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RESEARCHES REGARDING THE POWER PRODUCED BY A NEW TYPE OF STEAM FORCE MACHINE

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Abstract*: In this paper the authors present the constructive solution and the running principle for a new type of rotating machine that uses the overheated steam as working thermic agent. They compute the motor torque and the power of the rotating machine; they underline the advantages of rotating machines, in comparison to machines that use the pistons with straight alternating movement.*

Key words: *rotating machine, rotating piston.*

1. The Constructive Solution and the Running Principle

The rotating force machine consists of a rotating motor that has two subassemblies:

a) The mobile subassembly, composed by two identical rotors (1) and (2) fastened on the shafts (3) and (4) (fig. 1); every rotor is furnished with two rotating pistons (5) and (6), respectively (7) and (8). These pistons, during the rotation movement, penetrate in the cavities (9), (10) and (11), (12) of the adjacent rotor (fig. 1).

The two rotors rotate with the same angular speed due to the fact that two gear wheels with the same division diameter, constituting a cylindrical gear with straight teeth [1], [2], are fastened on the shafts (3) and (4), outside the machine. The sealing between the rotor and the casing can be made using a lamella with a special form, fastened in the rotor [3].

b) The fixed subassembly is composed by two cylindrical casings:

- the upper casing (13) (fig. 1)
- the lower casing (14), through which the whole machine is sustained by the foundation.

The input joint of the steam is fastened to the two casings (15) and the steam output joint (16), both of them having rectangular section. Taking into account the fact that the steam penetrates in the same time in the channels between the rotors and casings when entering the machine, in order to avoid an inutile expansion of the steam, the input joint will have the area section $2z \times l$ [m^2]; z - the height of the rotating piston; l - the length of the rotor [m], dimension perpendicular to the figure plane.

The motor can be composed from a single body in which the steam is expanded from a pressure p_1 to $p_2 < p_1$, or can be composed of two bodies; in the first body the steam expands from p_1 to p_x, and in the second body the steam expands from p_x to p_2. By p_x is denoted the optimal intermediate expansion pressure.

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2. Establishing the Variation of the Motor Torque Produced by a Rotor

The authors asked themselves if for this new steam motor type, modified towards the patented one [3], the motor torque had constant value at a 360° rotation or varied like in the internal combustion motor. A rotor is meant in this example; in the case of the internal combustion motor a piston inside a cylinder is meant.

The rotational movement of the upper rotor (1) will be analyzed when describing 360° ; the thermic agent exerts a force on the rotating pistons (5) and (6) generating the motor torques M_1 and respectively M_2 (fig. 1).

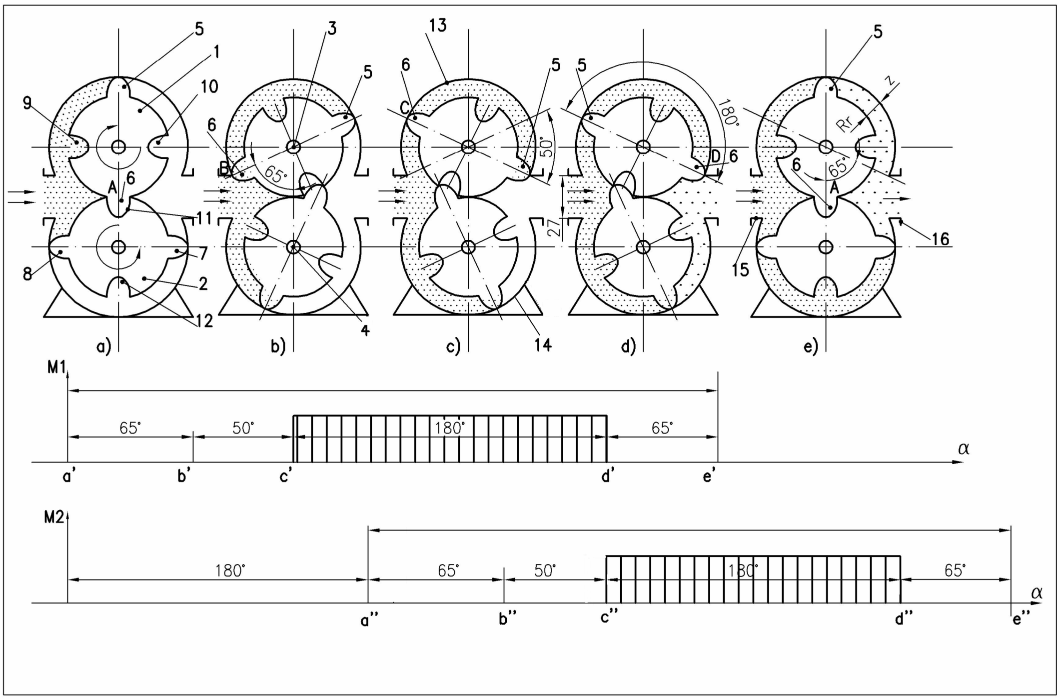

Fig. 1. *The motor torque developed by the steam pressing on the rotating pistons (5) and (6) of the upper rotor (1)*

The point A, placed in the tangency point of the rotors (fig.1), will be taken as initial point on the study of the rotational movement of the upper rotor (1). The rotational movement of the rotating piston (6), starting from the point A and describing 360°, will be followed.

The overheated steam enters the motor through the input joint (15) and presses over the rotating planes (5) and (8) with a high pressure, p_1, determining the rotation of the two rotors (fig. 1a). The piston (6) enters in the thermic agent, but on the two faces of the piston the pressure is equal to p_1 so the shaft does not rotate due to the motor torque.

Then, for a $\alpha = 65^o$ rotation from the point A to the point B, the rotor torque is zero ($M_1 = 0$). The value of the angle $\alpha = 65^o$ was chosen due to construction reasons.

In the moment B, the piston 6 closes the channel between the rotor (1) and the upper casing (13), the rotational movement continues with an angle equal to 50° till the point C. Between the points B and C the pressure exerted by the steam on the two faces of the rotating piston is zero. So then on the sectors a'-b' and b'-c' the motor torque will be zero $M_1 = 0$ (fig. 1)

The point C corresponds to the situation in that the piston top (5) (fig 1.c) leaves the upper casing (13) and the steam between the pistons (6) and (5) is sharply expanded till it reaches the pressure of the exterior ambient, namely the existing pressure in the machine condenser (p_2). From this moment, two pressures are exerted on the rotating piston (6):

- on a face of the piston the pressure p_1 is exerted;
- on the other face of the rotating piston the pressure p_2 is exerted.

As consequence the piston (6) will generate a force equal to:

$$F = A_p(p_1 - p_2) \text{ [N]} \quad (1)$$

in which A_p is the piston section area.

$$A_p = z \cdot l \text{ [m}^2\text{]} \quad (2)$$

This force creates a motor torque (M) at the shaft (3):

$$M_1 = F \cdot b \text{ [Nm]} \quad (3)$$

where b is the force arm.

The force arm is given by the sum between the rotor radius (R_r) and half of the height of the rotating piston; we consider that the force applies in the center of area A_p.

$$b = R_r + \frac{z}{2} \text{ [m]} \quad (4)$$

Accordingly, during the rotation with α=180°, from the position (C) to the position (d), a force is exerted on the piston (1), so a motor torque M_1 appears (fig. 1), which can be seen on the distance c'd'. In the point D the top of the piston (1) leaves the casing and the piston (6) enters in the range of the low-pressure steam (p_2). From the point D (fig 1.d) to the point A (fig 1.e), namely on the range of an angle α = 65° (d'-e'), on both the two faces of the piston (6) the same pressure p_2 is exerted so that $F = 0$; there is no motor torque ($M_1 = 0$).

Reaching again the point A (fig. 1 e), the phenomena that appear on the piston (6) are repeated at the next rotation.

The second rotating piston (5) of the upper rotor (1) is displaced with 180° to the rotating piston (6); consequently it will reach the point A after a rotation movement of 180° (fig. 1).

When arriving at the point A the piston (5) will obey to the same forces as the piston (6) the phenomena are repeated, a motor torque M_2 (fig. 1) equal to M_1 - will appear. It can be remarked from figure 1 that for the upper rotor the motor torque produced by the thermic agent at the shaft (3) is continuous and constant ($M_1 = M_2$) on a 360° tour (sections c'-d' and c''-d'').

3. The Calculus of the Motor Torque and of the Theoretical Power Produced by the Steam Motor

For the upper rotor, taking account of the relations (1), (2), (3) and (4), the value of the motor torque will be of:

$$M_1 = F \cdot b = z \cdot l(p_1 - p_2)\left(R_r + \frac{z}{2}\right) \quad (5)$$

It is denoted $\Delta p = p_1 - p_2$ [N/m²]

$$M_1 = zl \cdot \left(R_r + \frac{z}{2}\right) \cdot \Delta p \quad (6)$$

The power developed by a rotor of the engine will be:

$$P = M \cdot w \text{ [W]} \quad (7)$$

where ω is the angular velocity of the rotor:

$$w = \frac{2\pi \cdot n}{60} = \frac{\pi \cdot n}{30} \text{ [rad/s]} \quad (8)$$

where n denotes the rotating speed of the machine [rpm].

$$P = zl \cdot \left(R_r + \frac{z}{2} \right) \Delta p \cdot \frac{\pi n}{30} \quad (9)$$

$$P = \frac{\pi z \cdot l}{2} (2R_r + z) \Delta p \cdot \frac{n}{30}. \quad (10)$$

The motor has two rotors that produce the same motor torque; accordingly:

$$P_m = 2P = \pi lz(2R_r + z)\Delta p \frac{n}{30}. \quad (11)$$

From the relation (11) it can be noticed that the power produced by the motor depends on:

- Constructive elements: l, z^2, R_r;
- Functional elements: n, Δp.

The power developed by this type of machine increases linearly with $l, R_r, n, \Delta p$ and proportional to the square of the piston height (z); consequently, the essential element in producing the power by the machine is the piston height.

4. Conclusions

From the facts presented above the following advantages of the rotating machines are accentuated:

a) The motor torque created by the thermic agent at the machine shaft, for the two rotors, is constant for the time of a complete rotation.

b) The motor torque created at the machine shaft is maximal because $M = Fb \cdot \sin\beta$ and the angle between the force (F) and the arm $\left(R_r + \frac{z}{2} \right)$ is always equal to 90^0.

c) The machine presents safety in running, no special materials and manufacturing technologies are needed in order to build it [4], [5].

References

1. Băran, N., Marinescu, M., Radcenco, V.: *Termodinamică tehnică, teorie şi aplicaţii (Tehnical thermodynamics – theory and applications)*, vol. I, II, III. Bucureşti. Editura MATRIX ROM, 1998.
2. Băran, N.: *Maşini termice rotative, maşini de forţă, maşini de lucru*. Bucureşti. Editura MATRIX ROM, 1998.
3. Băran, N., Băran, Gh.: "*Steam rotating motor*". Patent no. 111296 – B1/1996, released by The Romanian State Office for Inventions and Trademarks, Bucharest.
4. Băran, N., Băran, Gh.et al.: *Research regarding the profile of a rotating piston used in the design of volumetric pump*. In: *U.P.B. Scientific Bulletin Series D*, vol. **68**, no. 4/2006, p. 59.
5. Băran, Gh., D. Duminică, et al.: *The influence of functional and constructive parameters on the volumetric efficiency of a new type rotating volumetric pump.* In: *Romanian Review Precision Mechanics, Optics & Mechatronics*, no.31/2007, p. 773.