Pneumatics and Hydraulics

Pneumatic actuators part 3

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Outline

- Air consumption
- Pneumatic motors

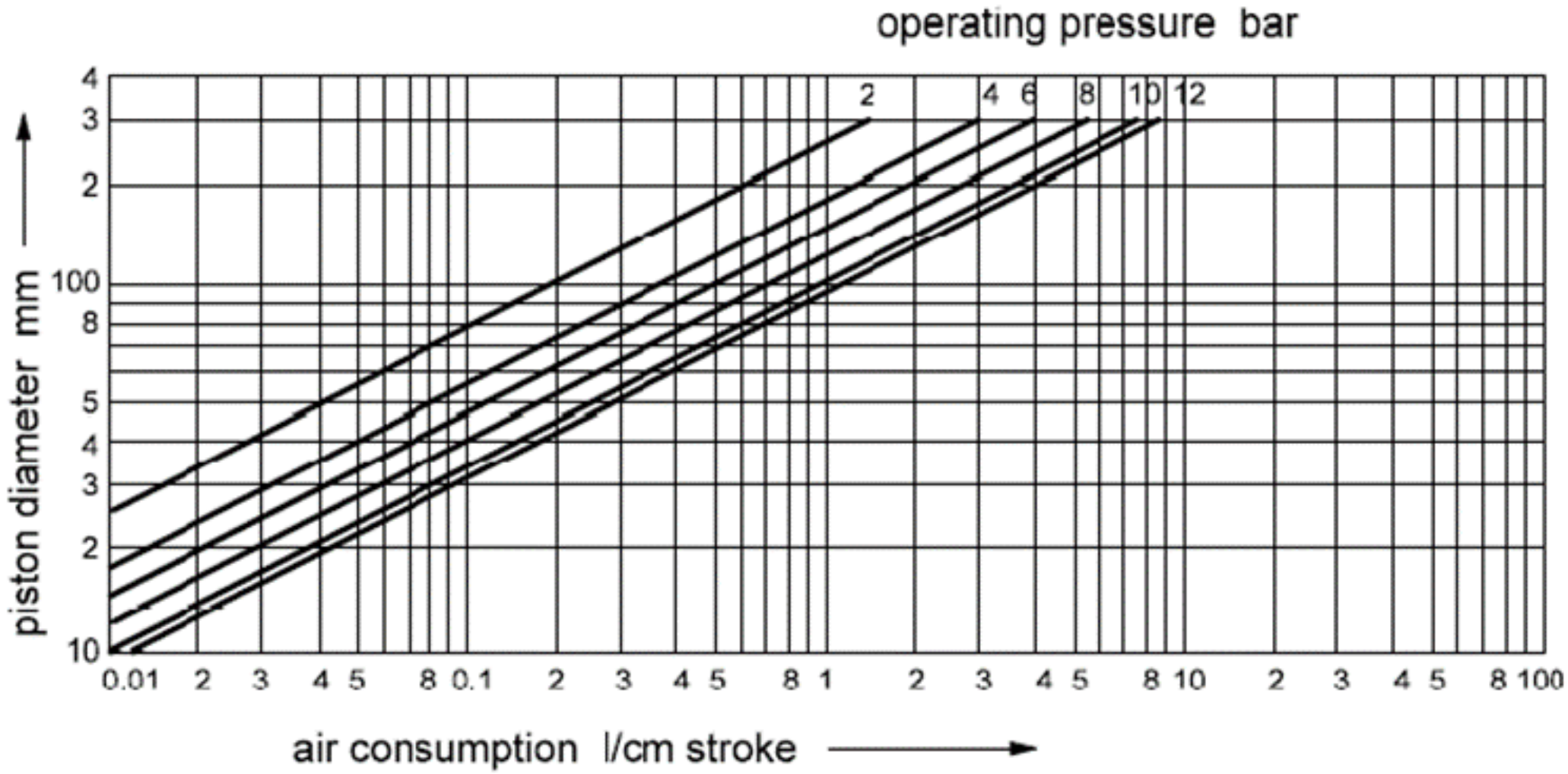
Air consumption

- For the preparation of the air, and to obtain facts concerning power costs, it is important to know the air consumption of the system.
- The air consumption is specified in liters of air drawn in per minute.
- For a particular operating pressure, piston diameter, stroke and stroke number, the air consumption is calculated by:

$$\text{Air consumption} = \text{Compression ratio} \bullet \text{Piston surface} \bullet \text{Stroke} \bullet \text{Stroke number per minute}$$

$$\text{Compression ratio} = \frac{101.3 + \text{Operating pressure (in kPa)}}{101.3}$$

Air consumption



Air consumption

The formulae for the calculation of air consumption in accordance with the air consumption diagram are as follows:

for single-acting cylinders

$q_B = s \bullet n \bullet q_H$

for double-acting cylinders

$q_B = 2 \bullet s \bullet n \bullet q_H$

q_B = Air consumption (l/min)
s = Stroke (cm)
n = Number of strokes per minute (1/min)
q_H = Air consumption per cm of stroke (l/cm)

Air consumption

Piston diameter in mm	*Cover side in cm^3*	*Base side in cm^3*
12	1	0.5
16	1	1.2
25	5	6
35	10	13
50	16	19

Piston diameter in mm	*Cover side in cm^3*	*Base side in cm^3*
70	27	31
100	80	88
140	128	150
200	425	448
250	2005	2337

Pneumatic motors

- Devices which transform pneumatic energy into mechanical rotary movement with the possibility of continuous motion are known as pneumatic motors.
- The pneumatic motor with unlimited angle of rotation has become one of the most widely used working elements operating on compressed air.
- The Pneumatic motor constructions is similar to hydraulic motors with some variation in size and shape, and the equations for determining the output torque and power for pneumatic motor are the same for hydraulic motors. However, because of the air compressibility, the accuracy of these equations is not as good for pneumatic motor as for hydraulic motors.

Pneumatic motors

Pneumatic motors are positive displacement units, so when a pressure differential is created within a pneumatic motor, the higher pressure air expands. This expanding air acts upon the internal surfaces of the motor to cause the motor output shaft to turn.

Pneumatic motors

Characteristics of pneumatic motors are:

- Smooth regulation of speed and torque.
- Simple design and construction.
- Small size (weight).
- Overload safe.
- Insensitive to dust, water, heat, cold.
- Explosion proof.
- Large speed selection.
- Maintenance minimal.
- Direction of rotation easily reversed.

Pneumatic motors

- Disadvantages of pneumatic motors are:
  - Low efficiency.
  - Higher noise level.
  - High speed drop.

Pneumatic motors

Pneumatic motors are categorized according to design:

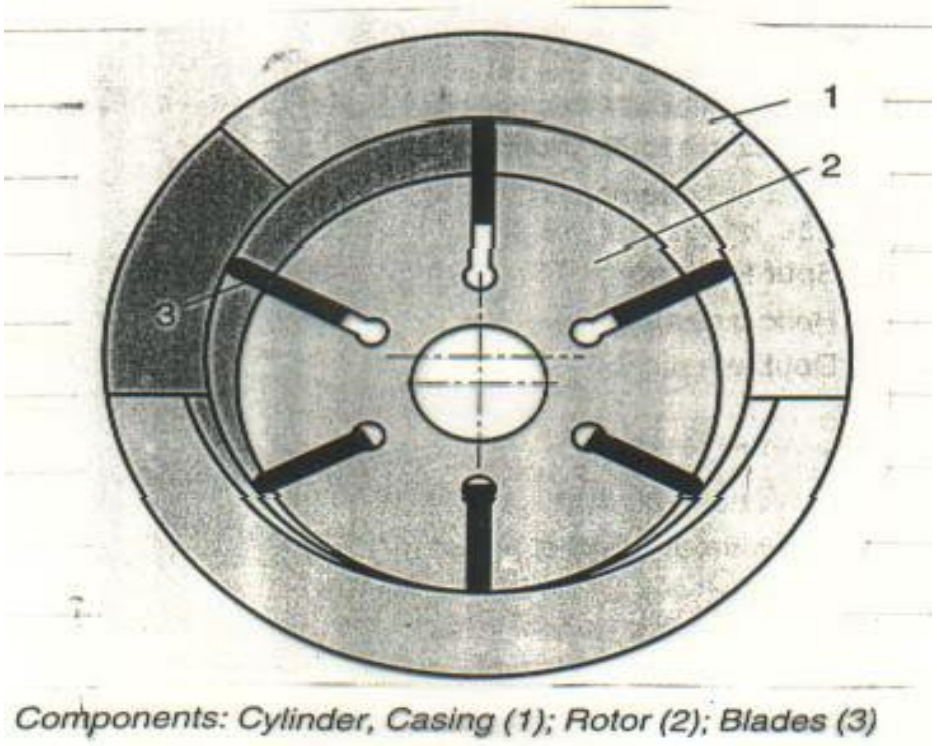
- Sliding-vane motors.
- Piston motors.
- Gear motors.
- Turbines (high flow).

Sliding vane motors

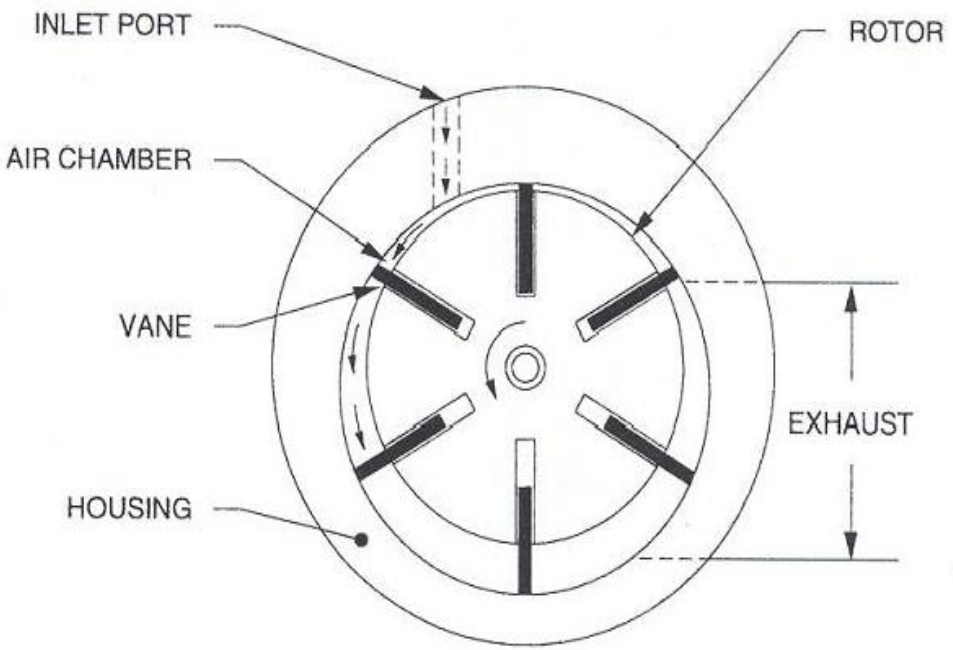
Constructions:

- Rotor.
- Motor Case.
- Blades (Vanes).
  - An ***eccentric*** rotor is contained in bearings in a cylindrical chamber.
  - Slots are arranged in the rotor.
  - The vanes are guided in the slots of the rotor and forced outwards against the inner wall of the cylinder by centrifugal force.
  - With other designs, the vanes are moved via springs. This ensures that the individual chambers are sealed.

Sliding vane motors



Components: Cylinder, Casing (1); Rotor (2); Blades (3)



Sliding vane motors

2- ***principle of operation:***

As compressed air enters the inlet port, it expands inside one of the air champers between two vanes. The rotor turns to create an increasing volume between the vanes to accommodate the expanding air. when air reaches the outlet side of the motor, it is expelled into the atmosphere through the exhaust port.

3- ***Characteristics:***

- Simple construction.
- Good weight to power ratio.

  (1Kg motor has 0.37 KW power)
- Clockwise or anticlockwise units are available.
- Power range 0.1 - 17 kW (0.14 - 24 hp).
- Rotor speed is between 1000 and 50000 rpm.
- Starting torque = 0.75 stopping torque.

Sliding vane motors

4- ***Disadvantages:***

- Low efficiency
- Not smooth rotation.
- High speed drop.

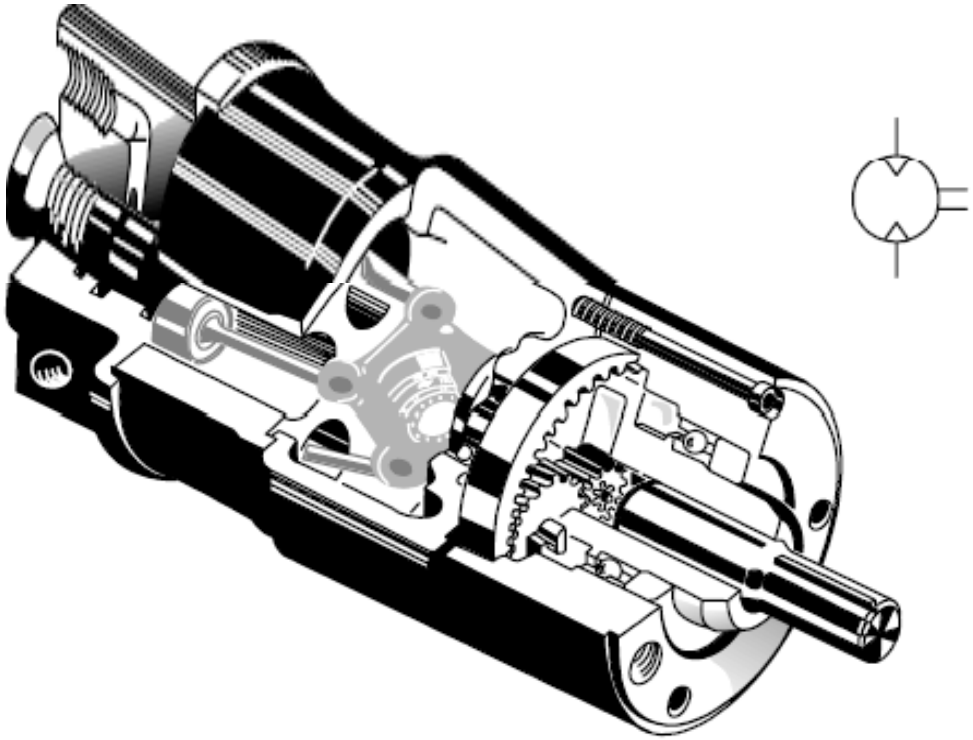
5- ***Applications:***

- Hand tools:
  - Drills.
  - Grinders.
  - Impact wrenches.
- Mixers.

Piston motors

- This type of design is further subdivided into:
- Axial piston motors.
- Radial piston motors.

Axial piston motors



- ***1- <u>Constructions:</u>***
  - Reciprocating pistons.
  - Connecting rods.
  - Swash plate.
  - Valve plate.
  - Gears and driving shaft.

•The cylinder block and the drive shaft are located on the same center line (Axial). Usually, this motor design contain 5 Reciprocating pistons or more (the number of reciprocating pistons should be odd).

Axial piston motors

principle of operation:

The output shaft of the motor is driven by the compressed air via reciprocating pistons and connecting rods. The force from 5 axially arranged cylinders is converted into a rotary motion via a swash plate. Compressed air is applied to two pistons simultaneously via a valve plate. To ensure smooth running several pistons are required. The power of the motor depends on input pressure, number of pistons, piston area, stroke and piston speed.

3- ***Characteristics:***

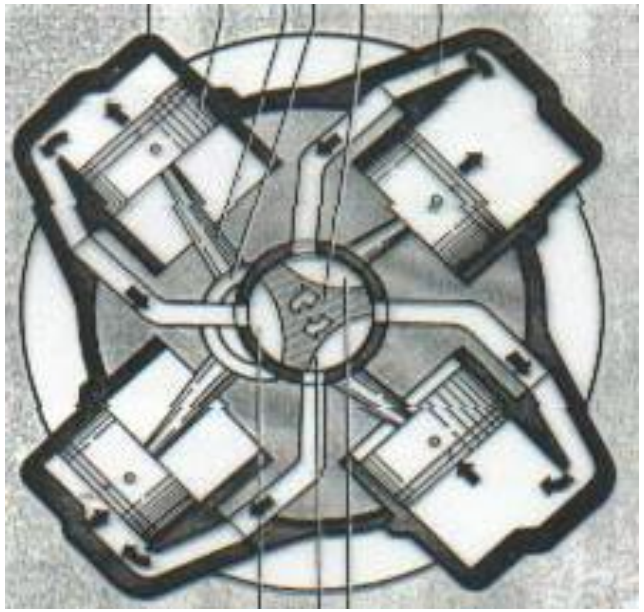
- Smooth running (even at low speed).
- High efficiency (more then vane type)
- Good speed regulation.
- Clockwise or anticlockwise units are available.
- Power range 1.5 - 4 kW.
- Rotor maximum speed is 5000 rpm.
- Starting torque = 0.5 stopping torque.

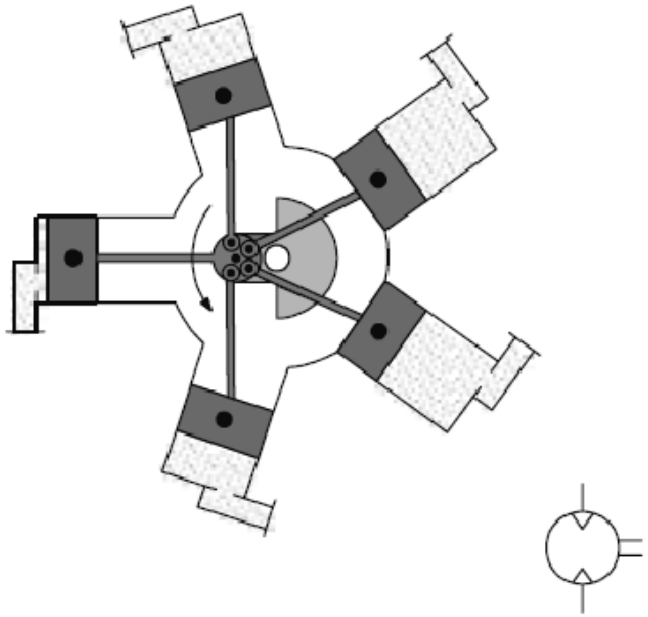
4- ***Disadvantages:***

- Low speeds (lower than vane type).
- Low torques.

Radial piston motors

- ***1- <u>Constructions:</u>***
  - Reciprocating pistons.
  - Connecting rods.
  - Crank shaft.
  - Rotary sliding Valve.





- The pistons movement are perpendicular to the crank shaft (Radial). Usually, this motor design contain 4 to 6 reciprocating pistons.

Radial piston motors

- 2- ***principle of operation:***

  •The output shaft of the motor is driven by the compressed air via reciprocating pistons and connecting rods. The force from 4 radially arranged cylinders is converted into a rotary motion via a crank shaft. Compressed air is applied to the pistons via a rotary sliding valve. The power of the motor depends on input pressure, number of pistons, piston area, stroke and piston speed.

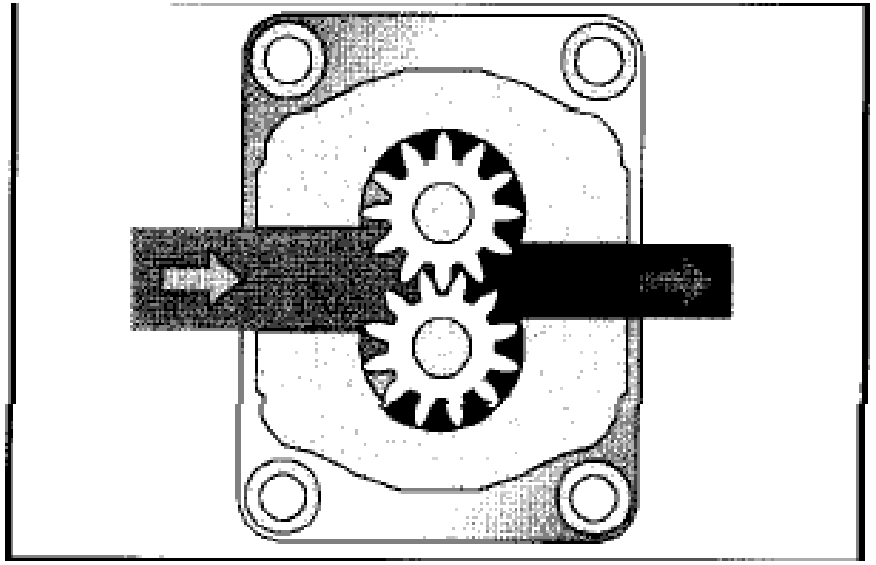
Radial piston motors

- 3- ***Characteristics:***
- Smooth running (even at low speed).
- High efficiency (more then vane type)
- Good speed regulation.
- High output power (more than vane and Axial types)
- Clockwise or anticlockwise units are available.
- Power range 1.5 - 19 kW.
- Rotor maximum speed is 5000 rpm.
- High starting torque (Starting torque = 0.5 stopping torque).

- 4- ***Disadvantages:***
- Low speeds (lower than vane type).
- Bulky

Gear motors

- In this design, torque is generated by the pressure of the air against the teeth profiles of two meshed gear wheels.
- One of the gear wheels is secured to the motor shaft.
- Gear motors are produced with spur or helical gearing.
- These gear motors are used in applications with a very high power rating (up to 44 kW/60 hp).
- The direction of rotation is also reversible for these motors.



Turbines (flow motors)

- Turbine motors can be used only where a low power is required. The speed range is very high.

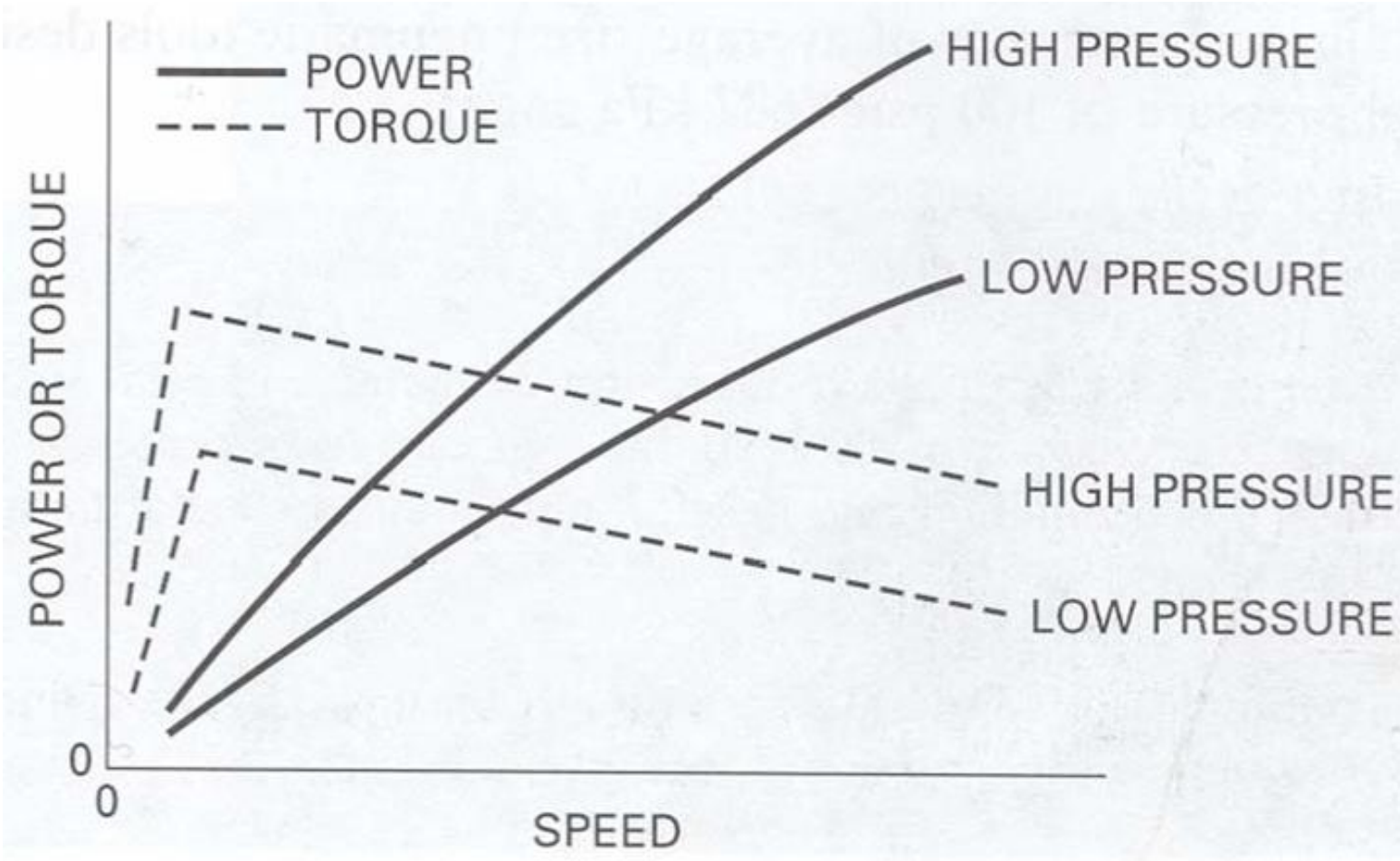
- For example, the Dentist's air drill operates at 500,000 rpm. The working principle is the reverse of the flow compressor. The direction cannot be reversible.

Motors performance characteristics

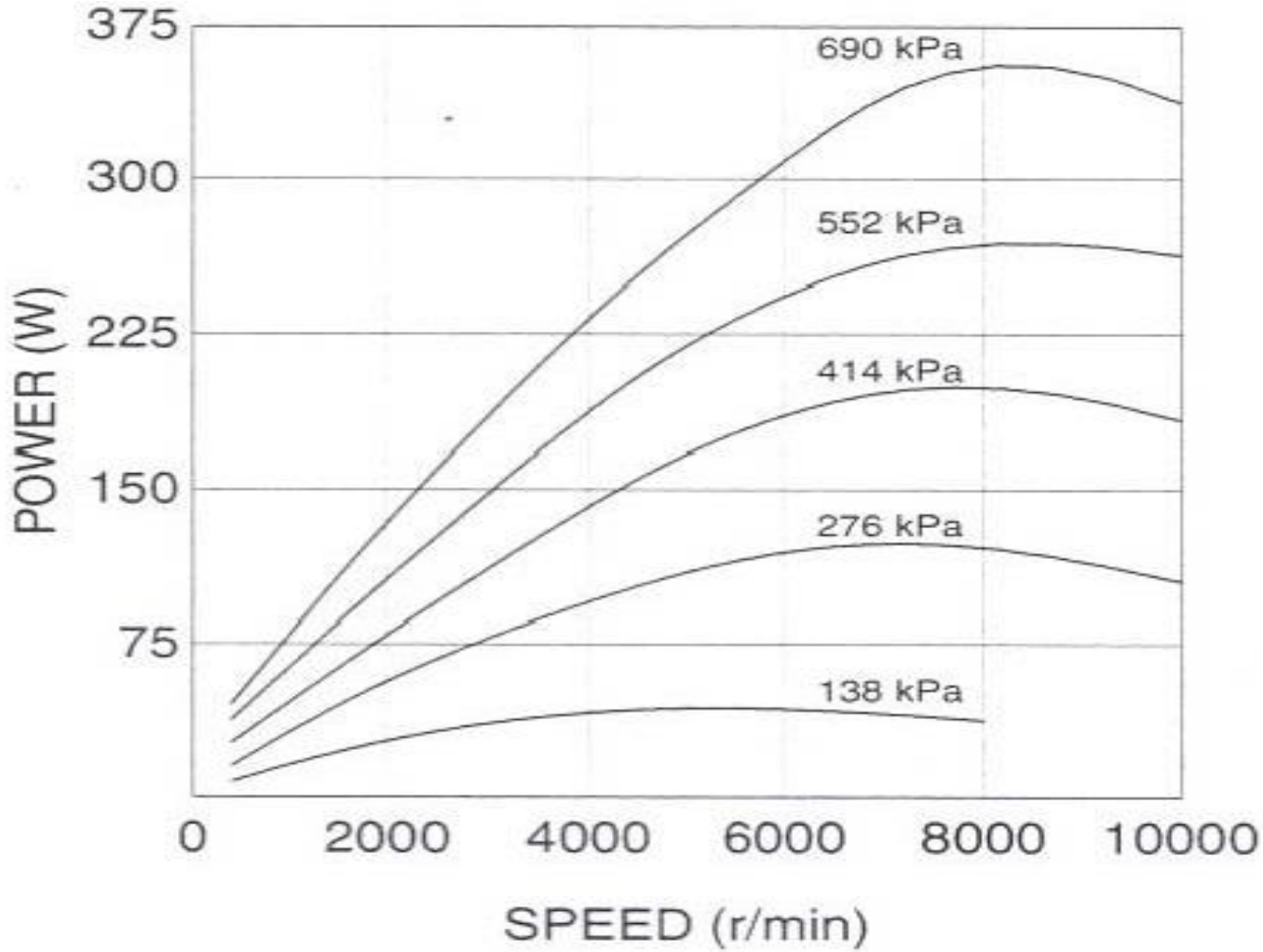
•Motors performance characteristics can be determined **theoretically** or by the use of **manufacturer's data**. Both methods are acceptable, but in general the manufacturer's data is more relevant to a particular design and application.

- Motor speed.
- Motor power.
- Motor Torque (starting and stopping torque)
- Air consumption.
- Motor service life, size, weight and noise.
- Motor mounting, operating and service cost

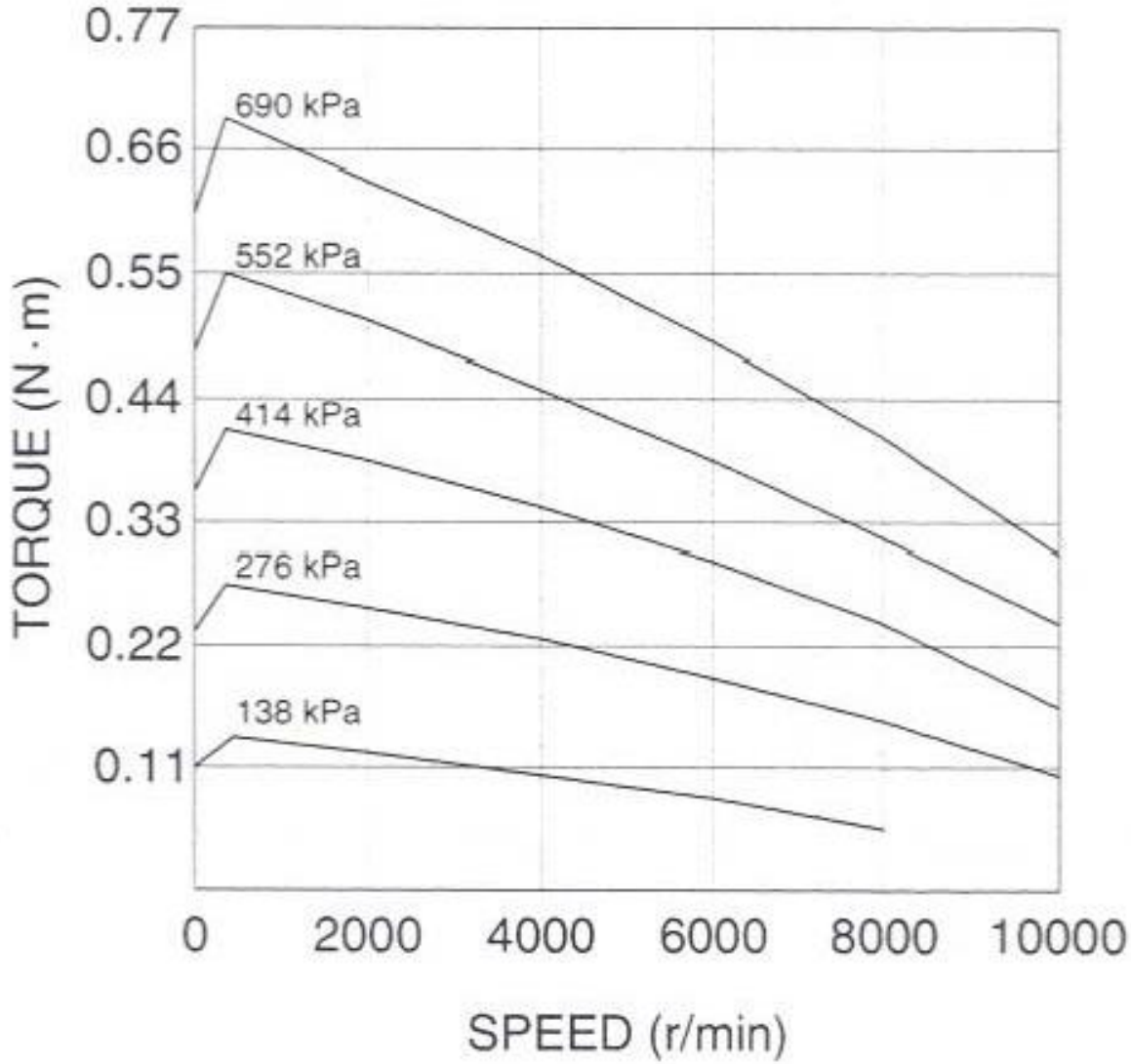
Motors performance characteristics



Motors performance characteristics



Motors performance characteristics



Motors performance characteristics