A new type of rotating working machine with one leader and one complementary rotor

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Abstract

A new constructive solution of a working machine which is simpler and has a higher reliability in comparison with other solutions is presented. The computation relations of the driving power and the flow rate for the rotating working machine are deducted; this machine can function as a pump, fan or low pressure compressor.

Any pure fluid substance or with suspensions is circulated from suction to discharge by a rotor with two profiled pistons.

Keywords: rotating machine, profiled rotors, rotating piston.

1. Introduction

At piston machines, the reciprocating motion of the piston is converted to rotation motion through a crank-rod mechanism, transformation that is accompanied by a number of frictions between the parts that perform this mechanism. Currently, researchers attention is directed toward eliminating this mechanism by constructing rotating machines such as motor machines (rotating motors) as well as working machines (pumps, compressors).

Scientific researchers aims as that the entire torque received at the machine shaft to be used in fluid circulation: $\vec{M} = \vec{F} x \vec{b}$; $M = Fb\sin\alpha$, where the arm (b) of the force (F), at rotating machines, is always perpendicular to the force, that is: $\sin\alpha = \sin 90^{\circ} = 1$.

There have been made some rotating compressors, such as Roots-type, etc., but it has the disadvantage that:

- the constructive solution is complicated, the manufacturing technology is very laborious;

- in operation, high friction between the moving parts (pallets, lobes) and the machine case (stator) occurs.

The constructive solution proposed by the authors is based on a patent [1] and it can be used as a working machine in several ways: as a pump to circulate of pure liquids or suspensions; as a fan; as low pressure compressor; as a flowmeter.

If the working machine operates as a pump, the rotating pistons located on the rotor has a triangular shape [2].

When the machine operates as a fan, compressor, flowmeter, in order to ensure a better sealing between the rotors, the rotating piston is curvilinear [3] [4]. Through this constructive solution, the paper seeks to open new research ways in the field of rotating machines.

2. Constructive solution description, operating principle

In this paper, the rotating machine will be presented as a rotating volumetric pump with profiled rotors (Fig. 1). The machine consists of two rotors:

- One rotor has two pistons and ensures the fluid circulation, so it is called leader rotor (1).

- The other rotor, called complementary rotor (2); does not circulate fluid, it provides the seal between the high pressure side (discharge) and the low pressure side (suction).

Unlike other design solutions of this type of rotating machine [5] the presented solution has a higher reliability degree because:

- The contact line (piston top- cavity) for one rotation occurs four times.
- In some constructive solutions, the complementary rotor also has two rotating pistons, the constructive solution is completely different and the contact line for one rotation occurs eight times, a large number of contacts lines leads to the decrease in the machine safety operation.

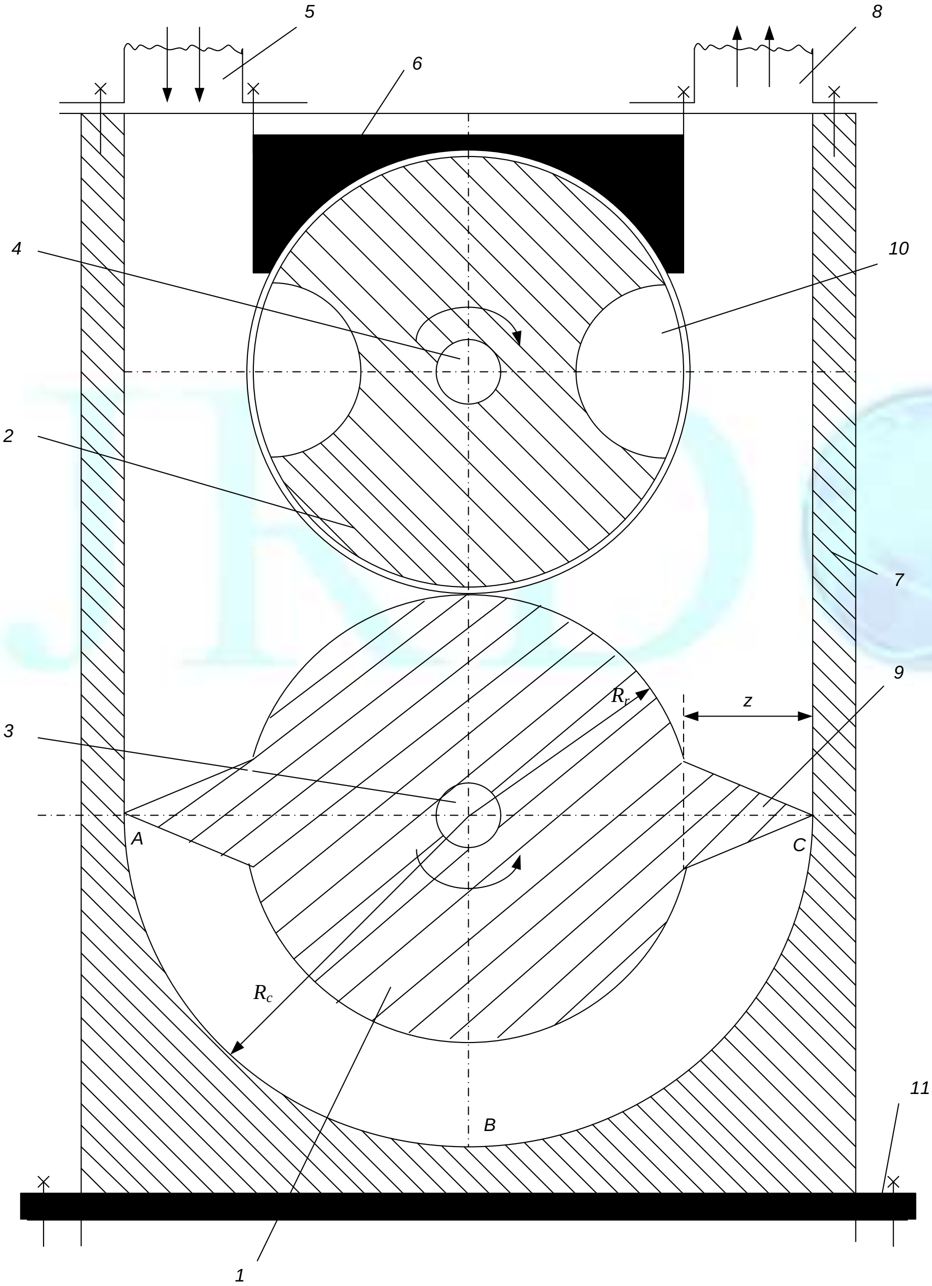

Fig. 1. Cross-section through the rotating machine

1- leader rotor; 2- rotor complementary; 3- driving shaft; 4- driven shaft; 5- fluid suction connection; 6- upper case; 7- lower case; 8- fluid discharge connection; 9- rotating piston; 10- cavity into which the rotating pistons enters; 11- the machine base plate

The rotating machine consists of a mobile part and a fixed one (Figure 1). The movable part is consists of:

- active rotor (1)
- complementary rotor (2)
- driving shaft (3)
- driven shaft (4)
- One cylindrical gear formed of two gear wheels with the same division diameter fixed on the shafts (3) and (4) which makes the two rotors to rotate at the same angular speed (the gear unit is positioned outside the machine).

The fixed part comprises (Fig.1):

- upper case (6);
- lower case (7);
- the lateral covers of the case (not shown in this section);
- fluid suction connection (5);
- fluid discharge connection (8);
- the machine base plate (11).

3. The machine flow rate and driving power computation relations

At each rotation of the driving shaft (3) two useful volumes are conveyed from suction to discharge (Fig. 1) V_{ABC}:

$$V_{ABC} = \frac{\left(\pi \cdot R_c^2 - \pi \cdot R_r^2\right) \cdot l}{2} \; [m^3 / rot] \tag{1}$$

where: R_c- case radius [m]; R_r- rotor radius [m]; l- rotor length [m].

The rotating piston height is:

$$z = R_c - R_r \text{ [m]} \tag{2}$$

Replacing: $R_c = R_r + z$ in (1) is obtained:

$$V_{ABC} = \frac{\pi \cdot \left(z^2 + 2R_r z\right) \cdot l}{2} \tag{3}$$

At one rotation of the shaft (3) from suction to discharge a flow rate will be circulated:

$$\dot{V} = 2V_{ABC} = \frac{2\pi lz \cdot (z + 2R_r)}{2} \left[\frac{m^3}{rot}\right] \quad (4)$$

For a machine speed of *n* [rot/min] the theoretical volumetric flow rate will be:

$$\dot{V} = \pi lz \cdot (z + 2R_r) \cdot n \quad \left[\frac{m^3}{\min}\right] \quad (5)$$

$$\dot{V} = \pi lz \cdot (z + 2R_r) \cdot \frac{n}{60} \quad \left[\frac{m^3}{s}\right] \quad (6)$$

Analyzing the relation (4), the question is: when the flow rate depending on z will be maximum? Taking z as a variable, the derivative is performed: $\dot{V}' = f(z)$ equalizing with 0 and from (4) is obtained:

$$\dot{V}(z) = 2\pi lz + \pi lz 2R_r = 0 \quad (7)$$

Results: $\dot{V}$ is maximum when:

$$z = R_r \quad (8)$$

This result is theoretical, because the technique $z < R_r$ [6].

From the relation (5) the following are observed:

- The volumetric flow rate increases linearly with the machine speed (n)
- The volumetric flow rate increases linearly with the rotor length and the rotor radius
- The volumetric flow rate increases with the square of the piston height (z).

The theoretical power required the drive the machine will be [7]:

$$P = \dot{V} \cdot \Delta p \;\; [W] \quad (9)$$

$\dot{V}$ - the volumetric flow rate [m^3/s];

Δp- the increased pressure between the machine suction and discharge [N/m^2].

The value of Δp can be expressed in another way [8] [9]:

$$\Delta p = \rho \cdot g \cdot H \; [N/m^2] \quad (10)$$

where: ρ- the fluid density [kg/m^3]; g- gravitational acceleration [m/s^2]; H- hydrostatic load [m].

$$P = \pi \cdot l \cdot z \cdot (z + 2R_r) \cdot \frac{n}{60} \cdot \rho \cdot g \cdot H \;\; [W] \quad (11)$$

It is noted that P depends on two categories of parameters:

- Geometric dimensions of the machine: l, z, R_r.
- Functional parameters: machine speed (*n*); fluid nature through ρ.

But it is known that [10]:

$$\rho = \frac{\eta}{\nu} \tag{12}$$

where: η- the fluid dynamic viscosity [Ns/m^2]; ν- the fluid kinematic viscosity [m^2/s].

So, the fluid viscosity influences the machine driving power.

Conclusion

1. The solution is original, ensures a high efficiency and an increased reliability.

2. For a chosen constructive solution (R_r, z, l), the machine flow rate increases linearly with the machine speed. The driving power increases with the circulated flow rate and with the pressure increase (Δp) between the machine suction and discharge.

3. The idea of creating a new rotating working machine that can transport any fluid substance, less or more viscous is beneficial for the petrochemical, energetic industry, etc.

4. We are concerned about finding application areas and users for the use of this new type of working machine that can convey any fluid substance.

References

1. N. Băran, Gh. Băran, "Rotating steam engine" (in Romanian), Patent, O.S.I.M., no. 111296-B1, Bucharest, 1996.

2. N. Băran, D. Despina, D. Besnea, A. O. Motorga, "Theoretical and experimental researches regarding's the performances of a new type of rotating machine with profiled rotors", ICMET 2011, Dallin, China.

3. N. Băran, I. Călușaru, A. Detzortzis, "Research regarding the testing of a new type of rotating machine with profiled rotors", Journal of Material Science and Engineering, vol. 2, no. 3, 2012, USA, pp.372-376 .

4. N. Băran, D. Despina, D. Besnea, A. Detzortzis, "Theoretical and experimental researches regarding the performances of a new type of rotating machine with profiled rotors", Advanced Materials Research, Trans Tech Publications, Switzerland, vol. 488-489, 2012, pp.1757-1761.

5. N. Băran, P. Răducanu, et al., "Technical Thermodynamics" (in Romanian), POLITEHNICA PRESS Publishing House, Bucharest 2010.

6. N. Băran, "The correlation between the driving power and the height of the rotating piston on a new type of compressor" (in Romanian), Journal of Chemistry, vol. 55, no. 1, 2004, pp. 51-53.

7. E. Anderson, "Thermodynamics", PWS PUBLISHING COMPANY, Boston, 1993.

8. D. Acheson, “Elementary Fluid Dynamics”, Clarendon Press, 1990.

9. C. Isbăşoiu, “Treatise of fluid mechanics” (in Romanian), AGIR Publishing House, Bucharest, 2011.

10. Al. Dobrovicescu., N. Băran et al., “Elements of thermodynamics” (in Romanian), vol.1, POLITEHNICA PRESS Publishing House, Bucharest, 2009.