Characteristic Curve of a Pump

Fundamentals

Hydraulic pumps transform mechanical into hydraulic energy. They thus form the “heart” so to speak of the hydraulic system.
In choosing a pump for a particular application a range of aspects must be taken into account; these include flow rate, operating pressure, efficiency, speed range, viscosity of the hydraulic fluid and the controllability of system flow and/or pressure etc.
In addition to these aspects, the suitable pump for a particular application can be chosen from a number of different designs (e.g. gear pumps, vane pumps, radial piston pumps, axial piston pumps). The pump used in the hydraulic training unit is a gear type pump. This pump belongs to the family of fixed displacement pumps, i.e. the flow rate is constant at constant drive speeds. Information regarding the exact installed pump can be found in the trainer system handbook.
The output flow of the gear pump is produced by the rotation of the gear sets. The increasing volume in the chambers between the gear teeth is filled by the action of atmospheric pressure on the surface of the fluid in the reservoir. The fluid travels in this chamber until such a point that the volume is being reduced at the outlet side due to the gears coming back into mesh. At this point this decreasing volume forces the fluid out into the hydraulic system. Therefore fluid travels in the direction of the arrows from the inlet (suction) to the outlet (pressure) side. The actual flow characteristic curve falls slightly with increasing pressure. The reason for this fall in the flow rate is due to leakage at the clearances between the inlet and outlet sides.

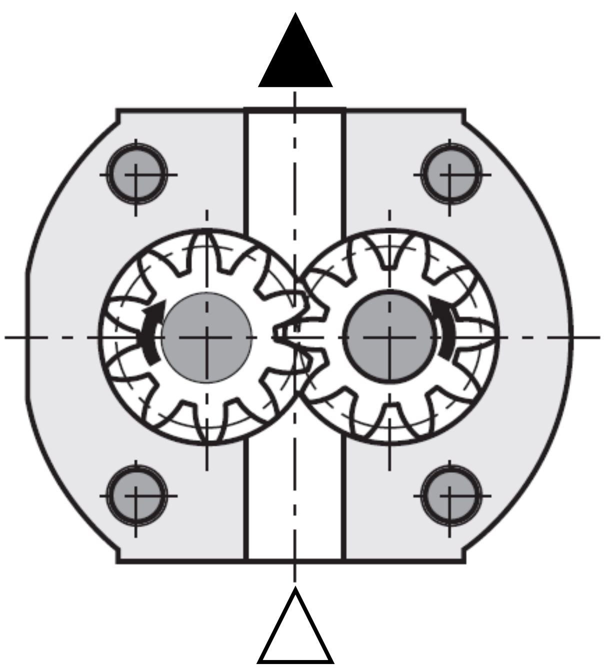


Fig. 1 Gear pump with external gearing

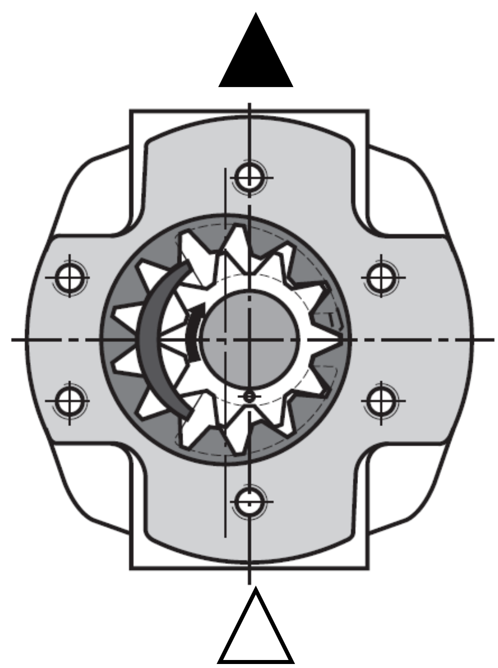


Fig. 2 Gear pump with internal gearing

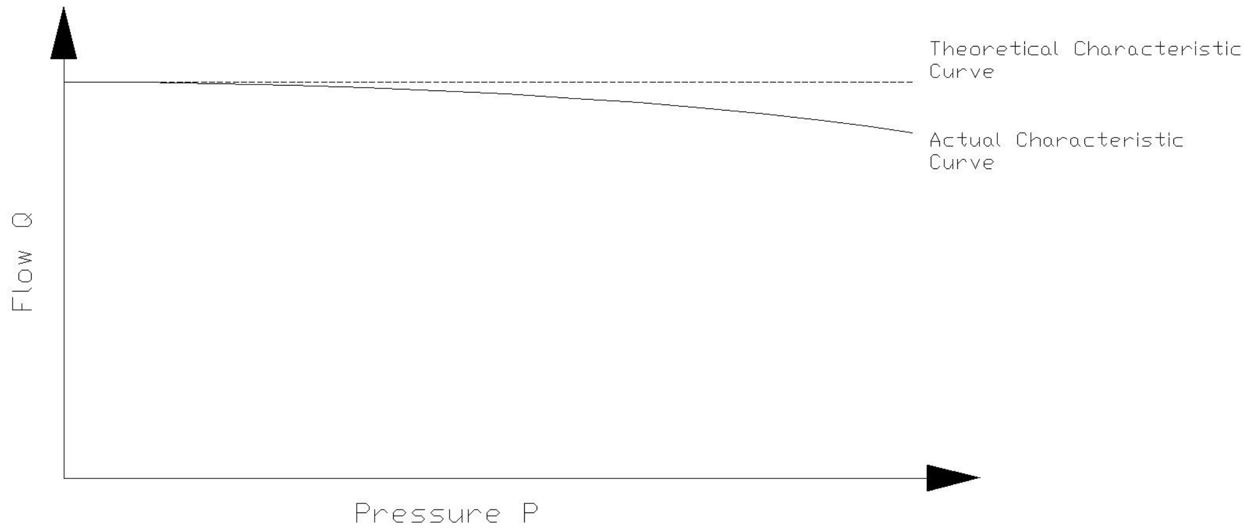
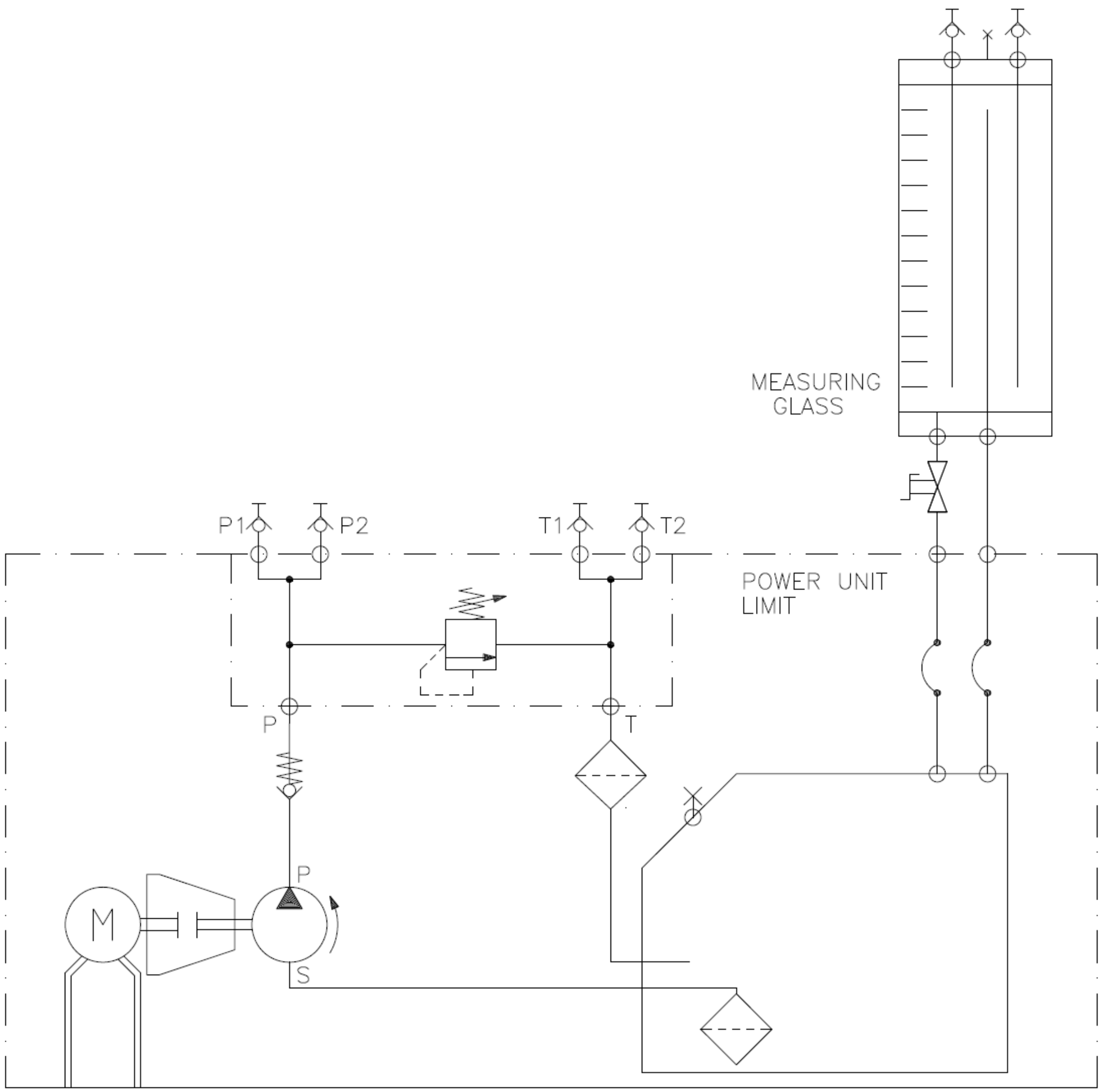
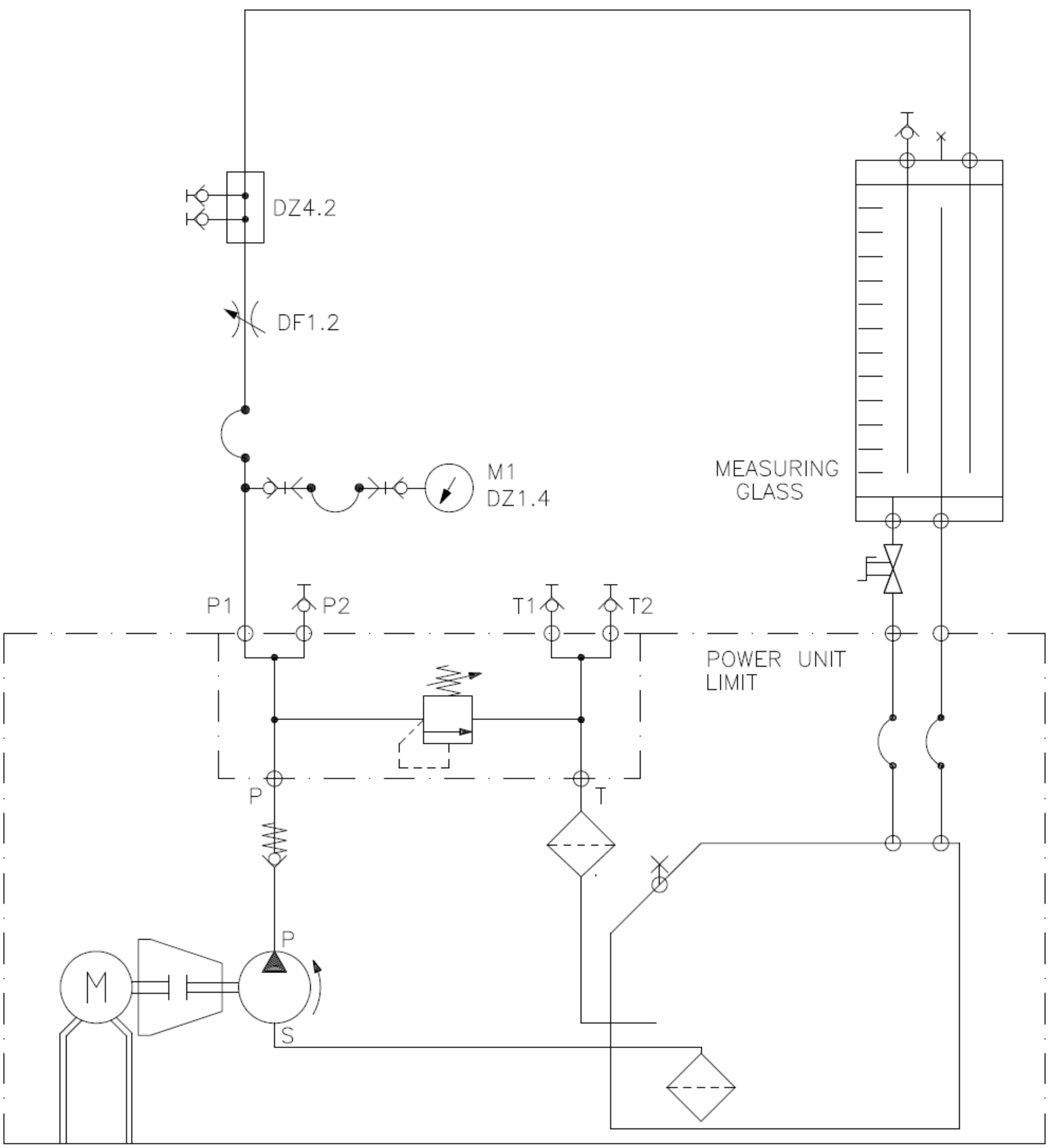


Fig. 3 Characteristic curve of a gear pump

Description of experiment
In this experiment you will determine the characteristic curve of the fixed displacement pump used in the hydraulic trainer. You will adjust the resistance to flow thereby increasing the pressure at the outlet of the pump. As a variable hydraulic resistance you can utilize a throttle valve and you can thus measure the flow characteristic curve at several points.

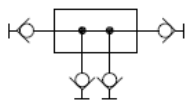
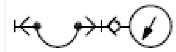
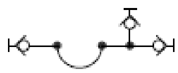
Description of exercise
Work out a circuit with which the characteristic curve of the pump can be measured and sketch it on the following page. Hint: To control the flow rate and cause a resistance at the pump outlet you will need a throttle valve, to read the pressure you require a pressure gauge. The flow rate is measured with the measuring glass and stopwatch.


MEASURING
GLASS
P1
P2
T1
T2
POWER UNIT
LIMIT
P
T
P
M
S



DZ4.2
DF1.2
M1
DZ1.4
MEASURING
GLASS
P1
P2
T1
T2
POWER UNIT
LIMIT
P
T
M
P
S

Preparation of experiment
Have the following equipment on hand:

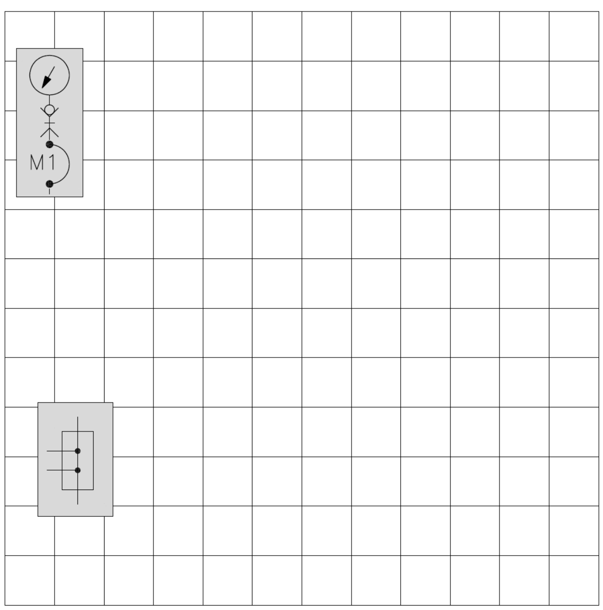
1x	Connection piece DZ4.2		1x	Pressure gauge DZ1.4	
2x	Pressure hose c/w gauge connection		1x	Throttle valve DF1.2	

Pressure hoses
Stopwatch

Before beginning the experiment read the **Rules for hydraulic trainer operation** sheet.

Setting up the experiment
Mount the individual units on the training stand grid and interconnect them according to the hydraulic schematic

Layout



Experimental procedure
Steps in the experimental procedure:
1. Has your instructor checked the constructed circuit?
2. Check again that all connection hoses are firmly coupled. (pull/turn to test)
3. Ensure the red E-STOP button is not engaged on either of the starters. (rotate the button to reset)
4. Open the drain valve on the bottom of the measuring glass
5. Open throttle valve DF1.2 completely
6. Switch on the pump via the green START push button.

Experiment
We will use the throttle valve to create a pressure at the pump outlet and then measure the flow at various pressure levels.

a) With the throttle valve fully open measure the pressure at the pressure gauge and the time it takes to fill 1 litre of oil into the measuring glass. i.e. Close the shut-off valve on the measuring glass and measure the time between oil level readings of 1 litre and 2 litre.
b) Enter the pressure measured time in the table in the column marked throttle “OPEN”
c) Switch off the pump via the red STOP push button and drain the measuring glass by opening the shut-off valve. When the measuring glass is empty, close the shut-off valve again.
d) Re-start the pump and begin closing off throttle valve DF 1.2 until a pressure of 15 bar can be read at pressure gauge.
e) Measure the time it takes to fill 1 litre of oil into the measuring glass. i.e. Close the shut-off valve on the measuring glass and measure the time between oil level readings of 1 litre and 2 litre.
f) Enter the measured time in the table
g) Switch off the pump via the red STOP push button and drain the measuring glass by opening the shut-off valve. When the measuring glass is empty, close the shut-off valve again.
h) Continue the experiment according to the table, following the exact procedure described under d).
i) Switch off the pump.
j) Conventionally the flow rate is given as litre per minute (l/m). We will also follow this convention. We can calculate this flow rate using the following formula.

$$Q = \frac{\text{volume (1litre)}}{\text{measured time (sec)}} \text{ x } \frac{\text{60 seconds}}{\text{1 minute}}$$

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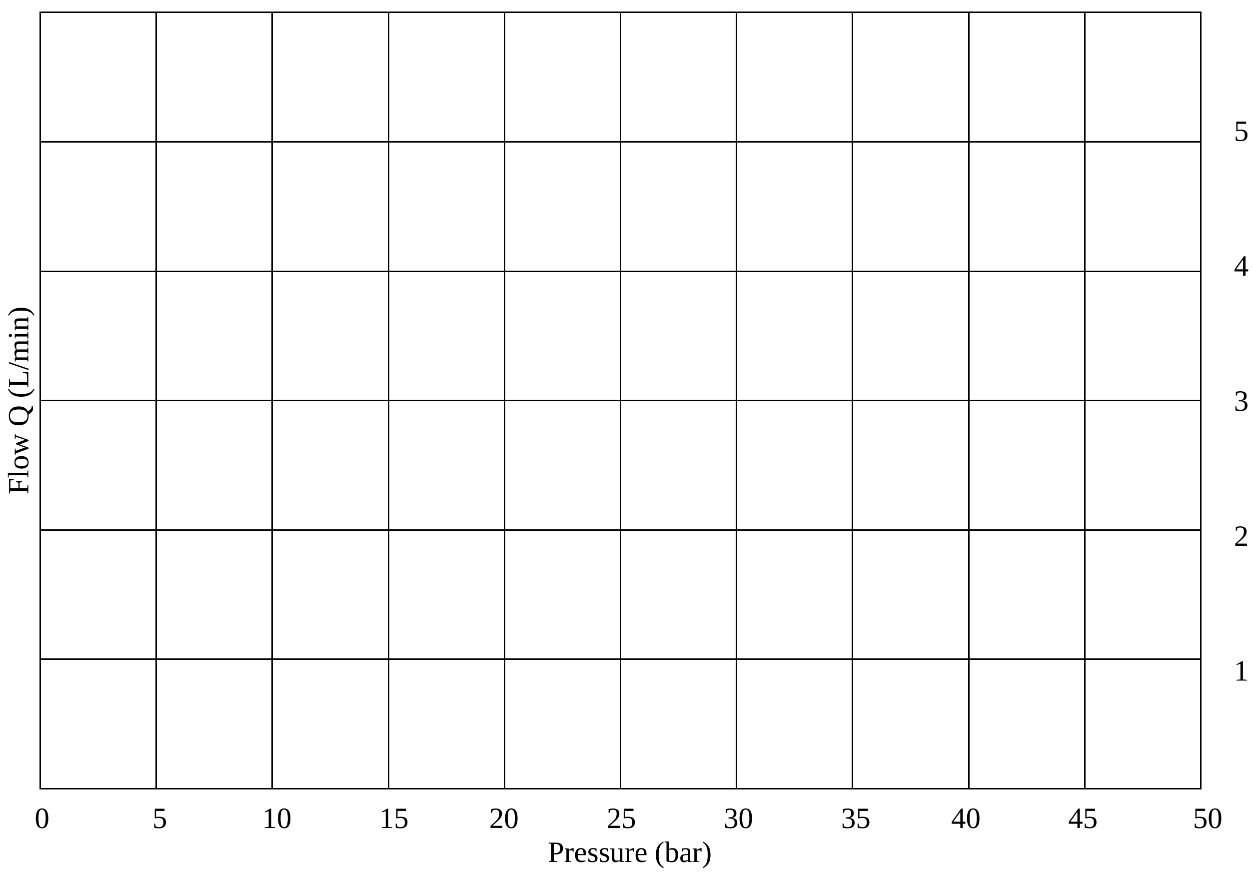
$$Q = \frac{60}{\text{measured time (sec)}}$$

Evaluation

Throttle open | Throttle closed

Pressure (p) bar		**15**	**20**	**25**	**30**	**35**	**40**	**45**	**47.5**	**50**	
Volume (V) litre	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Time (t) second											
Flow (Q) l/min											

Table 1



Characteristic curve

Explanation of experimental results

If you compare the curve that you have drawn with that shown in fig. 3, a much steeper drop off can be seen in your curve. The explanation can be found in the fact that a pressure relief valve adjusted to 50 bar (725 PSI) is connected downstream of the gear pump of the trainer in order to limit the maximum possible pressure. At a pressure of almost 50 bar a part of the flow passes through the pressure relief valve and into the tank. In this range, the characteristic curves of the pump and the pressure relief valve are superimposed.

A pressure relief valve is required because of the mode of operation of the gear pump:

The gear pump always delivers the same flow. Without a pressure safeguard, the pressure would either increase beyond the loading limits of the material or the motor control would cut out due to overloading of the drive motor. Another cause of the drop-off of the characteristic curve could possibly be a fall in the speed of the drive motor at high loads (pressure).

Conclusions

I. The smaller the area opening of a throttle valve the greater the increase in

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II. The physical quantities of _____________ and __________________ can be controlled using a throttle valve.

III. The gear pump is a ______________________________

This type of pump practically always delivers a ______________________________

IV. Name three types of pumps.

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