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NEW ASPECTS REGARDING THE RESEARCH AND DEVELOPMENT IN THE FIELD OF MECHANICAL ENGINEERING AT THE NORTH UNIVERSITY OF BAIA MARE

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***Abstract**: This paper presents in the first part a few experimental assessment concerning the function of radial bearings with HD lubrication in the case of huge challenging working and in the last section we have a presentation of the new developments of electromechanical linear actuators achieved within the research project CNCSIS. The experimentation methodology includes some practical experiments met during the working process of these bearings. There are highlightened the configuration structures bother mechanical and control and order ones compatible with the modern requirements and the top performances of intelligent flexible systems of fabrication where they are frequently used.*

***Key words:** radial hydrodynamic bearing, actuator, pressure distribution, machine-tools.*

1. INTRODUCTION

Taking into consideration the Stribeck curves, that can be applicable to sliding bearings it has been found that the minimum thickness of the lubrifiant film and the rubbing value can be modified depending on the challenging working, speed and oil dynamic viscosity [7].

In the case of sliding bearings the lubrifiant working conditions corresponding to h_{min} is imposed by rugosity; the medium height of the roughness can be reckoned for the spindle $R_{1\,\max} \cong 5$ μm; as for the bronze bushing $R_{2\,\max} \cong 5$ μm is to be considered [3]. So, in the case of fluid rubbing functioning conditions, the minimum lubrifiant thickness has to be bigger than an allowable value, $h_{\min,a} \geq 10$ μm.

We consider the closing motion between spindle and bushing on the direction of the center line, without the rotation of the spindle (the case of the non-rotating bearing), so that the lubricant expulsion effect be prevalent in the achieving of the squeeze film.

2. EXPERIMENTAL DEVICES AND ACQUISITION CHAINS

The assessment was made on the experimental stand of the Tribology and Manufactural Engines Lab from the North University of Baia Mare (Fig. 1), making use of the modern technology concerning the results'processing and acquisition [1].

The HD radial bearing is put into function by an electric engine with a power of 3 kW, and the entrance rotation is made due to a gear box, which assures the rotation of 960, 600 and 370 rot/min.

The research was made using a HD radial bearing with $L/D = 0.5$ and the spindle's diameter $d_e = 59.86$ mm, and the bushing diameter $D_e = 59.93$ mm, spindle's asperity 58-62 HRC, made of 18MoCr10, bronze bushing made of 88% Sn, 8%Sb, 4%Cu.

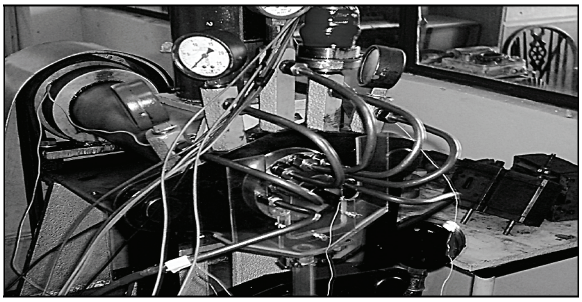

Fig. 1. The testing experimental devices.

The dynamic loading of the bearing is made through the launcing of a weight which hits the bearing at different heights. They were made assessments for heights between 5 and 40 cm, using a weight with $m = 5$ kg, so as for $H = 5$ cm we have $F_1 = 1\,665$ N, for $H = 20$ cm.

We have $F_2 = 2\,356$ N, and for $H = 40$ cm we have $F_3 = 3332$ N. The static working conditions is presented for the following value $H = 0$ cm.

All the tests were made at a 40°C of the lubrifiant, being constant, pressure distribution p_{in} having the following values, from 0.5 bar to 10 bar [3].

Using a lubrifiant oil for bearings of LA 32 STR 5152-89 type, with the viscosity of 31.3 cSt at 40°C, it was focussed on the determination pressure distribution from the film to be lubricated in various places of the bearing's body, with the help of pressure measuring dose with tensiometric translators put together through an amplifier placed at the acquisition plate ADuC 812.

In dynamic charging conditions, the pressure distribution was determined in the lubricated film in those 5 points on the bearing's body with the help of pressure measuring with tensometric translators.

The translator is a manometric capsule at which the sensible element to pressure is an enclosed tube at one end whose inner part is conected to the oil whose pressure is measured. The tube is made of steel with elastic properties on which there are 4 tensometric stamps, each of them having the electric resistivity of 129 Ω, two of them in axial direction, and two in perpendicular direction [2].

The tensometric translators are used in large scale due the simpleness and the extanded domain for application from 7 to 700 bar [6].

Those 4 tensometric stamps are conected in a tensometric bridge diagram, being related by an amplifier at the acquisition plate ADuC 812 [7].

Fig. 2 presents the pressure measuring chain in the lubrifiant film.

The exhibition of the pressure measuring dose was made in the case of dynamic charging, on the manometer's exibition stand, using the above chain, focussing on the variation exit sign and registering amplifier and the acquisition plate ADuC 812. The pressure increase was made bar by bar, the dose distortion being liniar with the pressure [4]. It was established the dependency relation between the pressure and the tension in the exit point in mV (2.3 mV = 1 bar Δp).

The acceleration of the moving bearing because of the shock, it determined with the help of acceleration sensor ADXL 190 WQC whose signal was acquisitioned with data acquisition system ADuC 812.

On the bushing, the acceleration senzor is rigurously fastened on the diametrical opposed direction of considered position through a sticky solution with a polyesther background.

The signal taken by the data acquisition system ADuC 812 have been analised by PC with the help of MATLAB 6.5.0.18091 3a program.

The lubricant film resistivity, which estimates the minimum lubricant thickness between spindle and bushing, it determined through the achievement of a circuit between spindle and bushing which include a standard resistance R_{12} = 49 KΩ [4, 6].

Fig. 3 presents the lubricant film resistivity measuring chain.

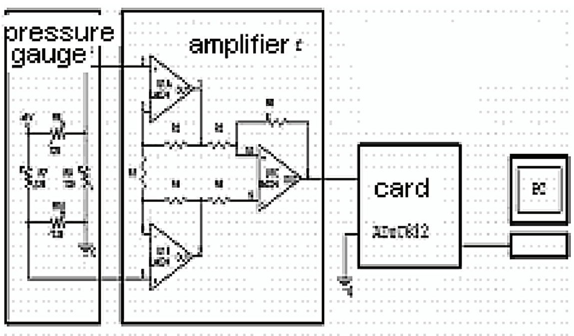

Fig. 2. The pressure measuring chain in the lubrifiant film.

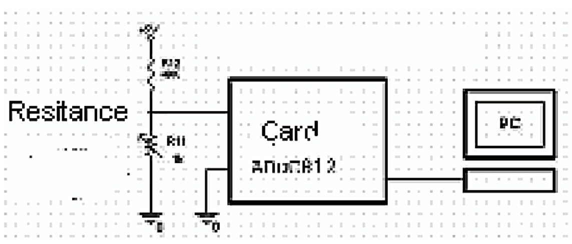

Fig. 3. The lubricant film resistivity measuring chain between spindle and bushing.

3. EXPERIMENTAL RESULTS

The pressure distribution on the peripheric side of the bushing, depending on the available supply pressure, the static and dynamic charging conditions at different spindle's rotations are presented in Fig. 4 for n = 370 rot/min, p_{in} = 0.5 bar; and Fig. 5, for n = 600 rot/min, p_{in} = 1.5 bar.

The bushing acceleration was measured with the help of ADXL 190 WQC acceleration senzor whose exit signal was acquired with the ADuC 812 acquiring plate, taken by the PC through the MATLAB 6.5.0.18091 3a programme.

Fig. 6 presents the bushing acceleration from the moment of shock for each position P1-P5 from the periphery of the bushing at the following rotation n = 370 rot/min in the case of the dynamic charging conditions.

In these plotting the maximum amplitude is to be found on the vertical axis, in the inferior position of the plotting, because of static and dynamic charging vertically directed from up to down.

Minimal resistance on the lubricant film, which estimates the minimum lubricant thickness between spindle and bushing depending on the available supply pressure, the static and dynamic charging conditions at different spindle's rotations are presented in Fig. 7 for n = 370 rot/min, p_{in} = 0.5 bar.

Some assessments were made for heights between 5 and 40 cm, using a weight with m = 5 kg, so as for

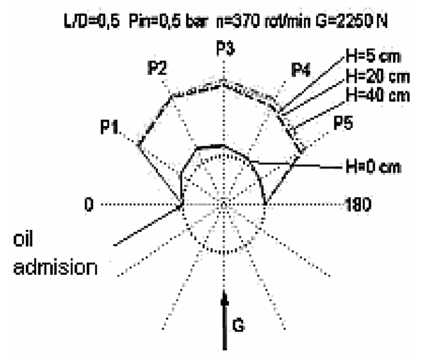

Fig. 4. The dynamic pressure distribution on the peripheral side of the bushing depending on the static and dynamic charging conditions of the bearing (n = 370 rot/min, p_{in} = 0.5 bar).

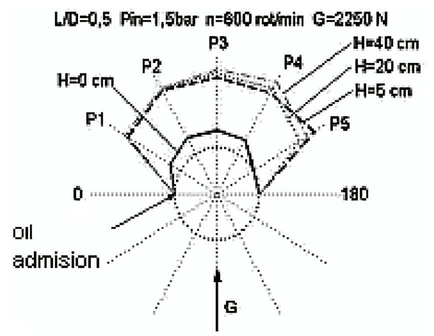

Fig. 5. The dynamic pressure distribution on the peripheric side of the bushing depending on the static and dynamic charging conditions of the bearing (n = 600 rot/min, p_{in} = 1.5 bar).

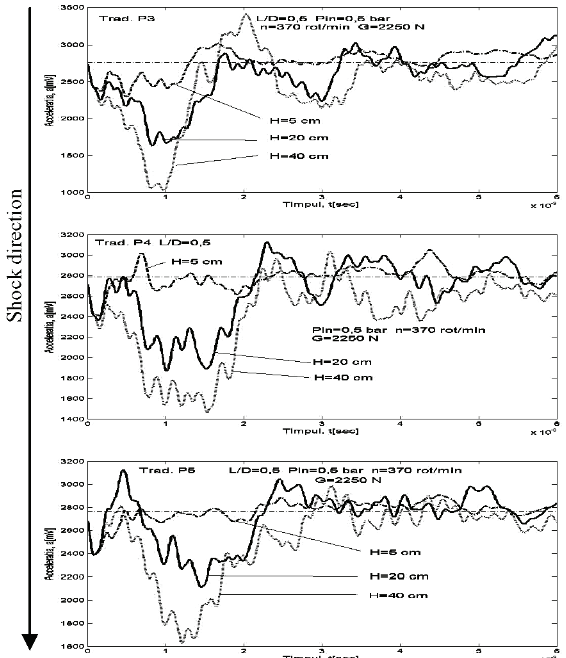

Fig. 6. The bushing acceleration in the moment of shock at $n = 370$ rot/min, $p_{in} = 0.5$ bar [6].

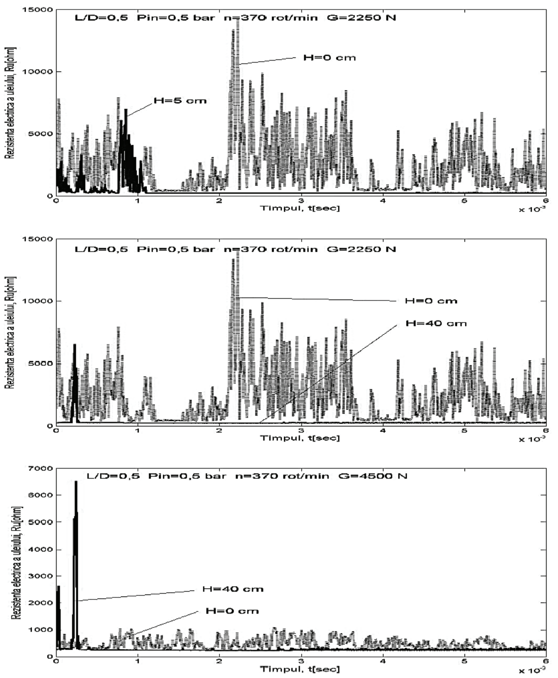

Fig. 7. The lubricant film resistivity for $n = 370$ rot/min, $p_{in} = 0.5$ bar, depending on the static and dynamic charging conditions.

$H = 5$ cm we have $F_1 = 1\,665$ N, for $H = 20$ cm we have $F_2 = 2\,356$ N, and for $H = 40$ cm we have $F_3 = 3\,332$ N.

The following conclusions may be taken into consideration:

- the dynamic pressure from the moment of shock is increased when increasing the dynamic charging conditions; this incresing process refers to the all portant zone, the dynamic pressure having values from 3.37 to 118 static pressure, depending on the studied position of the peripheral zone of the bushing;
- the static charging conditions of the bearing does not have an important influence regarding the changing in the pressure's values, as the static charging conditions gets bigger, so as the dynamic pressure is bigger;
- the draught's pressure in dynamic conditions has a slightly shifting to the entrance zone of the lubricant when static charging conditions are increasing;
- in all these situations the following fact is to bare in mind: the short time for pressure variation in dynamic charging (under 0.5 ms);
- maintaining the constant dynamic charging, at the same time as the static charging increasing, the shock taken by the bushing – lubricant film – spindle system becomes lower (the lubricant film thickness in the case of static functioning becomes lower, so as the shock absorbing made by the lubricant film becomes lower);
- initial shock absorbing in those two spindle rotation cases is made after about 5 ms, without taking into consideration the dynamic charging of the bearing;
- shock amplitude is bigger for the maximum position of the static pressure from the spindle, so: for the following rotations $n = 370$ rot/min and $n = 600$ rot/min this maximum is the same with P_3 position from the spindle;
- maximum amplitude of the shock, in these experimental researches, was registered in 0.5–1 ms period; at maximum dynamic loading $F_3 = 3\,332.5$ N, the maximum value of the bushing acceleration is between 56.8–68.6 m/s^2 for the following spindle rotation $n = 370$ rot/min, and between 45–58.8 m/s^2 for the spindle rotation $n = 600$ rot/min;
- for the radial HD bearing with $L/D = 0.5$ the mean value of the lubricant film resistivity, which estimates the lubricant film's minimum thickness, at revolutions $n = 370$ rot/min, it's approximate three times bigger in the static case, than in dynamic case, for the static change $G_1 = 2\,250$ N, respective two times bigger in the static case, than in dynamic case, for the static change $G_2 = 4\,500$ N; to be noticed the sudden decrease of lubricant film's thickness in area, which corresponds to the shock's time;
- through spindle revolution's rise at 600 rot/min, for the radial HD bearings with $L/D = 0.5$ it is noticed the rise of minimum film's thickness as much as the static charge is lower, the film's resistivity is bigger;
- once, with the dynamic charge's application $F_1 = 2\,355$ N, at $n = 600$ rot/min, it notices a decrease of mean value of the lubricant film resistivity in relation with value of static regime about seven times approximately.

5. NEW CONFIGURATION OF LINEAR ELECTROMECHANIC ACTUATORS

The main structural constructions developed within the project are presented in the following figures:

The actuator (Fig. 8) refers to a stand with a reduction linear mechanism of rotation to load and measure

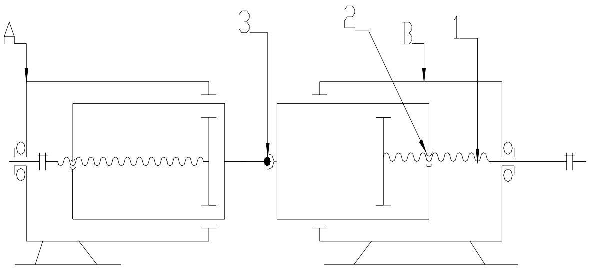

Fig. 8. The reduction linear mechanism.

the weight of the modular units of translation which uses a loading system made up of a screw-screwdriver mechanism with balls trained by a screwdriver, for the conversion of the linear movement in a rotation movement-coupled to an electromagnetic brake with powder and which can be made as a reduction linear mechanism of rotation in its version as an independent product.

Fig. 9 presents the mechanism planetary wheel with rolls.

The mechanism refers to a wheel mechanism with rolls with a planetary reduction for linear trainings at the machine-tools, or to other various precise linear actions.

The planetary wheel with rolls has an assembly of the engine wheel made of a planetary reduction gear on the frame of which, a wheel with cylindrical rolls gets together with a.

The mechanism of translation used on the industrial robots and in the construction of machine-tools has as its components a group of acting which is around axis which thread supported by a chain with bearing and which transmits the decreasing of a hub which thread attached with a cage with wheels that is supported from the outside on a hub fixed in a hull.

The telescopic translation mechanism (Fig. 10) is made up of a chained axis which transmits the rotation movement from the training group through a rut and a hub with balls to a pipe with thread realizing the movement in a hub fixed in a hull. Simultaneously there is another movement of another screw acted by rotating on a hub which thread fixed in the pipe which thread at a speed added up of the two screws (Fig. 11).

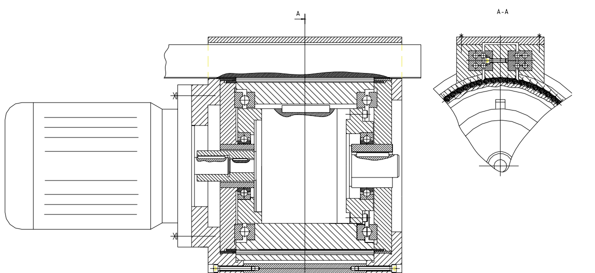

Fig. 9. Mechanism planetary wheel with rolls.

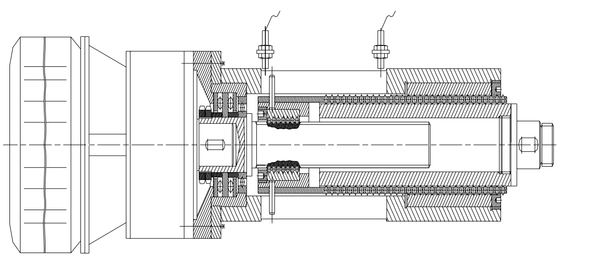

Fig. 10. The telescopic translation mechanism with bearing.

Some other units are considered. In Fig. 12 units with moveable screwdriver for machine masses are presented. Fig. 13 describes the construction of units with double acting by belts and couplings, and in Fig. 14 a linear actuator with worm gear is shown.

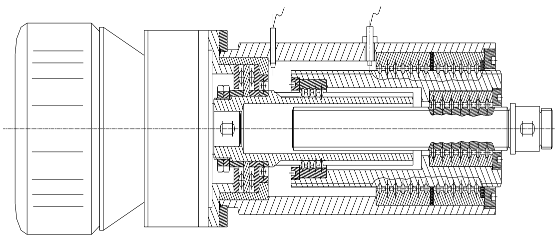

Fig.11. The telescopic translation mechanism which the two screws.

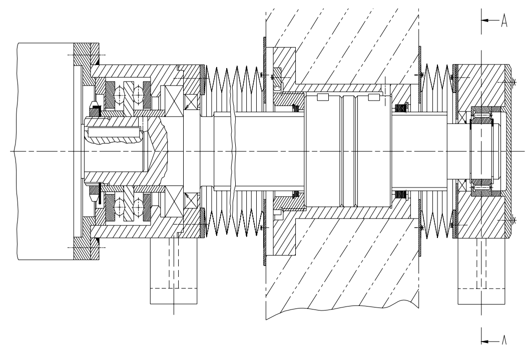

Fig. 12. Units with movable screwdriver for machine masses.

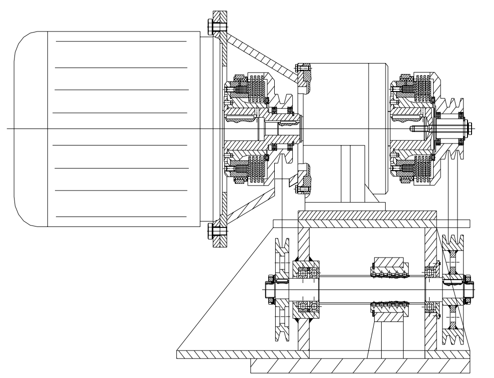

Fig. 13. Units with double acting by belts and couplings.

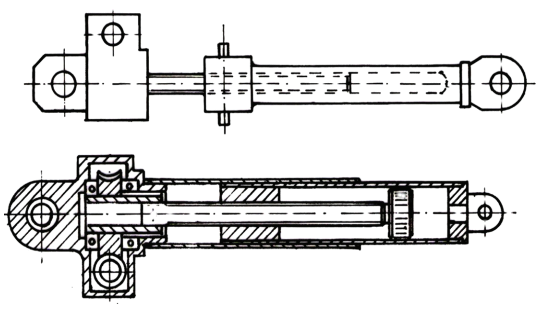

Fig. 14. Linear actuator with worm gear.

The actuator refers to a unit with parallel acting through dented belt having a mechanism of limitation of the course put into a mould. (Fig. 15).

The unit of translation is composed of a screw-screwdriver mechanism with rolling elements and another mechanism trained by them in a gear which limits the course in two tampons (Fig. 15).

The unity of translation destined to the linear electro mechanic acting's through a dented belt with a tampon is made up of a mechanism screw-screwdriver with a muff on whose axis is legacy with a screw.

The movement of the screw is protected by a sure couple when surpassing the regulated moment that act switch for the engine.

The regulation of the course is achieved in a system switches with some sliding rings blocked in certain position on an axis in the inside hull, according to the measure of the course and orders the microprocessors for the engine (Fig. 15).

The translation mechanism has components server of SRD type, belt with teeth, wheels with teeth, screw with balls and a mobile planetary gear on roller guiding (Fig. 16). The screw can be blocked through activating an electromagnetic brake (Fig. 17 and Fig. 18).

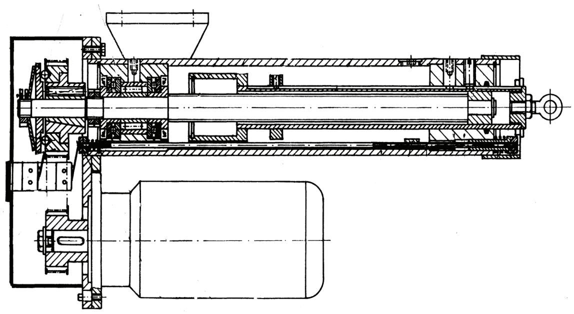

Fig. 15. Unit of translation with parallel acting.

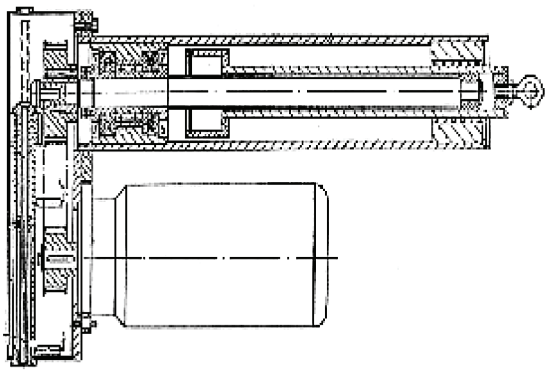

Fig. 16. Unit of translation with parallel acting by dented belts.

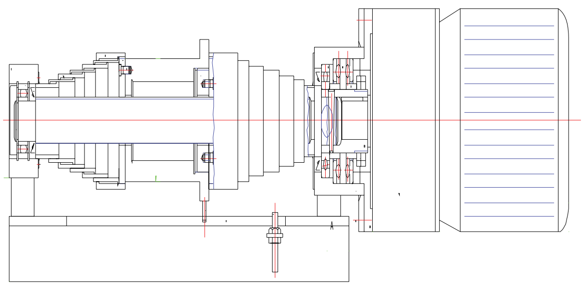

Fig. 17. Units with movable screwdriver with engine – variator.

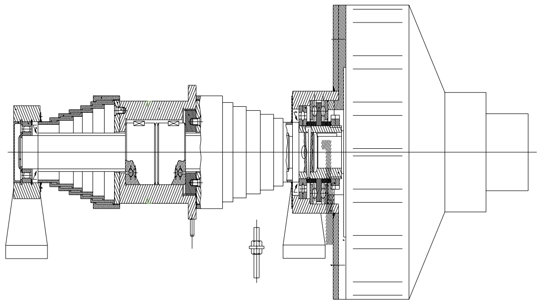

Fig. 18. Units with movable screwdriver and servo-engine.

The solutions presented from the constructive point of view correlated to the one of control of the movement is an important contribution to the development of same moderns system of linear acting for a larger range of applications (Fig. 19), from the most common ones to the intelligent systems of flexible fabrication.

Their development is not limited and has to take into the top industry which require high element regarding the generation and the control of linear movement. Pursuing a systematic tackling of the optimisation by completing the dynamic model and with these parameters roto-translation systems have been achieved.

The research is of great importance as the present calculation algorithms regarding the main dynamic parameters, power and mechanical efficiency.

The applicative and experimental researches viewed the practical checking and the making up of the theoretical patterns used in the output and also convergences to the ways of approaching the problems to reality.

The work integrates itself into the present day researches in the field of the development of the modern mechanic transmit ions making contributions in their optimal design.

The work deals with the assimilation of some modern systems of action of linear electro mechanic actuator type used to machine-tools (Fig. 20 and Fig. 21) from intelligent systems of production and to the ecologic industrial tools on the basis of some patent which should replace the classical ones, energy consuming, immediate use as acting mechanisms of the tubs and obstacle on the hydrotechnical arrangements.

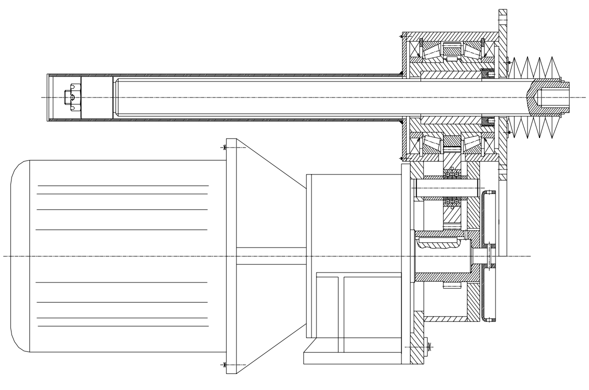

Fig. 19. Units with rotating screwdriver and the field of gears.

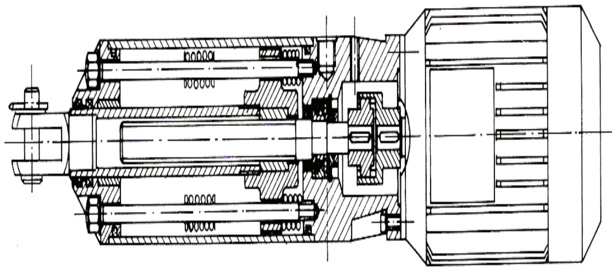

Fig. 20. Units with movable screwdriver.

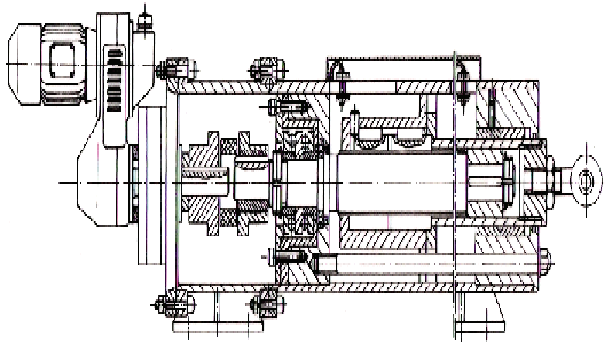

Fig. 21. Units with rotating variator with broad belts.

We also plant for these the achievement and the making use of an invention of my own used on the peak technique of the robots and of machine-tools with parallel cinematic of different industrial tools or spatial techniques.

This offers the best solution to linear actions owing to the large flexibility to the high efficiency to the cinematic, dynamic and high precision capacities.

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