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HYDROSTATIC MOTOR WITH VARIABLE ENGINE CAPACITY

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ABSTRACT

This paper presents a new constructive solution of a hydrostatic motor with variable engine capacity. The 3D model realized with NX 7.5 software and also the ensemble drawing offer designers the opportunity to standardize within dimensional range the hydrostatic engines with variable engine capacity.

KEYWORDS: hydrostatic motor, variable engine capacity, CAD.

1. Introduction

Hydrostatic rotary engines (fig. 1) are widely used in construction machinery industry, beginning with high-precision digital automatic controls and ending with excavators, rolling mills or high power drilling rigs.

Fig. 1 Hydrostatic rotary engine

One of the fundamental advantages of the engine is the gauge and low weight per unit of power.

Available engines for driving pumps usually have high speed and low momentum, so the engine capacity pumps must be fast and have good cavitations performance. Instead, action heavy loads, at low speed, require slow engine capacity that operates stably at low speeds and provides great momentum with high efficiency [1].

Radial piston engines with variable flow are destined for high pressure hydrostatic drive systems in the machine construction field.

Engines can be used at various transmissions and rotation mechanisms, such as: rotating digging equipment or ladder-type, rotating mechanisms of cast platform, shifting mechanisms track, winches, conveyor belt, etc.

2. Components, functioning

The hydrostatic engine with radial piston and variable flow is compact. It consists of an outer fixed housing and a rotor which is mounted on bearings with the bearings. The rotor housing extends outside with a shaft end with cotter (spike).

The working principle of the engine consists in the transformation of alternative straight line motion of two sets of seven radial pistons arranged in the continuous rotary motion of the rotor. This conversion occurs thanks to the balls located in pistons and which are permanently in contact with the undulated profile of cam pair (fig. 2).

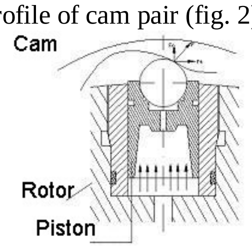

Fig. 2 Radial piston

By the pressure p of the hydraulic oil, the piston presses on the ball that is in permanent contact with the cam, making appear a tangential force F_t producing relative movement between the cam and ball-piston assembly.

After the power stroke, the piston is pushed into the initial position by the following cam profile waviness.

Directing the hydraulic oil between the feed holes and the piston is achieved with a flat front distribution. For one way of rotation, the hydraulic oil entered through P hole penetrates through horizontal channels (parallel to the axis of the rotor) C of the rotor, but first it gets into the a_d alveoli processed on one side of the fixed rotary distributor and the fixed one. The withdrawal of the piston stroke, the oil comes out of the a_d alveoli and the T hole.

The power stroke of the piston is between points of maximum of zero slope. Each semi-corrugation cam located between two successive extremes corresponds to one alveoli on the fixed distributor.

The alveoli corresponding to the semi-corrugation with slope in the same direction are connected to the same channel. The fixed distributor orientation relative to the cam profile is such that decks shutter between two successive alveoli corresponds to the points of the piston head stroke (points of zero slope).

This radial piston engine, through its construction, can get a variable flow by the phase shift cam, variable speed and a variable momentum at the end of the shaft. All these sizes have been achieved due to the variation mode of the engine capacity.

Because of these disadvantages, another way to particular variation of the engine capacity was chosen. On the lateral side of the two crowns without gear it was manufactured each control channel within which is the lower end of two arms. This end has the shape of a ball. At the other end of the arm there is a toothed rack which is translational movement by a cylindrical pinion.

During rolling the gear with a certain angle, the toothed racks move in different directions at the same time and with the same stroke simultaneously achieving angular movement of the two cams.

This situation is more advantageous than the first one due to higher precision and it is achieved an optimal distance between the two cams, from the technological point of view.

To increase engine capacity of the sloe engines with radial piston, some manufacturers use solution involving two rows of pistons and cams placed in two parallel rows. For an engine having a single cam with *n* corrugations (period of sinusoidal wrapped circle), the polar radius variation is expressed as:

$$R = R_0 - \frac{c}{2}\cos n\varphi; \qquad (1)$$

where:

R – polar radius of cam;

R_0- medium radius of profile;

c – piston stroke;

n – no. periods of sinusoidal cam;

φ - polar angle.

The relation between engine capacity and constructive sizes is:

$$V_0 = A \cdot z \cdot n \cdot c; \qquad (2)$$

or

$$V_0 = 2A \cdot z \cdot n \cdot c; \qquad (3)$$

where:

A – piston area – $A = \pi d^2 / 4$;

z - no. pistons.

The relation (3) refers to the construction of two cams and two rows of pistons, parallel arranged. It is noted that in this case the engine capacity is doubled although the volume of the hydrostatic engine increases with only 52%.

If in a certain case it acts in a cam moving angularly in one direction through an angle $+\alpha$ and another angle in the opposite direction $-\alpha$, the engine capacity is continuously adjustable.

Fig. 3 presents a procedure and a mechanism for rotating the cams.

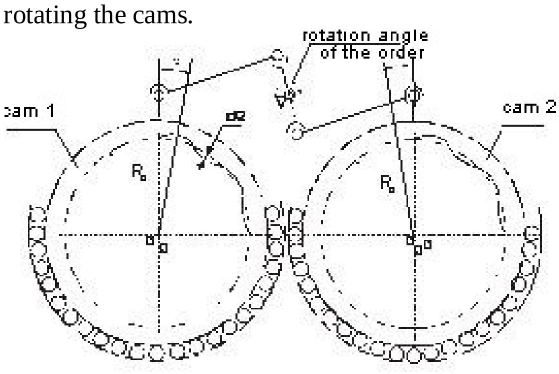

Fig. 3 Mechanism for rotating the cams

With the control system shown in principle in fig.3 we can adjust the absolute stroke of the engine so that when the cams are in phase opposition, the total engine capacity is zero. The initial normal state cams are out of phase as in fig. 4.

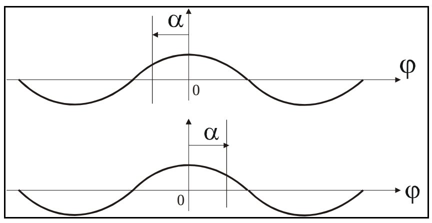

Fig. 4 Changing the rotating cam engine capacity function

Because engine capacity is not allowed to obtain zero engine capacity, leading to determination of the hydrostatic transmission ratio, the recommended minimum engine capacity is about 0.33 of the maximum engine capacity. This makes that for the secondary control (changing engine capacity) the hydrostatic transmission is:

$$i_H = \frac{V_{0P}}{V_{0M}} \in [i_H^* - 3{,}3 i_H^*], \qquad (4)$$

where:

V_{0P} – maximum engine capacity pump drive system,

V_{0M} – maximum engine capacity hydrostatic,

i_H^* - the value of the transmission ratio for V_{0P} and V_{0M}, given.

It follows that the secondary adjustment can triple the engine speed hydraulic drive. The method is used to drive traffic, to continue passing on technological movements (small) to travel on the public road at high speed.

Hydrostatic radial piston engines with multiple action are part of the internal power rotary engine capacity and irreversible rotation. The engine uses two cams in parallel, each cam having a number of corrugations (sinusoids focused on a central circle).

The novelty of this constructive solution is that the designed engine with radial piston is a slow engine (for driving large loads) with the possibility of moving, by adjusting the engine capacity, to the characteristics of a fast engine (high speed and low momentum). The first scheme satisfies functioning at high momentum and low speeds (slow mode), the second one for low momentum and high speeds (fast mode). The control system is called secondary adjustment.

In fig. 5 there is the assembly drawing and in fig. 6 the 3D modeling provided with NX 7.5 software of the hydrostatic engine with variable capacity engine.

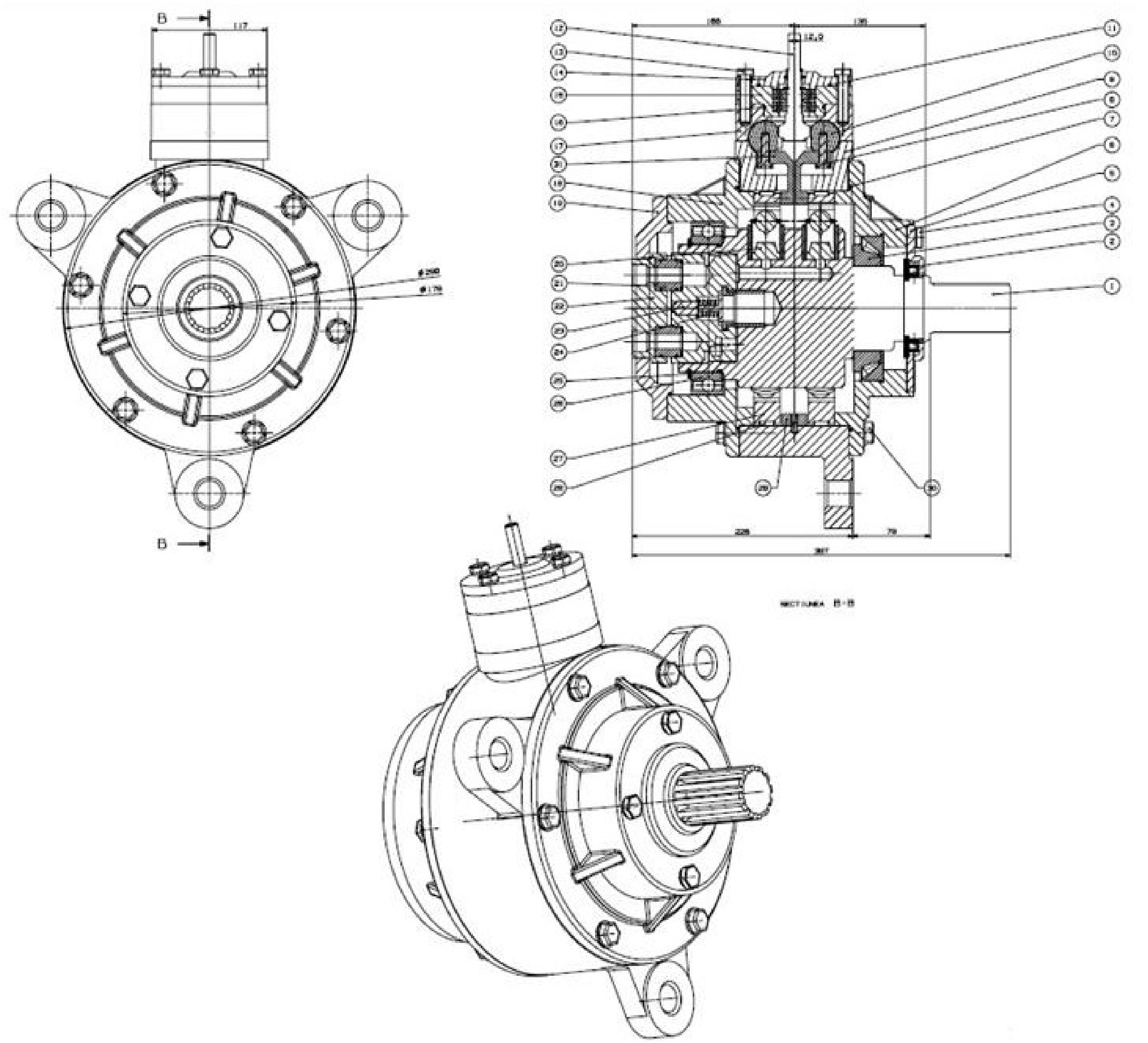

Fig. 5 Assembly drawing of the hydrostatic engine with variable engine capacity:
1. shaft; 2. lock washer; 3. bearing radial-axial; 4. screw M20; 5. cover 1; 6. cover 2; 7. ring; 8. screw M12; 9. cover 3; 10. gear rack; 11. ring; 12. adjustment shaft engine capacity; 13. screw M12; 14. cover 4; 15. cover 5; 16. ring; 17. cover 6; 18. cover 7; 19. cover 8; 20. piston; 21. intermediate sleeve; 22. oil supply; 23. fixed distributor; 24. spring preload; 25. ring SEEGER; 26. Ball bearing; 27. cam; 28. needles; 29. spacer cams; 30. screw M20; 31. engine capacity control.

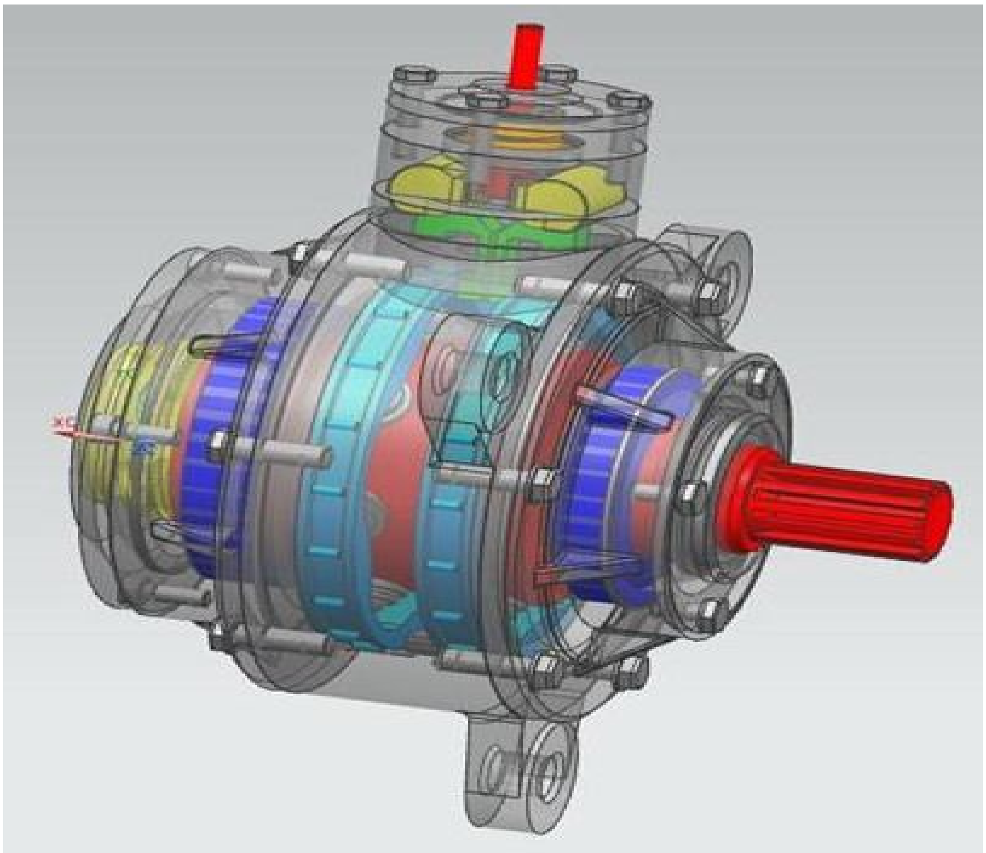

Fig.6 3D projection variable engine capacity for hydrostatic engine

A methodology was developed on the computer aided design :

- Kinematic calculation of the hydrostatic engine
- Calculation speed and acceleration
- Calculation of flow and flow pulsations
- Hydraulic calculation of hydrostatic engine
- Sizing circuits
- Sizing distributor
- Hydrostatic engine dynamics

The project and 3D model of the hydrostatic engine with radial piston with variable flow have the following dimensional and functional characteristics:

- piston diameter: $d_n = 12$ mm
- piston stroke: c = 4 mm
- number of pistons: Z = 7
- number of corrugations: N = 5
- maximum geometric volume:
  $V_{gmax} = 31{,}534\ cm^3/rot$

3. Conclusions

This paper presents a new constructive solution of a hydrostatic engine with variable engine capacity.

The design was implemented using NX 7.5 software that allowed parameterization in order to standardize the product.

The 3D model of the hydrostatic engine enabled verification of assembly and also optimization of surfaces forms for easy technology.

By extending standardization, this hydrostatic engine can be successfully used in different transmission and rotation mechanisms, such as: rotary digging equipment or ladder type, rotating mechanisms of (turntable) casting platforms, shifting mechanisms track, trolls, conveyor belt, etc

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