Equipment for Engineering Education

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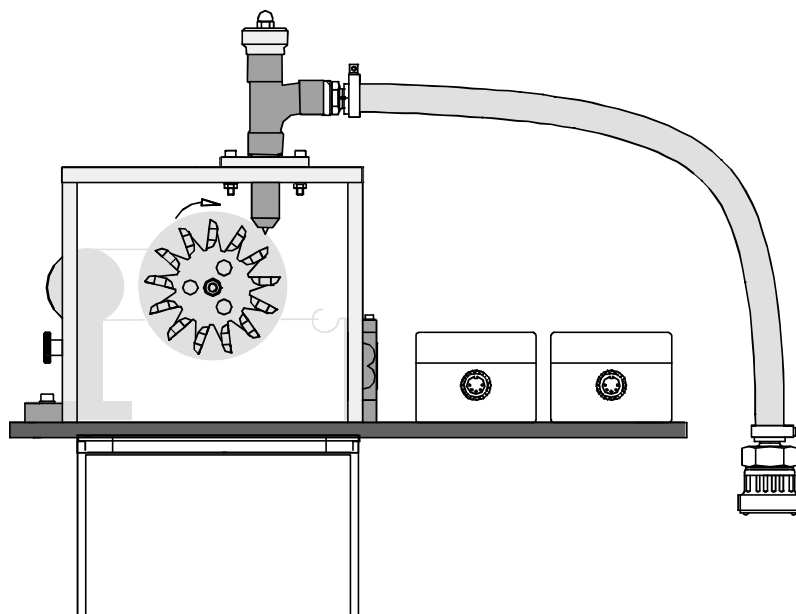# Instructions Manual

HM 289   Pelton Turbine
Demonstration Unit

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Instructions Manual

Please read and follow the instructions before the first installation!

HM 289   Pelton Turbine Demonstration Unit

Table of Contents

HM 289   Pelton Turbine Demonstration Unit

1   Introduction

The **G.U.N.T. HM 289 Pelton Turbine Demonstration Unit with PC Data Acquisition** is part of an equipment series that facilitates the investigation of a wide range of hydraulic engines and machines such as pumps, fans and water turbines.

All demonstration units in this range are equipped with electronic sensors for PC data acquisition.

In addition to the demonstration unit, the HM290 Turbine Service Unit, an Interface Module and a PC Data Acquisition Card with analysis software are required. This set-up permits the measured values to be displayed graphically and also facilitates the recording of characteristic curves.

Using the HM289 demonstration unit, the characteristic behaviour of a water turbine (impulse-type turbine) can be determined.

- Power as a function of volumetric flow rate, pressure and speed
- Recording of torque characteristic
- Determination of the turbine efficiency

The system is suitable for both practice-related training in vocational colleges and for laboratory experiments in technical colleges and universities.

The system is only intended to be used for training and experimental purposes.

HM 289   Pelton Turbine Demonstration Unit

2   Unit Description

In addition to the actual demonstration unit, termed experimental module in the following, a functional test stand includes an HM290 Turbine Service Unit, an Interface Module (HM280.01), a Data Acquisition Card with Software (HM280.03) and a Set of Connecting Cables (HM280.04). The HM290, HM280.01 - HM280.04 units are not included and must be ordered separately. They can also be used for other demonstration units in this series, e.g., HM288, 291 etc.

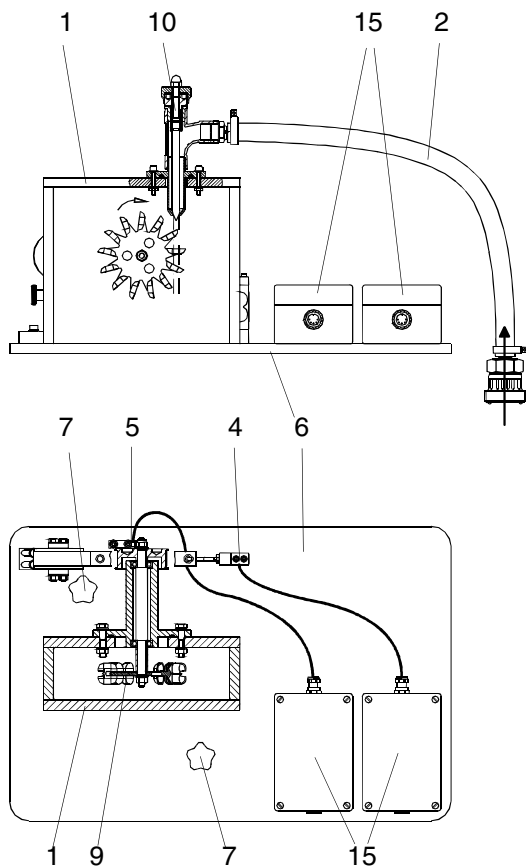### 2.1   Experimental Module

Fig. 2.1   Experimental Module Layout

The experimental module includes, in addition to the Pelton turbine (1) to be investigated, the water connecting pipe (2), a braking device with torque sensor (4) and a speed sensor (5). All components are fitted to a sturdy base plate (6) that is placed on the tank on the HM290 Turbine Service Unit and bolted in place using two bolts (7). Water is supplied via the Turbine Service Unit where the pressure and volumetric flow rate are also measured.

Specifically, the experimental module consists of the following components:

- Turbine (1) with transparent turbine housing and bolted bearing (8) for the wheel shaft (16). The water leaving the turbine passes through the open base in the housing direct to the Turbine Service Unit tank below. The over-hung-mounted wheel (9) is sprayed with the water jet from the needle jet (10). Using the jet needle, the jet cross-section and thus the water flow rate and power output of the turbine can be adjusted.

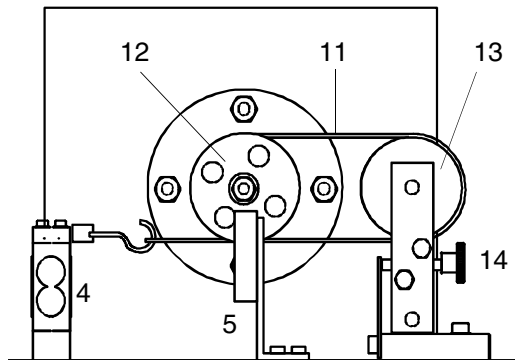# HM 289   Pelton Turbine Demonstration Unit

Fig. 2.3   Braking Device

- Braking device consisting of braking belt (11), belt pulley (12), guide roller (13) and tensioning bolt (14). The belt force is measured using a strain gauge (4). The speed is measured using an inductive proximity switch (5) on the front of the belt pulley.

- The signal processing electronics for the sensors are in splash protected housings (15) on the base plate. The connection to the Interface Module is made using 5-pole DIN connectors.
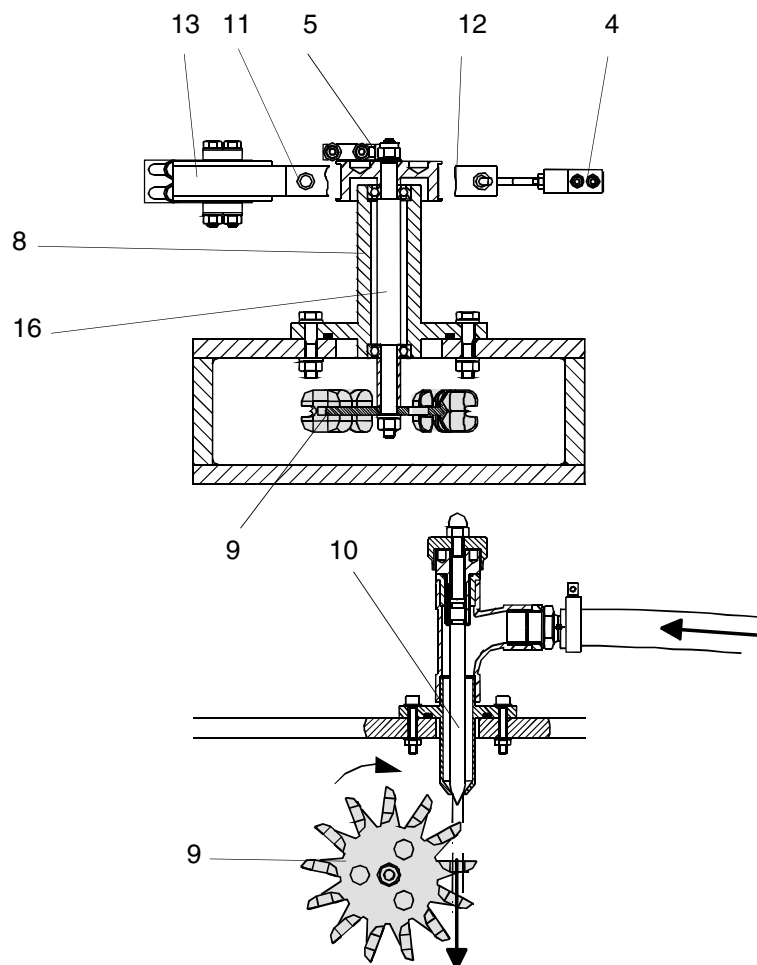

Fig. 2.2   Turbine

2.2   HM 280.01 Interface Module
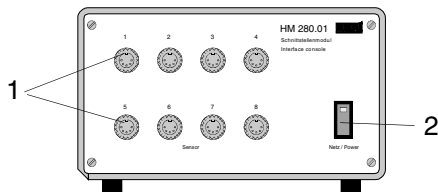

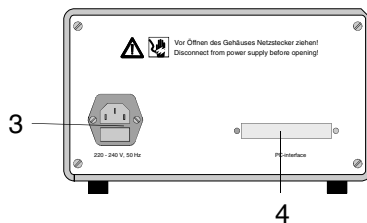Fig. 2.4   Front Panel

Fig. 2.5   Rear Panel

The Interface Module provides the power supply for the sensors and feeds the measured signals to the data acquisition card in the PC.

On the front panel of the Interface Module there are eight 5-pole sockets that are connected to the sensors using data cables. The sockets 1-8 (1) are for sensors with a voltage output of 0 - 5 V. Beside these it is also possible to connect TTL-based digital signals.

The pins on the sockets are assigned as follows:

- Pin 1:   +15 V

- Pin 2:   Analogue input(0 - 5 V)

- Pin 3:   Ground

- Pin 4:   Digital input (TTL)

- Pin 5:   -15 V

Also on the front panel of the module is an ON/OFF switch (2).

On the rear panel a mains connector with series fuse (3) is fitted, the module is supplied with 230V / 50 Hz via this connector.
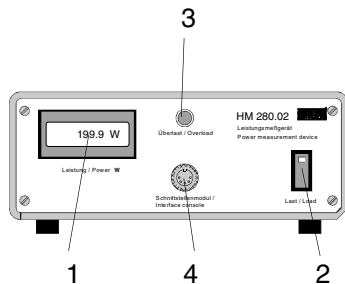A 50-pole socket (4) is used for data transfer to the PC.

HM 289   Pelton Turbine Demonstration Unit

2.3   HM280.02 Power Meter
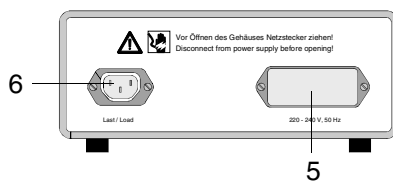

Fig. 2.6   Front Panel

Fig. 2.7   Rear Panel

ATTENTION

Whilst the Interface Module is imperative for the operation of the demonstration unit, the Power Meter is optional.

The following components are fitted to the front panel of the Power Meter:

-    Digital display (1) for displaying the power.

-    Master switch (2) for switching on and off the loads.

-    Red LED (3) for the indication of over range measurements.

-    5-pole socket (4) as analogue output (0 - 5 V).

The Power Meter is inserted in the mains cable to the demonstration unit. A unit is fitted to the rear panel that comprises a switch, connector and fuse (5), this is used for the supply from the mains (230V, 50Hz). The unit is then supplied via a socket (6).

ATTENTION!

Do not exceed the measuring range of max. 600 W

The analogue output signal is, as for the other sensor signals, connected to the HM280.01 Interface Module.

2.4   HM280.03 Data Acquisition Card

To be able to further process the measured data in a PC, it is necessary to install a Data Acquisition Card PCI-20428W-1 in the PC. This contains the necessary A/D converters and digital inputs. This card is inserted in a spare slot and requires the address 0320 HEX to be available in the computer. The Data Acquisition Card can process the following signals:

- $\pm$ 5 V
- $\pm$ 10 V (factory setting)
- 0 - 5 V
- 0 - 10 V

The card is preset in the factory. Further information on the multifunction card is contained in the handbook from Intelligent Instrumentation.

2.5   Analysis Software

The software is fully configured and is installed by the user on a PC. It is possible to select two screens on the monitor using a menu, these screens cover the following topics:

- Measured data and measuring points on the unit
- Recording of pump or fan curves
- Determination of the efficiency

Furthermore, the software provides the facility to store the measured data so that it can be processed in other programs (e.g. EXCEL).

The current screen can be printed out at the click of a button.

The analysis software is supplied with the HM280.03.

3 Safety and Operating Instructions

The unit left the factory in completely safe condition. To maintain the unit in this condition, and to ensure hazard-free operation, the following is to be observed:

HAZARD! Electric Shock

Before making any changes in the electrical circuits, unplug from the mains.

- Only have modifications and repairs to the electrical equipment carried out by qualified personnel.

- In case of visible defects (e.g. a cut in the insulation on the electrical cables), operation of the unit is **extremely dangerous**. The unit is then to be taken out of operation immediately.

- Do not bring the electrical parts into contact with water.

ATTENTION! Prior to placing the unit into operation, the students performing the experiment are to be briefed on its correct use.

- Only operate the unit in dry, closed rooms in which there are no flammable or caustic gases, vapours or dusts.

- The demonstration unit should not be placed into operation immediately after bringing moved from a cold room to a warm room. The condensation that could occur in this situation could irreparably damage the sensors fitted to the unit.

ATTENTION

- **The demonstration unit is only to be operated with pure wate.**
  Exception is made for the HM 286 Gear Pump. This Unit should be only used with Oil.

- Do not let the pump run dry!

- Do not connect external sources of power to the sensor sockets.

- Only connect the sensors using the cables provided for this task.

- Do not pull any tubes off the pressure sensors or measuring points, or swap them over, otherwise incorrect results will be displayed.

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4 Setting into Operation

4.1 Installing the Data Acquisition Card

The card should be installed in the PC as follows:

- Switch off PC and unplug from the mains.
- Open PC housing.
- Look for spare slot on the motherboard. (During this process ensure that the address 0320 HEX is not used in the computer.)
- Insert card and bolt in place.
- Close PC housing.

ATTENTION! It is imperative that static charging is prevented during the installation of the data acquisition card! Charging can be discharged by touching objects that are well earthed, e.g. radiators.

ATTENTION

4.2 Installation of the Software

The software is installed by the user on the PC. This is to be performed as follows:

- Switch on PC and start Windows.
- Insert first installation floppy disk in the drive.
- Open File Manager or Explorer under Windows
- Choose the drive that contains the installation floppy disk, e.g. A:.
- Look for the file install.exe and start by double-clicking.

Installation is then performed automatically. An icon is created in Windows, this is used to start the software.

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4.3   Setup and Connection of the Demonstration Unit

To use the demonstration unit, it is first connected to the Power Meter, if used, and to the Interface Module using the Set of Connecting Cables.

4.3.1   Connecting to the PC

Data transfer to the PC is performed using a ribbon cable that is inserted in a socket on the rear of the Interface Module. There is a corresponding socket on the Data Acquisition Card.
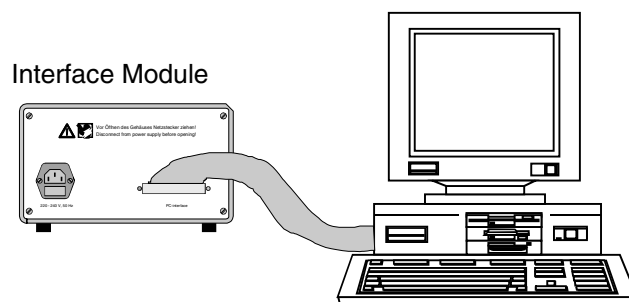
Interface Module

Fig. 4.1   Connection to PC

4.3.2   Connecting the Power Supply

The demonstration unit is supplied with power from the mains (230 V, 50 Hz).

The speed regulator (not on HM285/HM290) can also be supplied directly from the mains. However, it is then not possible to measure the power.

The following figure shows the connections.

Fig. 4.2   Mains Power Connection

HM 289   Pelton Turbine Demonstration Unit
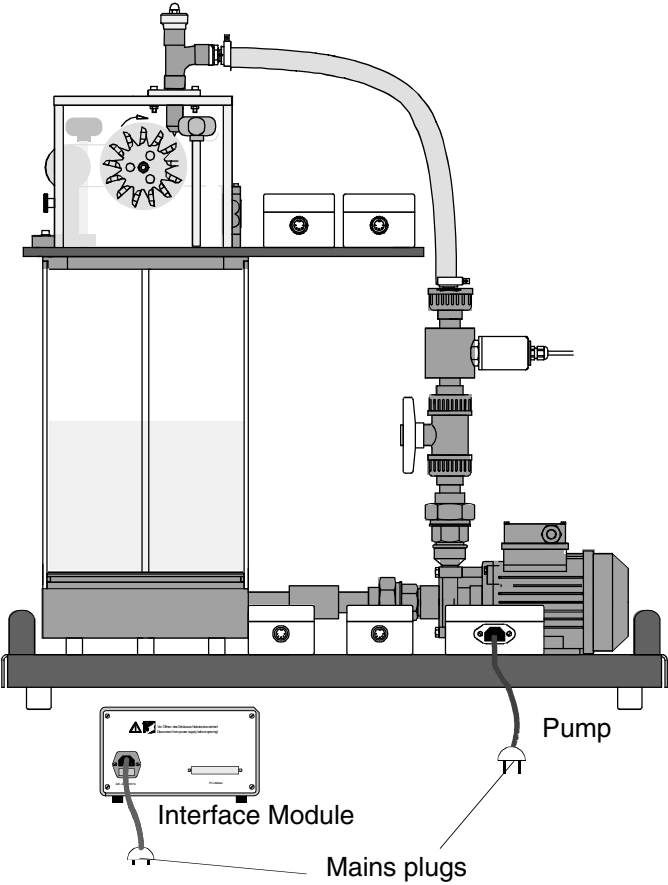
4.4   Connecting the Sensors

The connection between the transducers and the Interface Module is made using 5-pole cables. It should be noted that some transducers are on the HM290 Turbine Service Unit.

- Flow rate F1 (1) to sensor input 1 (HM290)

- Inlet pressure P1 (2) to sensor input 2 (HM290)

- Speed n1 (3) to sensor input 3 (HM289)

- Torque (4) to sensor input 4   (HM289)

- Power output of the pump (if fitted) (5) to sensor input 5 (HM280.02)

If the sensors are connected differently, incorrect measured values will be displayed.

4.5 Installation of the Turbine and Commissioning

Once the HM290 Turbine Service Unit has been placed on a flat surface, the components can be placed in operation in the following sequence:

- Fill supply tank with around 15 litres of clean water.

- Place HM289 turbine module on the tank and fix in place using two bolts. The overhanging part of the turbine module must point in the direction of the HM290 hose connection.

ATTENTION! Do not overtighten bolts, the base plate may distort and leak.

- Make hose connection using union nut.

- Switch on Interface Module.

- Switch on PC, start Windows and the runtime software for the HM280.03.
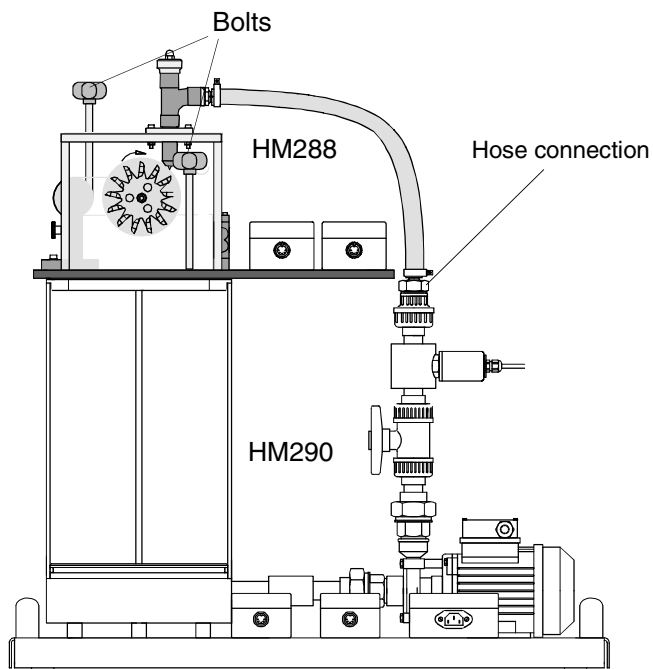

Fig. 4.3   Placing the Turbine Module on the Turbine Service Unit HM290

- Undo tensioning bolt on the braking device until the belt is no longer under tension.

- Switch on pump, open tap on Turbine Service Unit, check connections for leaks and run up turbine.

- Check whether plausible measured values are displayed. (Otherwise check sensor connections).

- Using the tensioning bolt, tension the belt and brake the turbine. Torque display on the PC should now increase.

5   Experiments

Start Windows and also start the analysis software with a double-click. For information on the operation of the software, please refer to the separate instructions for the HM280.03.

To display the current measured values, choose the **System Diagram** command on the menu.

The measured data can be saved in an ASCII file, HM289.AFD, and is then available for further processing in another program.

Each time the **Save Measurement** button is clicked from now on, the software appends a complete data record to the ASCII file opened previously. The data record consists of:

1. Time
2. Speed n in rpm
3. Mech. power P in W
4. Torque M in Ncm
5. Efficiency η in %
6. Volumetric flow rate F1 in l/h
7. Pressure p1 in bar
8. Hydr. power P_{hyd} in W
9. Elec. power P_{el} in W

The ASCII file is closed when **System Diagram** is left. The file can now be used for further processing, e.g. in a spreadsheet.

5.1   Recording Turbine Characteristic Curves

- Switch on Interface Module.

- Fully close regulating valve on HM290.

- Switch on pump HM290.

- Fully open HM290 regulating valve and set the required flow rate using the needle jet.

- Fully undo the turbine brake and record the first measured point without load. The turbine rotates at maximum speed.

- Increase load in small steps using tensioning bolt and record further measured points.

- Finally increase load to the point that the turbine locks. The characteristic curve is then fully recorded.

The turbine characteristic curve can be recorded again for other flow rates.

5.2   Measured Results

The measured results saved can be printed out.

The name of the student and the date can be added to the header on the print outs.

The following figure shows graphical output of the turbine characteristic curve.

Graphischer Meßdatenausdruck

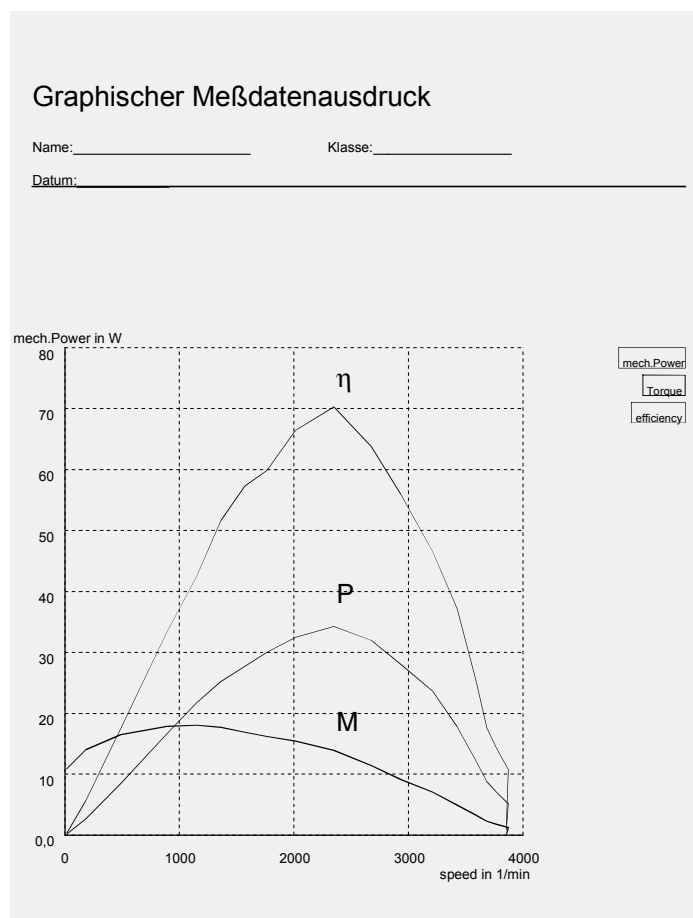Name:_____   Klasse:_____

Datum:_____

Fig. 5.1   Turbine Characteristic Curves

The torque curve (lower curve) drops, as is typical for a water turbine, with speed. The torque again drops at very low speeds due to the poor outlet flow of the water and the characteristic curve is not straight as per the theory, but is uneven. At zero torque the turbine reaches its no-load speed of

4000 rpm. The maximum torque of 18 Ncm is reached at around 1000 rpm.

The power output curve (middle curve) indicates the turbine's maximum power of 34 W at around 57% of the maximum speed.

At this speed, the turbine also achieves its maximum efficency (top curve) of 70%. At this speed the water leaves the wheel almost axially and the outlet loss reaches a minimum. The direction of the outlet of the water can be clearly observed due to the transparent housing.

Using the software, it is also possible to print out the measured results as tables of numerical values.

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6   Appendix

6.1   Technical Data

Dimensions

L x W x H:	450 x 300 x 300	mm
Weight :	approx. 20	kg

Supply

Water supply via HM290 Turbine Service Unit

Sensors are connected to the HM280.01 Interface Module.

Power Supply (HM290, HM280.01):

230 V,   50 Hz

Turbine

Type of Design:	Pelton turbine	
	Water inlet via needle jet	
Mean Wheel Diameter	70	mm
Number of Blades:	9	
Needle Jets	1	pc.
Nozzle Cross-Section:	¢5	mm
Speed Range:	0... 5000	rpm
Output Power Range:	0...30	W
Torque Range:	0...20	Ncm

Sensors

Speed

Measuring range:	0...10000	rpm
Output Signal:	0...5	V

Torque

Measuring Range:	0...50	Ncm
Output Signal:	0...5	V

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HM280.01 Interface Module

L x W x H	260 x 265 x 160	mm
Weight	5	kg
Sensor Connections	8	
Of which 7x	0...5	V
1x	TTL (counter)	
Sensor Power Supply:	± 15	V DC
Power Supply:	230 V,	50 Hz

HM280.02 Power Meter

L x W x H:	260 x 265 x 110	mm^3
Weight :	4	kg
Measuring Range:	0...600	W
Output Signal:	0...1.5	V
Power Supply:	230 V,	50 Hz

HM280.03 Data Acquisition Card

Analogue Inputs:	16 single / 8 diff	
Input Range:	±10	V
Analogue Outputs:	2	
Output Range:	±10	V
Digital Inputs:	8	TTL
Digital Outputs:	8	buffered TTL
Counter:	1, 16	bit TTL
Clock:	2, 16	MHz, TTL
Power supply via PC		

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