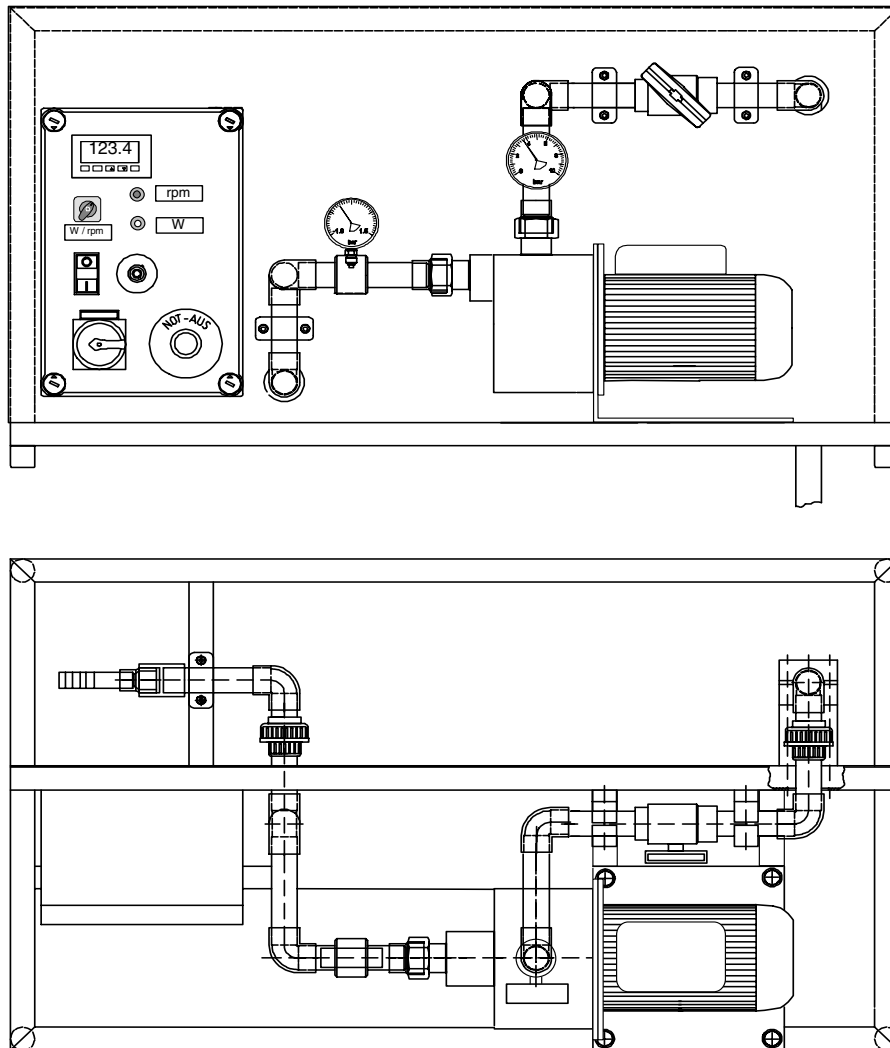


Experiment Instructions

HM 150.04 Variable Speed
Centrifugal Pump



Experiment Instruction

Please read and follow the instructions before the first installation!



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1 Description

The attachment set **HM150.04** Variable Speed Centrifugal Pump is used in conjunction with **HM150** Basic Hydraulics Bench to make use of measuring and supply facilities in the bench. However, the experimental set **HM150.04** can be used independently if water supply and other measuring facilities are available in the laboratory.

The connection with HM 150 is made by using a hose with quick fit. The centrifugal pump supplies water through the submerge pump of HM 150. The centrifugal pump is experimented without the pump of **HM150**. (It can also be experimented with the series connection of both pumps.)

The overall structure is made of anti-corrosion materials. The piping and the stop valves are made of plastic material.

The pump speed is controlled by an asynchronous motor with a frequency converter. The speed in rpm and the power consumption in W can be read on a digital display. The display can be switched manually between speed and power consumption.

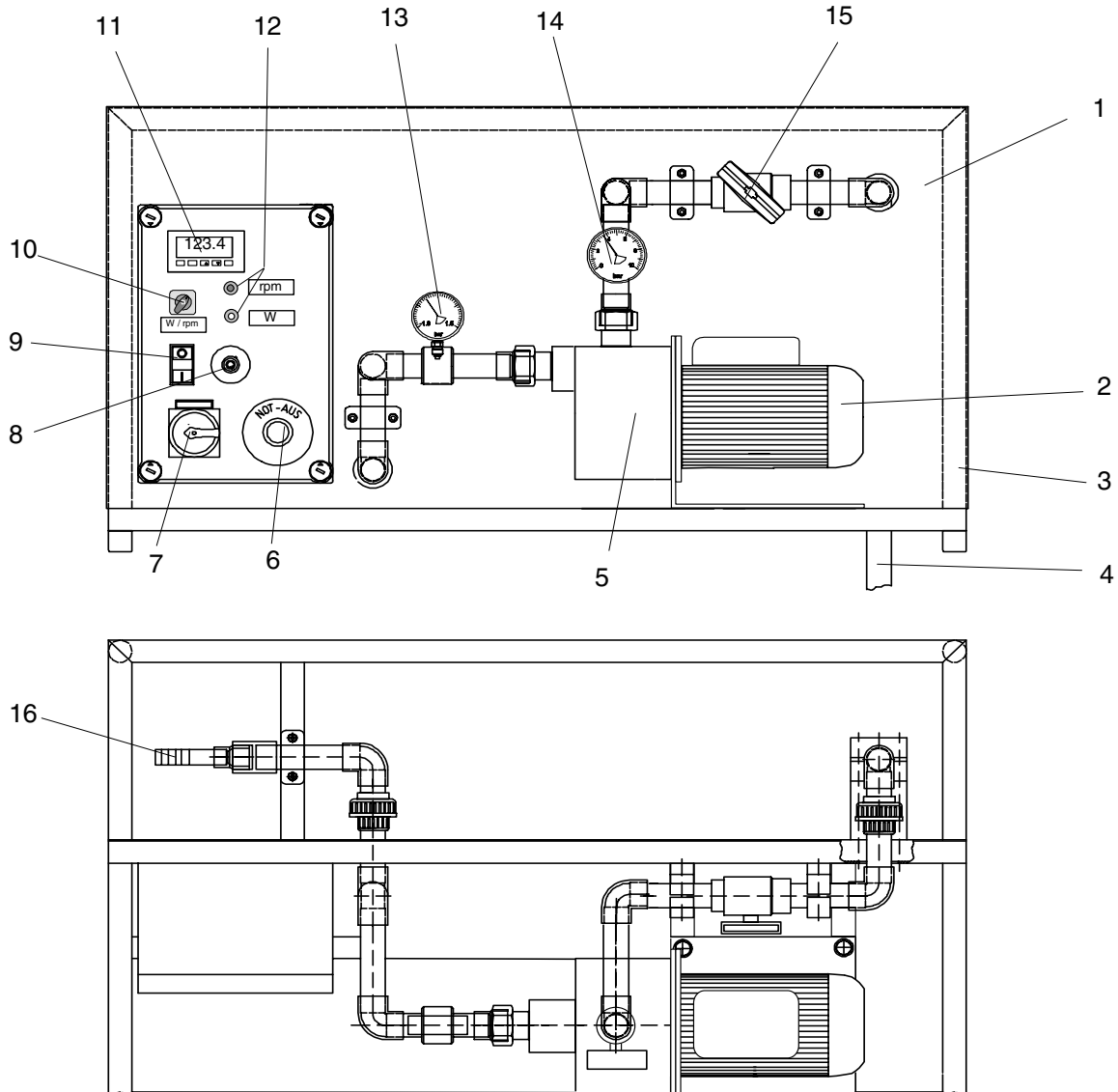
The suction pressure and delivery pressure are measured by 2 manometers.

The volume (mass) flow-rate is measured using the volumetric tank of **HM150**.

Experimental Capabilities:

- Determination of the relation between delivery head and volume flow rate.
- Effect of pump speed on the delivery power.
- Measurement of the suction and delivery pressures.
- Measurement of the speed and the power consumption of the pump.
- Determination of the efficiency of the pump system.

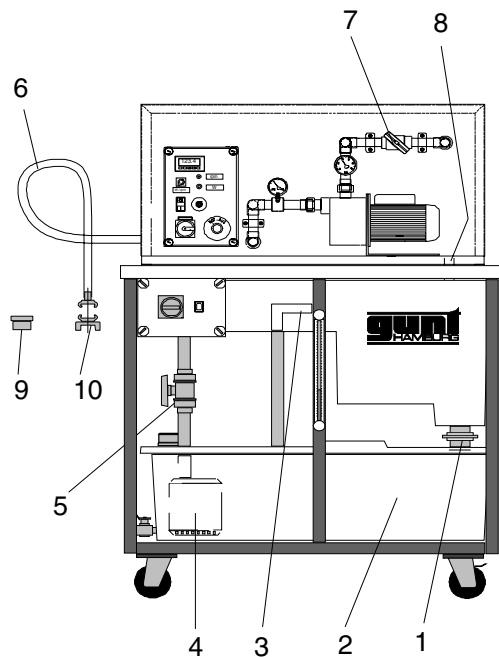
1.1 Details of the System



- | | | | |
|----|--|----|--|
| 1 | Instrument panel | 11 | Digital display |
| 2 | A.C. drive motor | 12 | Display of the switch position |
| 3 | Welded frame | 13 | Manometer for suction-pressure measurement |
| 4 | Back-flow pipe in the tank of HM150 | 14 | Manometer for delivery-pressure measurement |
| 5 | Centrifugal pump | 15 | Ball valve for throttling the centrifugal pump |
| 6 | Emergency-off switch | 16 | Hose connection for water supply to the centrifugal pump |
| 7 | Master switch | | |
| 8 | Potentiometer for speed | | |
| 9 | On-off switch for the Centrifugal pump | | |
| 10 | Alteration switch of the digital display | | |

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2 Experimental Preparation



If you have a hydraulics bench in your laboratory, mount the attachment set **HM150.04** on top of **HM150**, so that the drain (8) gets into the channel.

Connect the hose (6) with the quick fit between **HM150** and the apparatus HM 150.04. In order to do this remove the cover (9) from the water inlet of HM 150. Substitute the cover with a special screw fitting (10) with quick fit.

- Open the drain (1) of the **HM150**.
- Open the ball valve (7) (no throttling).
- Open the ball valve (5) (pressure side of the submerged pump)
- Fill the tank (2) of **HM150**.
- Connect the electricity mains supply.
- Deaerate the centrifugal pump:
Fill the centrifugal pump with the delivered water from the submerged pump (4). Do this by switching the submerged pump on for a short time.

3 Experiments

3.1 Effect of the Rotational Speed on the Pump Efficiency

To determine the pump efficiency, the electrical input power of the drive motor and the hydraulic output power of the pump are needed.

3.1.1 Motor Input-Power

The motor input-power is given from the frequency converter and shown on the digital display.

$$P_A$$

3.1.2 Hydraulic-Pump Output Power

The output power of the hydraulic pump is calculated from:

$$P_{Hyd.} = \dot{V} \cdot H \cdot \rho \cdot g$$

H is the delivery head, ρ the water density and g the gravitational acceleration.

To measure the volume flow-rate \dot{V} , you need to measure the time t needed to fill the volumetric tank of **HM150** from 20 l to 30 l. (If the hydraulics bench is not available, use any other method to measure the volume flow-rate, e.g., by measuring the time to fill a volumetric cylinder).

3.1.3 Volume Flow-Rate

The volume flow-rate is calculated as

$$\dot{V} = \frac{\Delta V}{\Delta t}$$

The density of water is considered as

$$\rho = 998 \frac{\text{kg}}{\text{m}^3}$$

The gravity acceleration $g = 9.81 \frac{\text{m}}{\text{s}^2}$

3.1.4 Delivery Head of the Pump

The delivery head is calculated as follows:

$$H = \frac{p_D - p_S}{g \cdot \rho} + y + \frac{c_D^2 - c_S^2}{2 \cdot g}$$

The influences of the flow speeds c_D and c_S cancel each other due to equal cross-sections in suction and pressure connections.

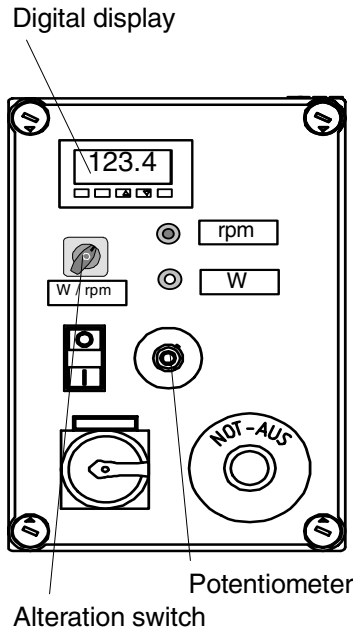
y is the height difference of the two manometer, where $y=0.18$ m.

3.1.5 Pump Efficiency

The pump efficiency is calculated from the hydraulic-pump power and the electric-motor power. With a motor efficiency of $\eta_{Motor} = 0.92$ the pump efficiency is

$$\eta_P = \frac{P_{Hyd.}}{P_A \cdot \eta_{Motor}}$$

3.2 Pump Characteristic-Curves



Delivery pressure is adjusted by the ball valve (page 2-pos.15).

The speed in rpm is adjusted via the potentiometer on the switch box.

The speed and the power consumption of the centrifugal pump are being displayed on the digital display.

Change-over between rpm and power-consumption must be done manual.

The following results were obtained for various speeds (rpm).

3.2.1 Results

rpm $n = 1000 \text{ min}^{-1}$.

ps [bar]	pD [bar]	V [l]	t [s]	\dot{V} [l/h]	H [m]	PA [W]	P _{Hyd} [W]	η_P [%]
-0.11	0	10	30.94	1163.5	1.30	75	4.12	5.98
-0.11	0.03	10	32.44	1109.7	1.61	75	4.86	7.04
-0.08	0.07	10	70.44	511.07	1.71	73	2.38	3.54
-0.08	0.30	10	105.00	342.86	4.01	72	3.74	5.65
-0.07	0.50	10	183.56	196.12	6.00	72	3.20	4.83
-0.06	1.10	10	∞	-	12.03	72	-	-

rpm $n = 2000 \text{ min}^{-1}$.

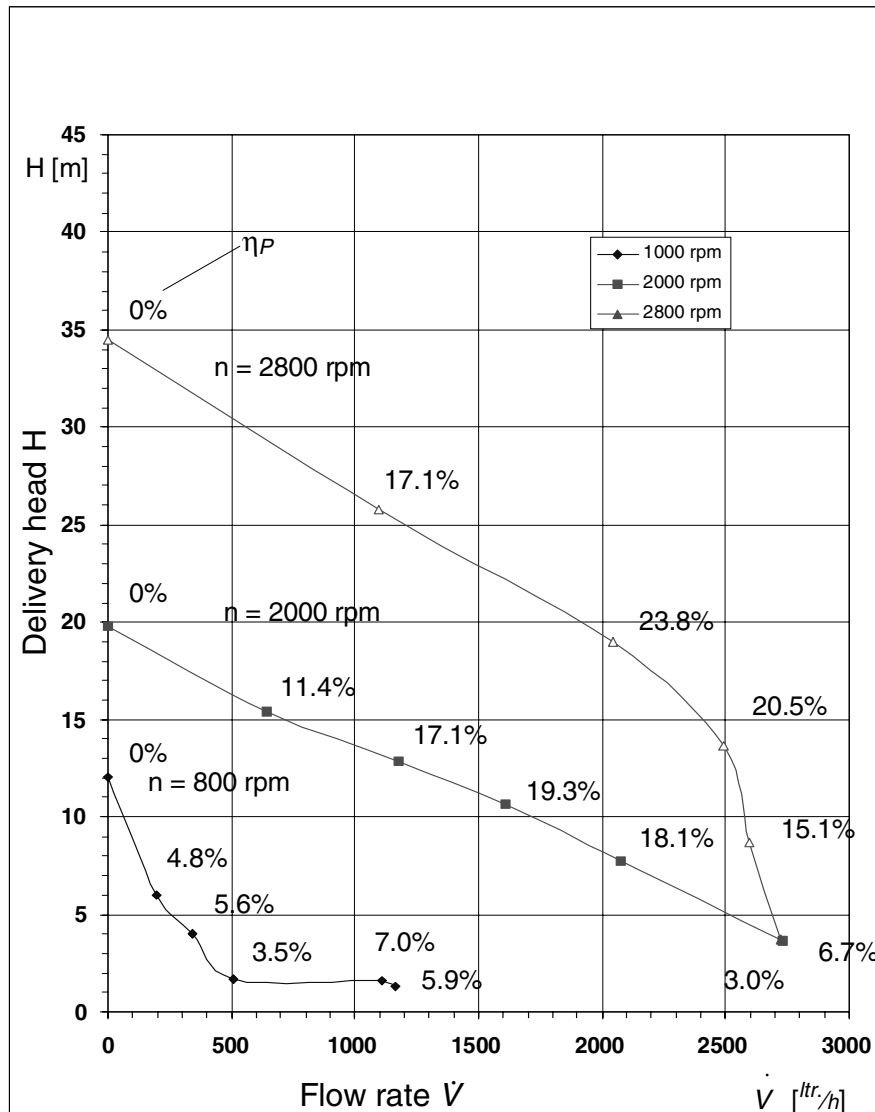
ps [bar]	pD [bar]	V [l]	t [s]	\dot{V} [l/h]	H [m]	PA [W]	P _{Hyd} [W]	η_P [%]
-0.34	0	10	13.18	2731.4	3.65	260	27.13	11.34
-0.24	0.50	10	17.35	2074.9	7.74	262	43.67	18.12
-0.18	0.85	10	22.32	1612.9	10.65	263	46.71	19.31
-0.14	1.10	10	30.66	1174.1	12.85	260	41.02	17.15
-0.09	1.40	10	55.94	643.5	15.40	257	26.95	11.4
-0.07	1.85	10	∞	-	19.79	248	-	-

rpm $n = 2800 \text{ min}^{-1}$.

ps [bar]	pD [bar]	V [l]	t [s]	\dot{V} [l/h]	H [m]	PA [W]	P _{Hyd} [W]	η_P [%]
-0.35	0	10	13.22	2723.1	3.75	450	27.81	6.72
-0.33	0.50	10	13.87	2595.5	8.66	440	61.11	15.1
-0.32	1.00	10	14.44	2493.1	13.66	490	92.63	20.55
-0.24	1.60	10	17.63	2041.9	18.97	480	105.37	23.86
-0.11	2.40	10	32.78	1098.2	25.82	490	77.11	17.1
-0.06	3.30	10	∞	-	34.5	480	-	-

3.2.2 Presentation of the Measured Values

The measurement results give the following characteristic curves.



4 Technical Data

Manometer, pressure side:

Type: Bourdon
 Range: 0 ... 10 bar
 Diameter: 63 mm

Manometer, suction side:

Type: Bourdon
 Range: -1.0 ... 1.5 bar
 Diameter: 63 mm

Pump:

Type: Centrifugal, BG (M)3
 Delivery head: 36.9 m max.
 Flow rate: 3000 l/h max.
 Nominal speed: 2850 min⁻¹
 Material: Housing stainless steel

Motor:

Type: A.C. motor (asynchron)
 Nominal power: 0,68 kW at 2850 min⁻¹
 RPM: 0 ... 2850 min⁻¹

Power supply: 230V / 50 Hz, 1ph
 Alternatives optional,
 see type plate

Overall dimensions:

Height: 600 mm
 Width: 1100 mm
 Depth: 640 mm

Weight: 65 kg