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About Medical Gear Pumps

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ABSTRACT

This work on basis of literary studies and analysis of the author are examined the principle of action and some characteristics of the medical gear pump. Below are shown the ways to determine the basic parameters of these dispensers. There have been some experimental studies on these characteristics.
Keywords: Gear pump, Dispenser

I. INTRODUCTION

Volumetric pumps work on the so-called volumetric principle of action in which liquid is sucked from the workspace due to the change in volume. Suction and pressure spaces are hermetically sealed by means of valves, plates, gates, distributors, etc. [2].

In volumetric pumps, the energy of the liquid increases by varying the volume of the working chambers of the pump. When changing the working volume, a certain compressive force is transmitted directly to the fluid from a piston, plate or other workpiece. The magnitude of the force acting on the operating element is determined by the pressure that the liquid in the working chamber must have. This pressure, in turn, depends on the resistances that must overcome the liquid to the point of its intended use, and the pressure it must have there.

Depending on the principle of working, the volumetric pumps are divided into piston and rotary pumps.

In the piston pumps, the liquid is transferred from a stationary chamber as a result of a reciprocating motion of a piston, a membrane, and etc.

In the case of rotary pumps, the liquid is transferred from the working chambers as a result of rotational or reciprocating movement.

Volumetric pumps can be considered as volume dispensers for liquids in which a certain flow rate is provided by a specified dosing accuracy [1]. They are equipped with a drive mechanism that allows the flow to be regulated over a wide range of specialized dosing systems as well as other technical systems using hydrostation [2]. The main types of displacement pumps, which are used in various technical installations and systems [2], [6] are: piston, vane, bellows, gear, diaphragm, infusion (by syringe) and peristaltic.

The gear pump has a simple design, low weight and gauge, and works for a long time with high reliability. It provides a non-pulsating flow in case gears with inclined teeth are used. The gear pump operates under and overpressure.

Gear pumps have the following advantages:

- ✓ simple construction;
- ✓ easy to manufacture and exploit;
- ✓ compact size and mass;
- ✓ long durability;
- ✓ high reliability;
- ✓ interchangeable gears that are with low cost;
- ✓ no gasket between the motor and the pump head;
- ✓ pump system is low probability of breakthroughs;
- ✓ application for aggressive substances, clean substances (blood, drugs and etc);
- ✓ reduced pulses at high pressures.

II. STRUCTURE AND PRINCIPLE OF GEAR PUMPS

A summary block diagram of a medical gear pump is shown in Figure 1. The pump is driven by an electric motor (M). The rotary motion of the electric motor is fed to a transmission mechanism (TM) that reduces and transmits this movement to pump head (PH).

Figure 1. Summary block diagram of a medical gear pump

Gear pump which is shown in Figure 2 comprises a pair of gears with a small number of teeth, placed in a special housing providing a seal of the sprockets diametrically laterally [2]. In this housing there are two holes for bringing and removing the liquid. One of the gears is a leading one and receives movement from an electric or other motor and the other is driven (driven).

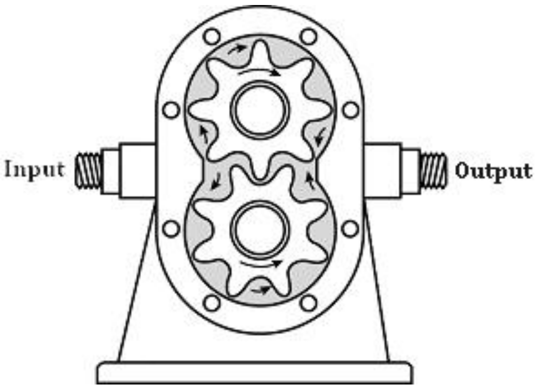

Figure 2. Principle of working of gear pump

Upon rotation of the pinion is provided a rotation and of the driven, but in the opposite direction. The engagement of the wheels and the sealing of the same in the casing (s) sideways and legally provides sealing between the suction and discharge sides of the pump. Upon rotation of the upper gear of Figure 2, clockwise, will carry liquid by gullets on both wheels of the suction side (Input) on the pressure side (Output) as shown in the figure.

The possibility of good engagement, good compaction of the gears and the absence of inertial forces allow the speed and pressure to reach high values.

If the movement of the motor passes through a magnetic coupling, sealing may occur where the probability of breakthrough is small (Figure 3) [2]. Such constructs find a great application in medicine, for example, in the hemodialysis, pumps having such a device for transporting the dialysis fluid are used.

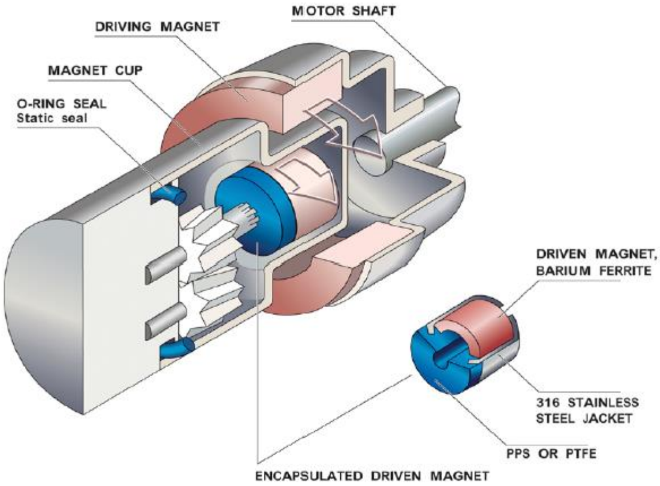

Figure 3. Structure of gear pump with non-contact drive

The clutch is used to provide patient safety as other types of connectors are likely to flow through the salt solution pumped through the system and are a very strong electrolyte. The magnet coupling also has other advantages:

- ✓ ability to work at low and high temperatures;
- ✓ work at high pressure and vacuum;
- ✓ high efficiency;
- ✓ Absence of wear and tear;
- ✓ reduced noise and vibrations;
- ✓ transmitting energy in hermetically sealed volumes without seals, through thin-walled metal screens;
- ✓ high reliability;
- ✓ safe operation.

These advantages provide the application of the magnetic coupling at:

- ✓ life processes for which perforation or contamination of the product is unacceptable (for example: medical devices for renal dialysis, blood analyzers, temperature control systems, etc.);
- ✓ dealing with toxic materials, pharmaceuticals and other high-sensitivity products.

III. EXPERIMENTAL STAND

The scheme of the experimental stand is shown in Figure 4 [4]. Water is used as a liquid for experiments, as it has the closest indicators, particularly viscosity and density, to liquids that are transported in medicine and is also most readily available. The liquid is located in the bathtub 1, which is scaled to volume units. The two pumps to which the characteristics are measured are given in the diagrams 3 and 4. The pressure is measured by the vacuum meter 2 and the overpressure by the pressure gauge 6. The flow rate of the pumps is measured with the flowmeter 5 which has a digital output and it is connected to the computer 7. In this way, the instantaneous flow rate is recorded on the flow meter display 5 and the pulsations through the computer 7 with an oscilloscope program. With the help of the valves 8 and 9 we switch the two pumps to work separately or together in a counter phase.

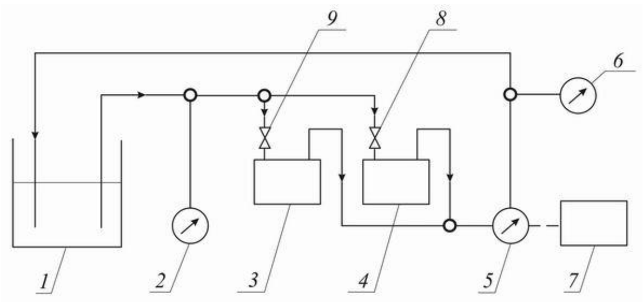

Figure 4. Scheme of experimental stand

IV. EXPERIMENTAL RESULTS

The characteristics of the gear pumps is calculated by the following equations [2], [5]:

-The work volume will be:

$$q = 6{,}5.m_n^2.b(z+1) \ ,$$

where m_n is the normal module of the teeth of the gear wheels;

b - the width of the gears;

z - number of teeth of gears.

-The effective flow rate of the pump is:

$$Q_T = q.n.\eta_v \ ,$$

where n is rotational speed;

η_v – volumetric efficiency (η_v =0,98)

The results of the conducted experiments are given in Table 1, and the graphical representation of the characteristics is shown in Figure 5.

Table 1. Results from experiments

Gear Pump	Q_T (ml/min)	Q_m (ml/min)	$\Delta=Q_m-Q_T$	δ=□/Q_T,%	z	m_n (mm)	b (mm)	q (mm^3)	n (rpm)
1	0,95	0,92	-0,03	-3,56	12	1,2	20	2433,6	400
1	1,91	1,86	-0,05	-2,51	12	1,2	20	2433,6	800
1	2,86	2,81	-0,05	-1,81	12	1,2	20	2433,6	1200
1	3,82	3,76	-0,06	-1,46	12	1,2	20	2433,6	1600
1	4,77	4,70	-0,07	-1,46	12	1,2	20	2433,6	2000
2	1,38	1,32	-0,06	-4,06	14	1,2	25	3510	400
2	2,75	2,69	-0,06	-2,25	14	1,2	25	3510	800
2	4,13	4,06	-0,07	-1,64	14	1,2	25	3510	1200
2	5,50	5,42	-0,08	-1,52	14	1,2	25	3510	1600
2	6,88	6,78	-0,10	-1,45	14	1,2	25	3510	2000

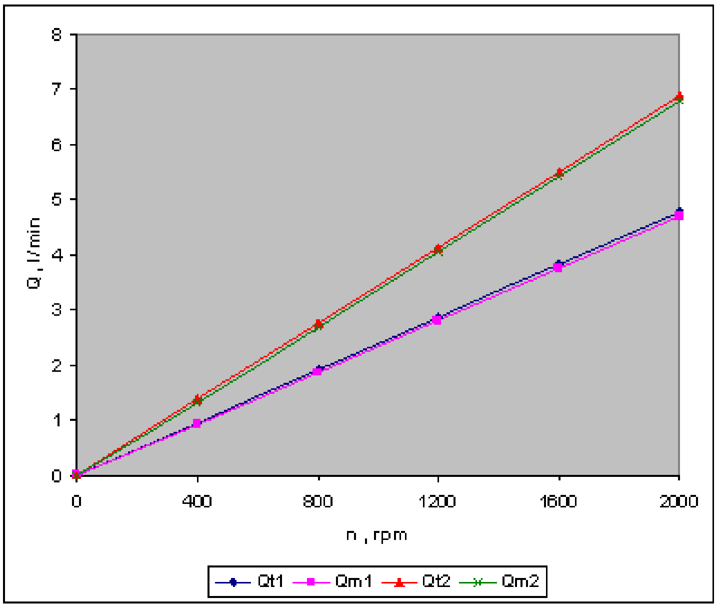

Figure 5. Graphical representation of the characteristics of gear pump

V. CONCLUSION

The results of the experiments indicate that the flow rate of the gear pump depends in direct proportion as the frequency of rotation n, as well as the width b of the sprockets. The difference between the measured and the calculated flow does not pass a 5% relative error.

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