 downstream of the rotor, red: c_3 downstream of the guide vane system; v velocity, r radial position of the probe along the blade from hub to tip

Specification

[1] investigate two-stage axial fan
[2] 2 identical single-stage fans in series configuration or individual operation
[3] individually adjustable blades
[4] fans both with variable speed via frequency converter
[5] flow-optimised nozzle and flow straightener for smooth, low-turbulence flow
[6] air flow in the pipe section can be adjusted via throttle valve
[7] optional pipe bend at the outlet for flow deflection
[8] measuring device with three-hole probe for determining the differential pressure on rotor and guide vane system
[9] sensors for pressure and temperature upstream and downstream of each fan
[10] volumetric flow rate measured via inlet nozzle
[11] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

2 fans
- drive motor rated output: 3,45kW
- max. pressure difference: 798Pa
- speed: 0...2850min^{-1}
- blade angle adjustable up to 39°

Measuring section inner diameter: 400mm

Measuring ranges
- temperature: 0...100°C
- differential pressure: ±25mbar
- radial position of the probe: 100...200mm

400V, 50Hz, 3 phases
400V, 60Hz, 3 phases
LxWxH without pipe outlet: 4325x970x1800mm
Length with pipe outlet: 5225mm
Weight: approx. 250kg

Required for operation

PC with Windows recommended

Scope of delivery

1 trainer with 2 fans
1 pipe bend
1 measuring device
1 set of measuring hose with quick-release couplings
1 CD with GUNT software + USB cable
1 set of instructional material

HM 210
Characteristic variables of a radial fan

Learning objectives/experiments

- setup and principle of a radial fan
- plotting fan and system characteristics
- flow rate measurement methods based on the differential pressure method using:
  - iris diaphragm
  - Venturi nozzle
  - comparison of both measurement methods
- familiarisation with various differential pressure gauges
- determining efficiency

Description

- **investigation of a radial fan and determination of characteristic variables**
- **determination of flow rate via iris diaphragm or Venturi nozzle**
- **different liquid column manometers measure the differential pressure with varying accuracy**

Fans are key components of ventilation systems, providing ventilation, cooling, drying or pneumatic transport. For optimum design of such systems, it is important to know the characteristic variables of a fan.

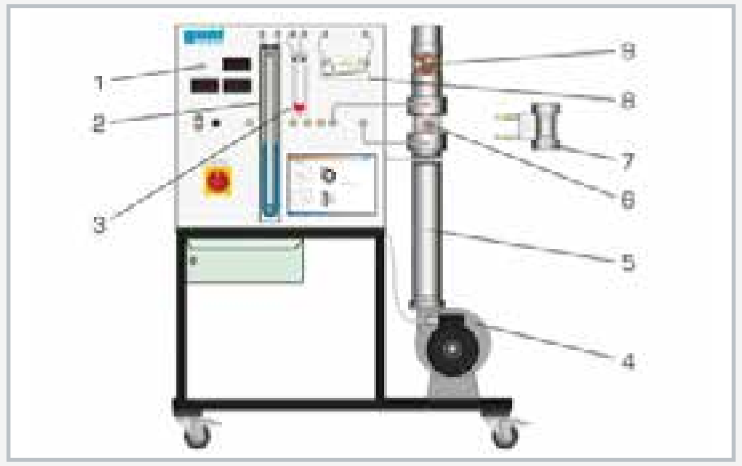
HM 210 investigates a radial fan. This trainer determines the interdependencies between the head and flow rate as well as the influence of the fan speed on the head and flow rate.

The radial fan aspirates the air in axially from the surrounding environment. The high-speed rotating rotor accelerates the air outwards. The high velocity at the outlet from the rotor is partially converted into pressure energy in the spiral housing. The vertical pipe section is connected to the spiral housing. A Venturi nozzle to measure the flow rate and a throttle valve to adjust the flow rate are inserted into the pipe section. An iris diaphragm can optionally be used. Its variable cross-section enables simultaneous adjustment and determination of the flow rate. The effective pressures to calculate the flow rate are read from liquid column manometers. The head of the radial fan is likewise measured by liquid column manometers. U-tube manometer, single tube manometer and inclined tube manometer with graduated measuring ranges are available.

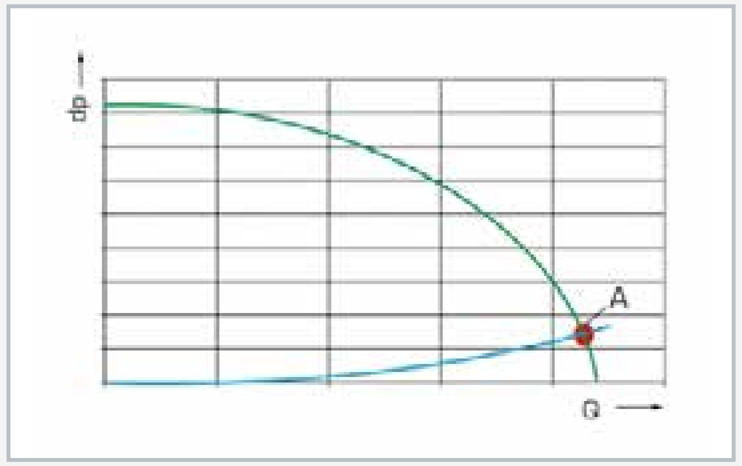
A frequency converter is used to adjust the fan speed. The speed, torque and electric power capacity are digitally displayed. This permits energy analyses, and enables the efficiency of the fan to be determined.

The system characteristic curve is determined by recording the characteristic variables at a constant throttle setting but at variable speed. The interaction of the fan and system at the operation point – the so-called system dimensioning – is investigated.

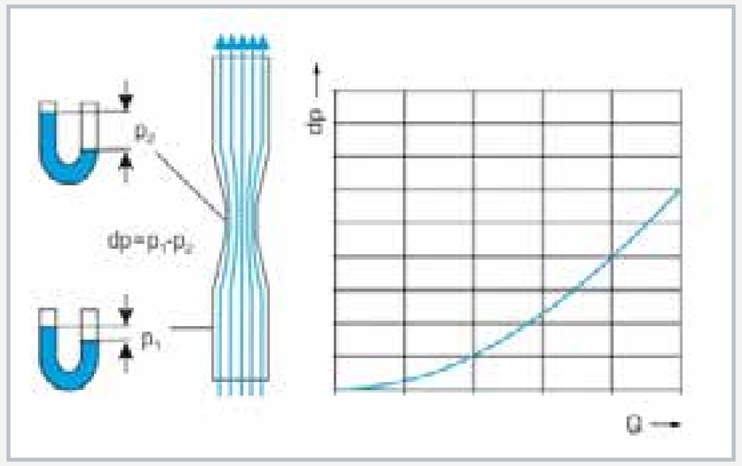
HM 210
Characteristic variables of a radial fan



1 switch cabinet with display elements, 2 U-tube manometer, 3 single tube manometer, 4 radial fan with air intake, 5 pipe section, 6 iris diaphragm, 7 Venturi nozzle, 8 inclined tube manometer, 9 throttle valve



Green: fan characteristic; blue: system characteristic; A, red: system operation point



Air flow in the Venturi nozzle; p_1, p_2 pressure measuring points; graph: differential pressure dp as function of flow rate Q

Specification

[1] radial fan as turbomachine
[2] iris diaphragm or Venturi nozzle to determine flow rate via the differential pressure
[3] speed adjustment by frequency converter
[4] U-tube manometer, single tube manometer and inclined tube manometer measure the differential pressure
[5] air flow rate in pipe section adjustable by throttle valve or iris diaphragm
[6] speed, torque and electric power capacity digitally displayed

Technical data

Radial fan
- max. power consumption: 370W
- max. pressure difference: 860Pa
- max. volumetric flow rate: $4m^3/min$
- nominal speed: $3000min^{-1}$
- speed range: $1000...3000min^{-1}$

Iris diaphragm adjustable in 6 stages
- diameter: 40...70mm
- k=1,8....7,8

Venturi nozzle
- air inlet diameter: 100mm
- pipe neck diameter: 80mm
- k=7,32

Measuring ranges
- differential pressure:
  - 30...0...30mbar (U-tube manometer)
  - 0...15mbar (single tube manometer)
  - 0...50Pa (inclined tube manometer)

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 230V, 60Hz, 3 phases
UL/CSA optional
LxWxH: 1300x720x1640mm
Weight: approx. 123kg

Scope of delivery

1 trainer
1 Venturi nozzle
1 iris diaphragm
1 set of accessories
1 set of instructional material

HM 280
Experiments with a radial fan

Learning objectives/experiments

- operating behaviour and characteristic variables of a radial fan
- recording the fan characteristic (pressure difference as a function of the flow rate)
- effect of the rotor speed on the pressure
- effect of the rotor speed on the flow rate
- effect of different blade shapes on the fan characteristic and efficiency
- determination of hydraulical power output and efficiencies

Description

- **2 interchangeable rotors**
- **transparent delivery pipe and intake pipe**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

Radial fans are used to transport gases with non-excessive pressure differences. The medium is drawn in axially to the drive shaft of the radial fan and is deflected by 90° by the rotation of the rotor and discharged radially.

The experimental unit provides the basic experiments to get to know the operating behaviour and the most important characteristic variables of radial fans.

HM 280 features a radial fan with variable speed via a frequency converter, an intake pipe and a delivery pipe. The transparent intake pipe is fitted with guide plates for flow guidance and with a flow straightener to calm the air. This enables precise measurements even with heavily reduced operation. The air flow is adjusted by a throttle valve at the end of the delivery pipe.

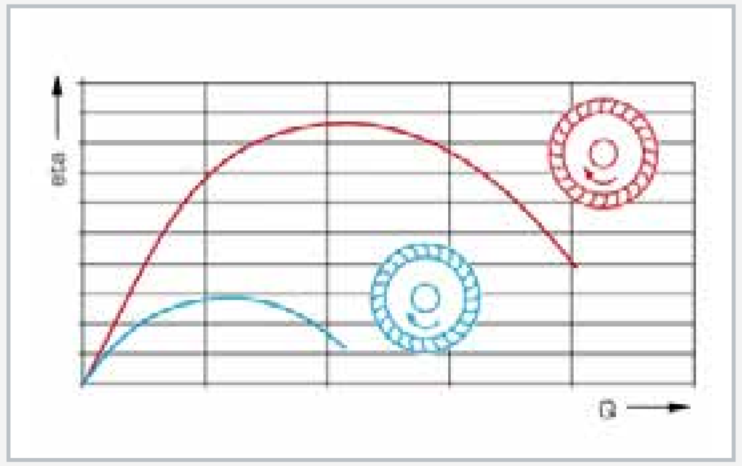
To demonstrate the effect of different blade shapes two rotors are included in the scope of delivery: one rotor with forward curved blades and one with backward curved blades. The rotors are easily interchangeable.

The experimental unit is fitted with sensors for pressure and temperature. The flow rate is determinated via differential pressure measurement on the intake nozzle. The microprocessor-based measuring technique is well protected in the housing. The measured values are transmitted directly to a PC via USB where they can be analysed using the software included.

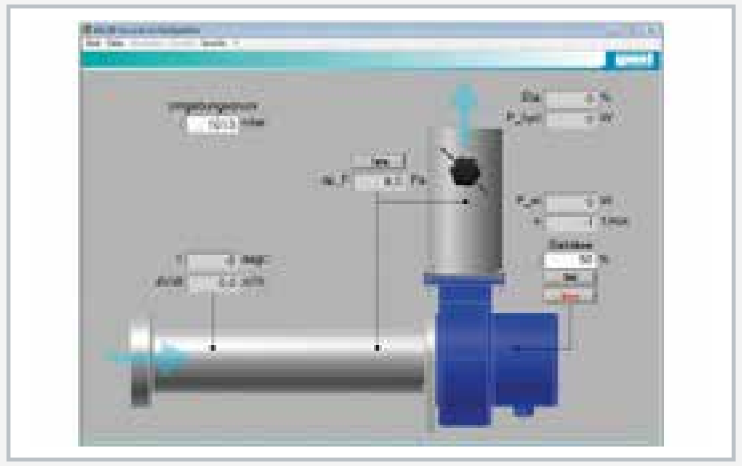
All the advantages of software-supported experiments with operation and evaluation are offered by the GUNT software and the microprocessor.

HM 280
Experiments with a radial fan

1 measuring points for pressure, 2 measuring point for temperature, 3 inlet nozzle with measuring point for static pressure, 4 intake pipe, 5 guide plates, 6 radial fan with drive motor, 7 delivery pipe, 8 throttle valve



Efficiencies in comparison; red: rotor with forward curved blades, blue: rotor with backward curved blades; eta efficiency, Q débit



Operating interface of the powerful software

Specification

[1] functioning and operating behaviour of a radial fan
[2] radial fan with 3-phase AC motor
[3] variable speed via frequency converter
[4] transparent intake and delivery pipes
[5] throttle valve to adjust the air flow in the delivery pipe
[6] interchangeable rotors: 1 rotor with forward curved blades and 1 rotor with backward curved blades
[7] determination of flow rate via intake nozzle
[8] display of differential pressure, flow rate, speed, electrical power consumption and hydraulical power output, temperature and efficiency
[9] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[10] display and evaluation of the measured values as well as operation of the unit via software
[11] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Intake pipe
- inner diameter: 90mm
- length: 430mm

Delivery pipe
- inner diameter: 100mm
- length: 530mm

Radial fan
- power consumption: 110W
- nominal speed: 2800min^{-1}
- max. volumetric flow rate: 480m^3/h
- max. pressure difference: 300Pa

Measuring ranges
- differential pressure: 0...1800Pa
- flow rate: 0...1000m^3/h
- temperature: 0...100°C
- speed: 0...3300min^{-1}
- electrical power consumption: 0...250W

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 670x340x940mm
Weight: approx. 20kg

Required for operation

PC with Windows

Scope of delivery

1 experimental unit
2 rotors
1 GUNT software CD + USB cable
1 set of instructional material

HM 292

Experiments with a radial compressor

Description

- **illustrative model of a radial compressor**
- **transparent delivery pipe and intake pipe**
- **GUNT software for data acquisition, visualisation and operation**
- **part of the GUNT-Labline fluid energy machines**

Radial compressors are used to compress gases. The medium is drawn in axially to the drive shaft by the rotation of the rotor and flows through the rotor rotating at high speed. By means of centrifugal force, the medium is accelerated towards the outer edge and is compressed in this manner.

The experimental unit provides the basic experiments to get to know the operating behaviour and the important characteristic variables of radial compressors.

HM 292 features a two-stage radial compressor with variable speed via a frequency converter, an intake pipe and a delivery pipe. The intake and delivery pipes are transparent. A protective plate placed in front of the inlet of the intake pipe prevents larger objects from being drawn in or the clogging of the intake opening. The air flow is adjusted by a throttle valve at the end of the delivery pipe.

The experimental unit is fitted with sensors for pressure, temperature and speed. The flow rate is determined via differential pressure measurement on the intake nozzle.

The microprocessor-based measuring technique is well protected in the housing. All the advantages of software-supported experiments and evaluation are offered by the GUNT software and the microprocessor. The connection to a PC is made by USB.

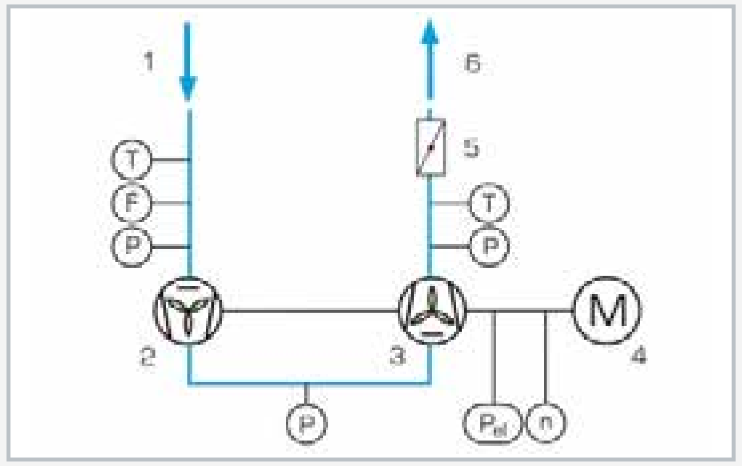
Learning objectives/experiments

- operating behaviour and characteristic variables of a radial compressor
- recording of the compressor curve for both stages
- effect of the rotor speed on the pressure
- effect of the rotor speed on the flow rate
- distribution of stage pressure ratios
- effect of compression on the temperature increase
- determination of hydraulical power output and efficiencies

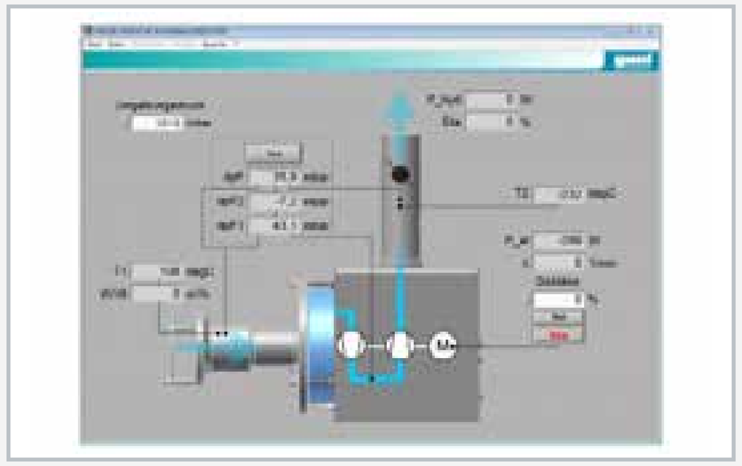
HM 292

Experiments with a radial compressor

1 air inlet with protecting plate, 2 two-stage radial compressor with drive motor, 3 delivery pipe, 4 throttle valve, 5 temperature sensor, 6 intake pipe, 7 pressure sensor



1 air inlet, 2 radial compressor stage 1, 3 radial compressor stage 2, 4 drive motor, 5 throttle valve, 6 air outlet;
T temperature, F flow rate, P pressure, P_{el} power consumption, n speed



Operating interface of the powerful software

Specification

[1] functioning and operating behaviour of a radial compressor
[2] two-stage radial compressor with drive motor
[3] variable speed via frequency converter
[4] transparent intake and delivery pipes
[5] throttle valve for adjusting the air flow in the delivery pipe
[6] protecting plate at air inlet for undisturbed air flow
[7] determination of flow rate via intake nozzle
[8] display of differential pressures, flow rate, speed, electrical power consumption and hydraulical power output, temperatures and efficiency
[9] due to integrated microprocessor-based instrumentation no additional devices with error-prone wiring are required
[10] GUNT software with control functions and data acquisition via USB under Windows 7, 8.1, 10

Technical data

Intake pipe
- inner diameter: 44mm

Delivery pipe
- inner diameter: 34mm

Two-stage radial compressor
- power consumption: 1000W
- speed: 1000...16000min^{-1}
- max. volumetric flow rate: 180m^3/h
- max. pressure difference: 235mbar

Measuring ranges
- differential pressure (stage 1 / stage 2): 0...350mbar
- flow rate: 0...120m^3/h
- temperature: 2x 0...100°C
- speed (compressor): 0...21000min^{-1}
- electrical power consumption: 0...1000W

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 670x340x530mm
Weight: approx. 20kg

Required for operation

PC with Windows

Scope of delivery

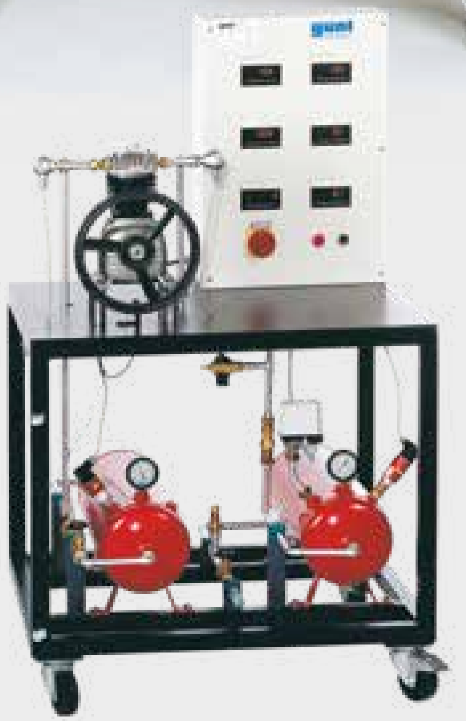
1 experimental unit
1 GUNT software CD + USB cable
1 set of instructional material

ET 513
Single-stage piston compressor with drive unit HM 365

Part of the GUNT-FEMLine

- operating principle of a piston compressor
- measurement of volumetric flow rate and pressures
- power measurement
- determination of efficiency
- plotting of compressor characteristic
- determination of intake and volumetric efficiency

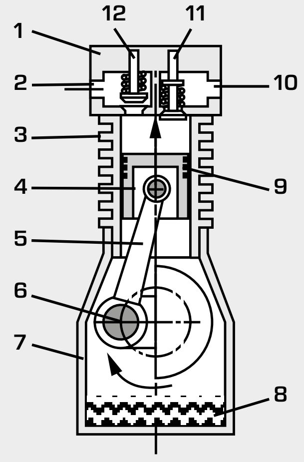
HM 365 Universal drive and brake unit



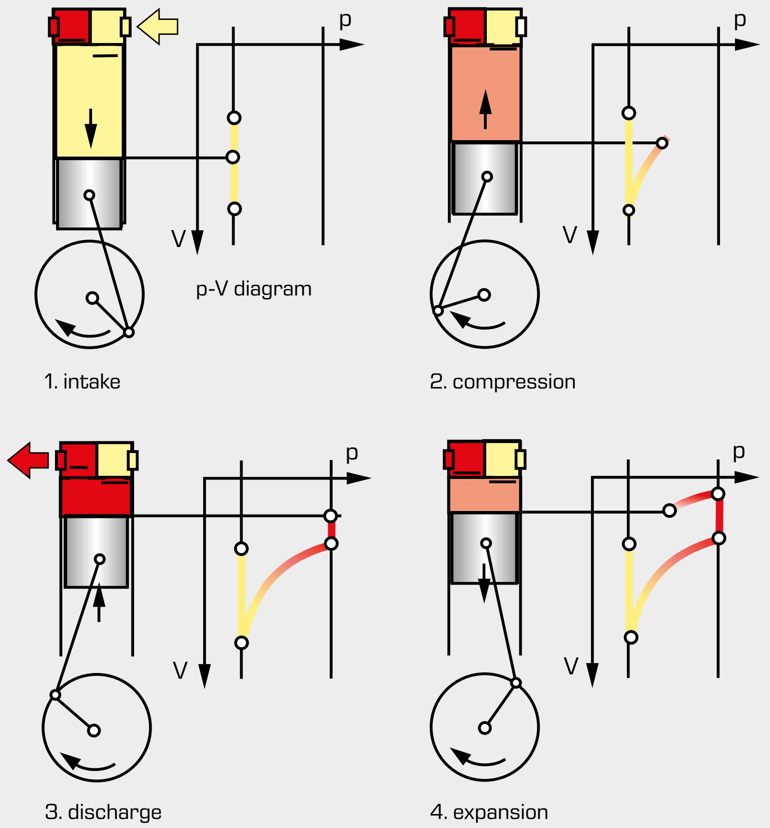
ET 513 Single-stage piston compressor

Piston compressors deliver compressible media such as gas or air.

Piston compressors are positive displacement machines. The piston (displacement element) forms a space with variable volume together with cylinder and cylinder cover. A crank mechanism generates the periodic reciprocating movement of the piston inside the cylinder. The self-acting valves in the cylinder cover control the inflow and the outflow of the delivered medium.



1 cylinder head,
2 air outlet,
3 cylinder with cooling fins,
4 piston,
5 connecting rod,
6 crank shaft,
7 crank case,
8 oil sump,
9 piston rings,
10 air intake,
11 intake valve,
12 discharge valve



The process of delivery is divided into four steps

1. intake
The piston moves downwards and the delivery medium (air) is sucked into the cylinder via the opened intake valve.

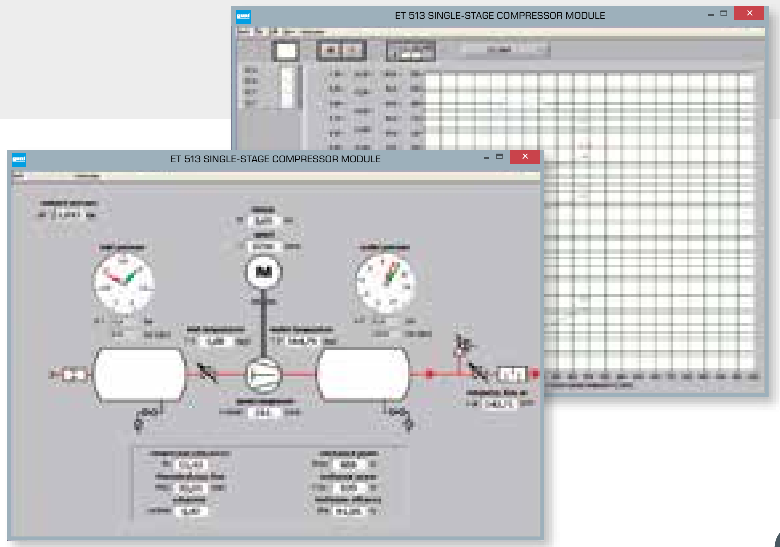
2. compression
The piston moves upwards, the intake valve is closed and the pressure in the cylinder increases.

3. discharge
Once the pressure in the cylinder exceeds the pressure inside the outlet line, the discharge valve opens and the piston pushes the compressed medium into the outlet line.

4. expansion
The cylinder volume is not emptied completely into the outlet line. A small part remains inside the cylinder. This part expands during the downward movement of the piston until the pressure inside the intake line is reached. The first step (intake) follows.

The software enables display of measured values on a PC. Recording and saving of data history is possible.

With the help of spreadsheet programmes (e.g. MS Excel) saved data can be evaluated. The measured values are directly transmitted to the PC via USB.



ET 513
Single-stage piston compressor

Learning objectives/experiments

- setup and operating behaviour of a compressed air generation system with single-stage piston compressor
- determination of the characteristic curve
- determination of the volumetric efficiency
- determination of the mechanical efficiency

Description

- **single-stage piston compressor**
- **part of the GUNT-FEMLine**
- **setup of a complete compressor unit in combination with the universal drive and brake unit HM 365**

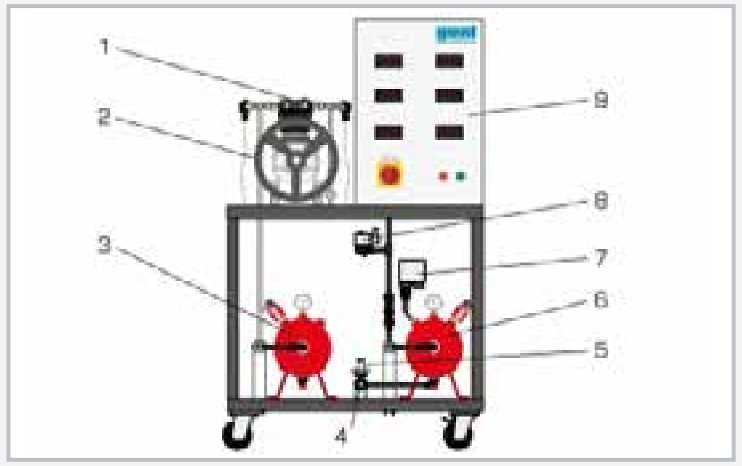
The generation of compressed air for industrial and commercial purposes in areas where compressed air is used as a source of energy requires what are known as compressed air generation plants. A central part of these systems is the compressor. It is responsible for generating a pressure increase of the air by means of mechanical energy. Compressed air generation plants are used to power machines in the mining industry, for pneumatic control systems in assembly facilities or as tyre inflation units at petrol stations.

The single-stage piston compressor in ET 513 and the drive unit HM 365 together form a complete compressed air generation system.

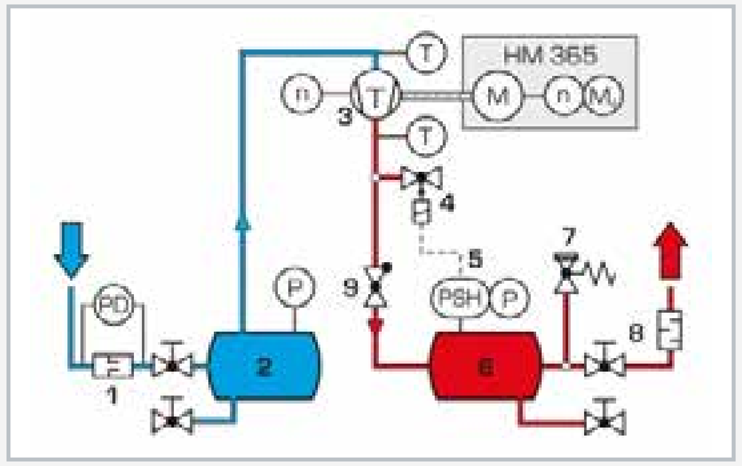
The drive unit HM 365 powers the compressor by means of a V-belt. The speed of the compressor is set on HM 365. The air is sucked into the intake vessel, where it settles before it is compressed inside the compressor. The compressed air is then delivered to a pressure vessel and is available as a working medium. To set a steady flow operating mode, the compressed air can be discharged over a blow-off valve with a silencer. A pressure switch with a solenoid valve for limiting the pressure and a safety valve complete the system.

A measuring nozzle at the intake vessel is used to determine the suction volumetric flow rate. Sensors record the pressures and temperatures in front of and behind the compressor. The pressure is also displayed on manometers in the tanks. The measured values are read from digital displays and can be transmitted simultaneously via USB directly to a PC, where they can be analysed using the software included. The speed and torque measurement is integrated in HM 365.

ET 513
Single-stage piston compressor



1 compressor, 2 V-belt pulley, 3 intake vessel, 4 blow-off valve with silencer, 5 safety valve, 6 pressure vessel, 7 pressure switch, 8 solenoid valve, 9 switch cabinet with digital displays



1 measuring nozzle, 2 intake vessel, 3 piston compressor, 4 solenoid valve, 5 pressure switch, 6 pressure vessel, 7 safety valve, 8 blow-off valve with silencer,9 non-return valve; P pressure, PD differential pressure, T temperature, n speed, M_d torque

The illustration shows a complete experimental setup with ET 513 and HM 365

Specification

[1] investigation of a driven machine for compressed air generation
[2] single-stage piston compressor with one cylinder
[3] drive and speed adjustment via HM 365
[4] intake vessel with measuring nozzle for determination of the suction volumetric flow rate
[5] intake vessel and pressure vessel, both with pressure sensor and additional manometer
[6] safety valve and pressure switch with solenoid valve for limiting the pressure
[7] blow-off valve with silencer for setting a steady flow operating mode
[8] pressure and temperature sensors in front of and behind the compressor
[9] digital display for air flow rate, temperatures, pressures, differential pressures and compressor speed
[10] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Compressor, 1 cylinder, single-stage
- power consumption: 750W
- nominal speed: 980min^{-1}
- positive operating pressure: 8bar
- max. pressure: 10bar
- intake capacity: 150L/min at 8bar
- borehole: 65mm
- stroke: 46mm

Safety valve: 10bar
Pressure vessel
- 16bar
- volume: 20L

Intake vessel: 20L

Measuring ranges
- temperature: 1x 0...200°C / 1x 0...100°C
- pressure: 0...16bar / -1...1bar
- flow rate: 0...150L/min
- speed: 0...1000min^{-1}

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 900x800x1510mm
Weight: approx. 130kg

Required for operation

PC with Windows recommended

Scope of delivery

trainer, 1 GUNT software CD + USB cable, 1 V-belt, 1 V-belt guard, 1 set of instructional material

HM 299 Comparison of positive displacement machines and turbomachines

HM 299 Comparison of positive displacement machines and turbomachines:
The illustration shows the trainer with two centrifugal pumps connected in parallel

Driven machines

	Turbomachines	Positive displacement machines	
		Rotating	Oscillating
Liquid Incompressible working medium water	 Centrifugal pump	 Impeller pump	 Piston pump
Gaseous Compressible working medium air		 Rotary vane compressor	 Piston compressor

The HM 299 trainer is used to study and compare different positive displacement and turbomachines. It comes with two centrifugal pumps, an impeller pump, a piston pump and two different compressors. All driven machines are arranged on the compact trainer and can be placed in the measuring section easily and quickly. Guide rails enable accurate and simple installation of the devices without additional alignment of the drive. Silicone hoses are connected via quick-release couplings.

Ambient air is used as a compressible working medium, so a compressed air connection is not needed. Two generously sized stabilisation tanks for the compressed air ensure interference-free measurement.

The didactic concept of this compact trainer includes several learning units so that a comprehensive and effective course on driven machines is offered. The experiments can be carried out both by the lecturer as a demonstration in front of the students and by the students themselves in the form of practical laboratory experiments or project work. The simple conversion of the machines enables a variety of experiments in a short time in order to familiarise students with the operational behaviour of positive-displacement and turbomachines.

The experiments are supported by the GUNT data acquisition software.

The comprehensive instructional materials include a detailed introduction to the subject.

GUNT software for data acquisition

The GUNT software included in the scope of delivery displays the measurement results and assists in the evaluation of the experiments.

Learning objectives / experiments

- familiarisation with the function and distinctive features of positive displacement machines and turbomachines
- identifying characteristic data
- recording pump, compressor and system characteristics
- representing operating points

HM 299
Comparison of positive displacement machines and turbomachines

The illustration shows a similar unit.

Description

■ **investigation of different driven machines: pumps and compressors**
■ **experiments with liquid or gaseous media**

Driven machines release absorbed mechanical work to a liquid or gaseous medium. They are divided into positive displacement machines and turbomachine according to their function. For large volumetric flow rates the benefits of turbomachines are predominant, such as centrifugal pumps; for small volumetric flow rates piston engines are more likely to be used.

The HM 299 trainer allows the comparison of different machines for liquid and gaseous media. One turbomachine and four different positive displacement machines, two with rotating pistons and two with oscillating pistons, are supplied. Software for data acquisition and visualisation makes the experiments especially clear and enables fast execution of experiments with reliable results.

HM 299 includes a drive motor with speed adjustment, belt drive and protective hood, two pressure vessels for experiments with compressors and two water tanks for experiments with pumps. Each machine is mounted on a plate and can easily be placed in the trainer. The machines are driven by a belt drive. The pumps are connected to a closed water circuit via hoses with quick-release couplings. Sensors measure the pressures at inlet and outlet, temperature, engine speed and engine output. The respective flow rate is measured indirectly via fill level (water) or Venturi nozzle (air).

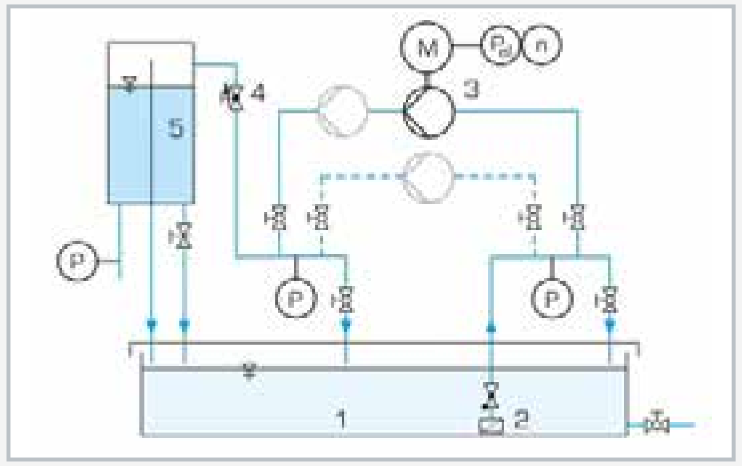
The measured values are read from digital displays and can at the same time be transmitted via USB directly to a PC where they can be analysed using the software included.

Learning objectives/experiments

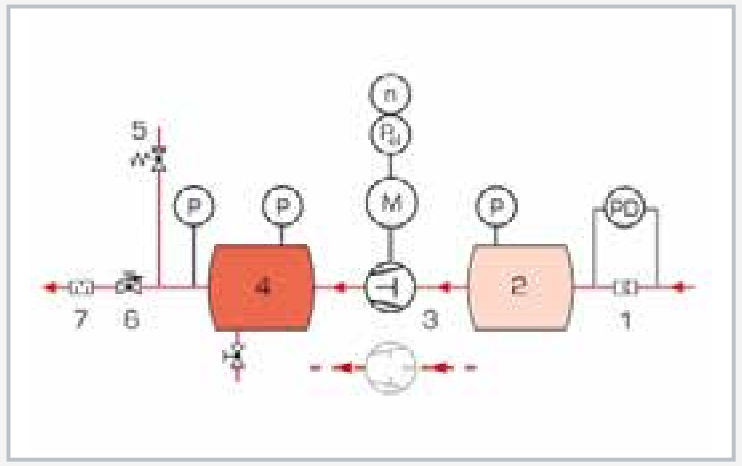
■ different pump and compressor types
■ identifying characteristic data
■ recording pump, compressor and system characteristics
■ representation of operating points in series and parallel configuration of centrifugal pumps
■ comparison of the different delivery properties

HM 299
Comparison of positive displacement machines and turbomachines

1 measuring tank, 2 displays and controls, 3 stabilisation and pressure vessel, 4 supply tank, 5 pumps and compressors, 6 drive motor



Experiments (centrifugal pumps): 1 supply tank, 2 strainer, 3 pump with drive motor, 4 valve for adjusting the flow rate, 5 measuring tank; P pressure, n speed, P_{el} power



Experiments (compressors): 1 Venturi nozzle for flow measurement, 2 stabilisation tank, 3 compressor with drive motor, 4 pressure vessel, 5 safety valve, 6 valve for adjusting the flow rate, 7 sound damper; P pressure, PD differential pressure, P_{el} power, n speed

Specification

[1] comparison of driven machines for liquid and gaseous media
[2] closed water circuit
[3] 2 compressors: piston compressor and rotary vane compressor
[4] 4 pumps: piston pump, impeller pump, 2 centrifugal pumps
[5] drive motor with variable speed
[6] flow determined by level (water) or Venturi tube (air)
[7] digital displays for pressure, differential pressure, temperature, speed and drive power
[8] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Piston compressor
■ max. volumetric flow rate: 115L/min
■ max. pressure difference: 10bar
Rotary vane compressor
■ max. volumetric flow rate: 90L/min
■ max. pressure difference: 0...7bar
■ safety valve: 0,8bar
2 centrifugal pumps
■ max. flow rate: 60L/min, max. head: 18m
Piston pump
■ max. flow rate: 14,6L/min
■ system pressure is limited to max. 6bar
Impeller pump
■ max. flow rate: 25L/min, max. pressure: 1,5bar
Drive motor, 4-pole
■ max. power: 0,75kW
■ nominal speed: 1370min^{-1}
2 pressure vessels: 10L, max. 10bar
2 water tanks: 60L, 10L

Measuring ranges
■ speed: 0...2500min^{-1}
■ power consumption: 0...1375W
■ temperature: 0...200°C
■ pressure: 1x 0...2bar; 1x 0...6bar; 1x 0...10bar
■ differential pressure: 0...10mbar

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 2100x650x1550mm
Weight: approx. 205kg

Required for operation

PC with Windows recommended

Scope of delivery

1 trainer
2x compressor
4x pump
1 set of accessories
1 GUNT software CD + USB cable
1 set of instructional material