THE INCREASING OF THE TRIBOLOGICAL PERFORMANCES OF THE FLUID POWER EQUIPMENTS

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Abstract: The article presents a series of tribological researches regarding the increasing of the performances of fluid power equipments, developed in the ***Laboratory of Tribology and Lubrication Systems***, within ***Hydraulics and Pneumatics Research Institute*** in Bucharest-INOE 2000-IHP, including some concrete results obtained. In particular, are presented, some researches on the tribological behavior of sealing systems of hydraulic cylinders, as well as several testing devices of some tribology couplings which are specific to hydraulic equipment.

Keywords: tribology, hydraulics, testing laboratory, testing stand, lubrication systems,

1 Introduction

Having **over 50 years** of experience in Fluid Power field, in the current research, besides the theoretical aspects needed to be clarified a series of specific aspects,, in the institute a particular attention has the experimental research, designed to confirm the theoretical research, or showing certain performance of the components or for the equipment which are investigated..
The main research directions in the activity of the institute are:

- hydrotronics, mechatronics and **tribology;**
- green energies;
- technological transfer.

Between the ***10 research laboratories*****, which** were developed in the institute, one of the most important laboratories is **The Research Laboratory for Tribology and Lubrication Equipments,** where were developed o s**eries of research activities** regarding the knowing the tribological behavior of the hydraulic elements and systems, in order to optimize the energetic efficiency of all hydraulic driving systems. It is meant for research in the general field of tribology, especially for the systems and equipments centralized lubrication, that are important for the security of technological systems.

2. The main direction of the tribological research

In t**he Research Laboratory for Tribology and Lubrication Equipments, t**he main direction of the research activities, which are developed are:

1. The tribological research of the sealing systems from the hydraulic drive sistems, especially from the hydraulic and pneumatic cylinders:
2. The tribological investigation of the material couples with radial relative motion, from hydraulic drive systems (radial bearings, radial seals, radial joints, etc..), including hydrostatic radial bearings;
3. Tribological Research of the the material couples with relative frontal /axial motion, from the hydraulic drive systems (flat bearings, axial or frontal, front seals, etc..), Including hydrostatic thrust bearings;

4. Tribological Research of the material couples with the relative translational motion, from the hydraulic drive systems (axial couples, translational seals, and, also, the specific translational systems of the piston on cylinder;
5. Tribological research on classical, modern and modernized lubrication systems.

3. The tribological research of the sealing systems of the hydraulic cylinders

Hydraulic cylinders, which are basic components of hydraulic control and actuation systems, convert hydrostatic energy into mechanical energy, by achieving, in a certain time, a certain force, with a certain speed in a straight stroke and must ensure a proper dynamic behavior,
The researches, regarding the tribological behavior of the sealing system of the hydraulic cylinders, were developed together the specialists from the *University of Poitiers, Poitiers, France*. Until now, were developed two steps:

1. Experimental research regarding experimental the **determination of frictional forces that** occur between the rods of hydraulic cylinders and their seals.;
2. Experimental research in order **to measure** the **friction forces which appear in the pistons seal** of the hydraulic cylinders.

3.1 Experimental researches for determining of the frictional forces from sealing of rod of hydraulic cylinders

This are presented some aspects of conducting, within INOE 2000-IHP, of experimental research on the **determination of frictional forces that** occur between the rods of hydraulic cylinders and their seals. In the first part, are presented some specific elements of the experimental stand developed and in the second part are presented some graphical results.

For experimental determination of frictional forces, occurring **between the seals and hydraulic cylinder rod,** was designed and developed a **testing stand** equipped with modern "on-line" system for measuring the evolution of the parameters of interest. The main unit of the test stand is the experimental device, which contains the investigated sealing and is mounted on the framework of the drive system Figure 1, where it can be seen both the dual sealing sleeve which contains the two gasket U shape, Figure 2**,** the pressure and temperature transducer, as well as the force transducer, Figure 3. A general view of the stand can seen in Figure 4, a, b.

Fig. 1: The experimental device mounted on stand.

Fig.2 The pressure and temperature transducer.

Fig. 3 The force transducer.

a): General view if the stand

b) The manual acting of the pump

Fig. 4: The general view of the testing stand

Some experimental graphical results for rod sealing

To concretize the above mentioned, below will show some examples of complex graphics obtained for **certain pressure** and **speed steps**, which will reveal some interesting and instructive points.

Thus, in Figure 5 si Figura 6**,** are represented the complex characteristic graphs for pressure steps values of **100** bar and **200** bar and theoretical **100** mm/s).

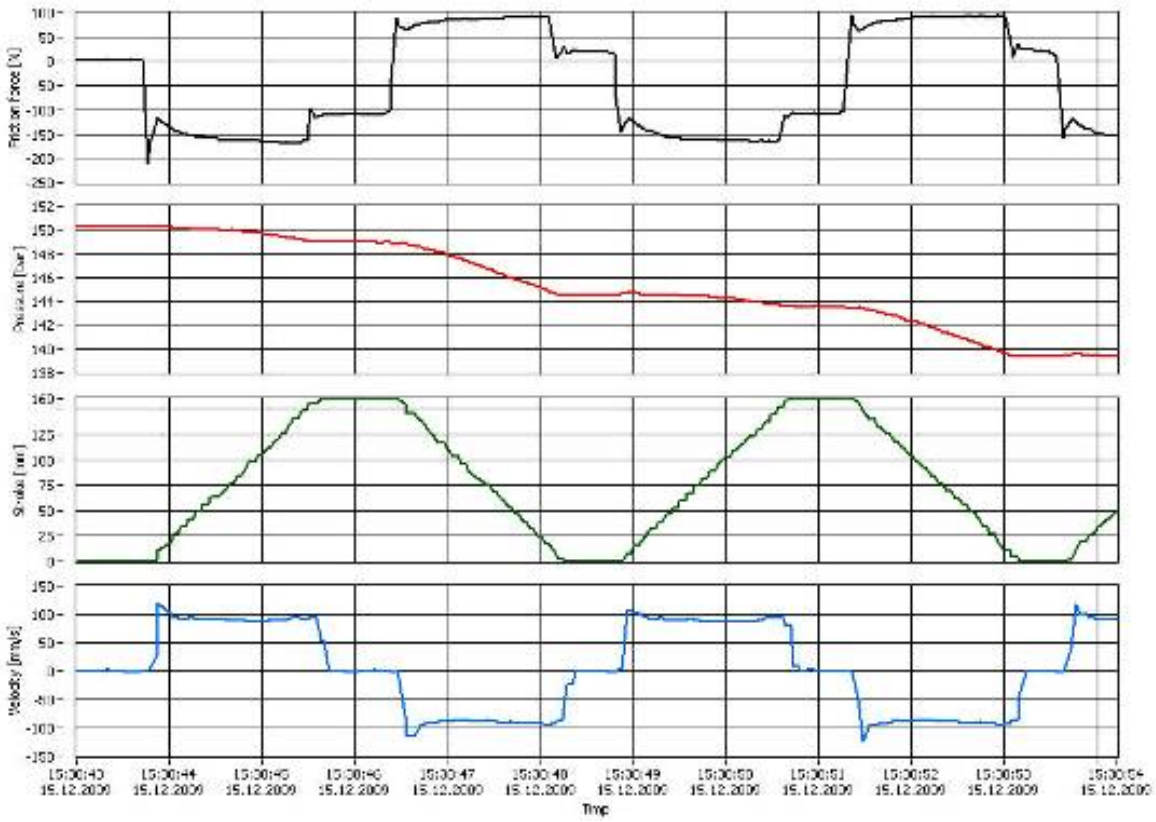


Fig. 5 The complex graphics for **rod sealing** at pressure of **100 bar.**

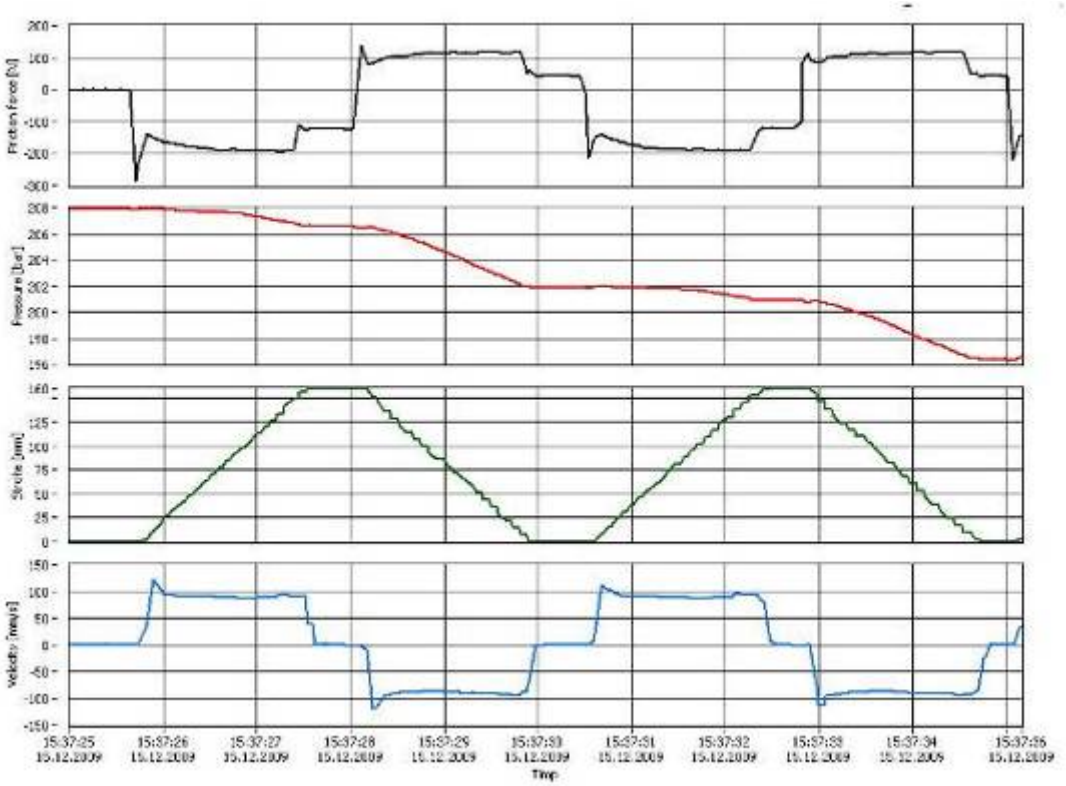
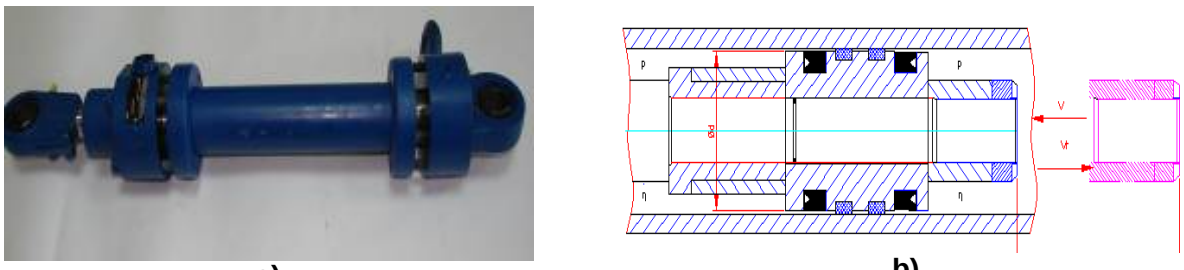


Fig. 6 The complex graphics for **rod sealing** at pressure of **200 bar.**

3.2. Experimental research for measuring the friction forces which appear in the pistons seal of the hydraulic cylinders

The mobile/dynamic translation sealing are specific to the hydraulic cylinders, Figure 7a, where realize the sealing on the piston with diameter *d*, being in reciprocating translation motion on the stroke, in a fluid medium with the constant viscosity *η* and under pressure *p*. In Figure 7b, *d* is the piston diameter, *S* is the stroke, *v* and *vr* are velocities in the both senses



a) **b)**

Fig. 7 Hidraulic cylinders piston sealing

For evaluating the friction forces from the **piston seal** of the hydraulic cylinders, there was **designed and developed a special experimental device**, which was conceived purposefully for working by mounting on an existing stand, which provides operational strokes for piston.
The adopted technical solution was the replacement of the piston, with one new piston double sealed, which contains two spaces where are placed 2 U seal shape type seals, fixed with the wings facing one another.
The pressure of working oil, sealed by the two gaskets tested, is created by using a hand pump, which has a pressure gauge to indicate directly the working pressure and, also, a local display pressure transducer.

The **experimental device**, prezented in Figure 8, operates in vertical position and it needs the mounting of the rod of the experimental device on the mobile rod of the hydraulic cylinder from one existing Stand.. Figure 9 presents the pressure and temperature transducer and Figure 10 presents the force transducer, used to measure the friction forces.

Fig. 8: The experimental -device mounted on stand.

Fig. 9: The pressure and temperature transducer.

Fig. 10: The force transducer.

Also, the stand has others transducers as: stroke transducer, a digital thermometer for the ambient temperature and flow transducer.
By means of special electric cables, all signals provided by transducers reach the acquisition board installed on the computer, and this one, based on specialized software, allows the capture, storage and processing of data.

Some experimental graphical results for piston sealing

To concretize the above mentioned, below will show some examples of complex graphics obtained for **certain pressure** and **speed steps**, which will reveal some interesting and instructive points. Thus, in Figure 11 si Figure 12**,** are represented the complex characteristic graphs for pressure steps values of **100** bar and **200** bar and theoretical **100** mm/s).

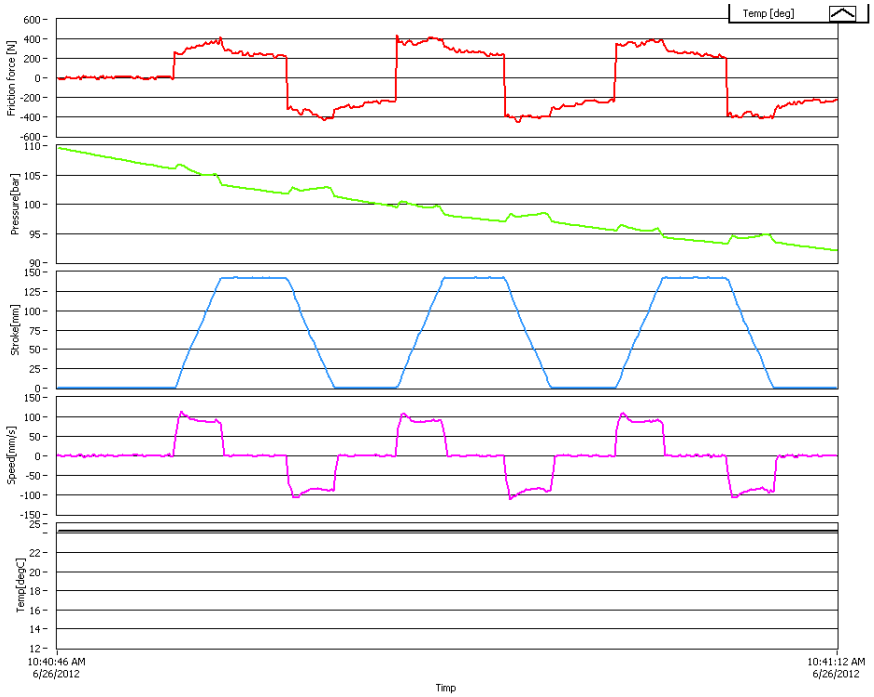


Fig. 11 The complex graphics for piston sealing at pressure of **100 bar.**

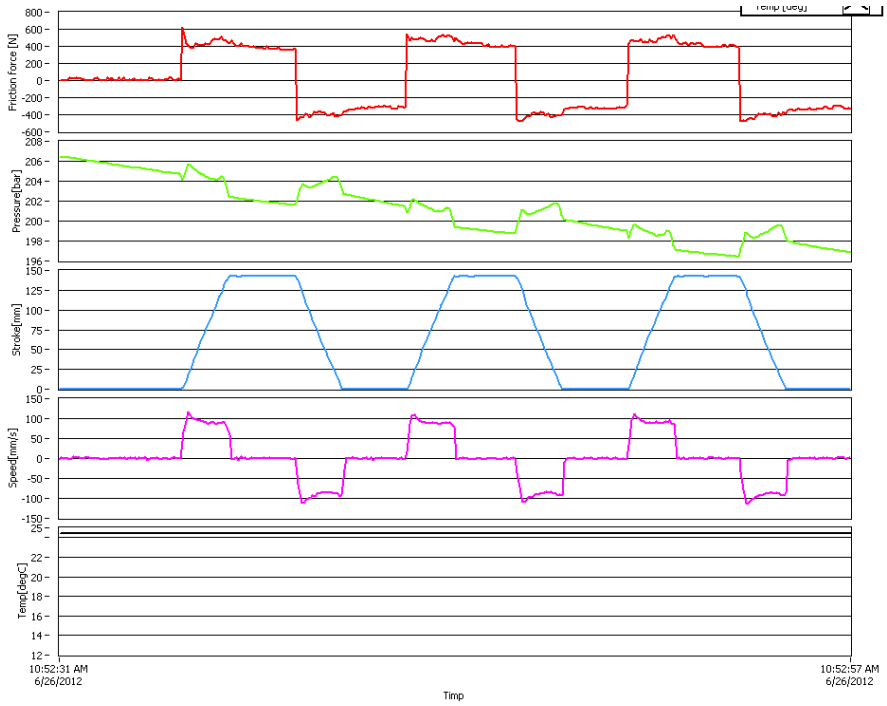


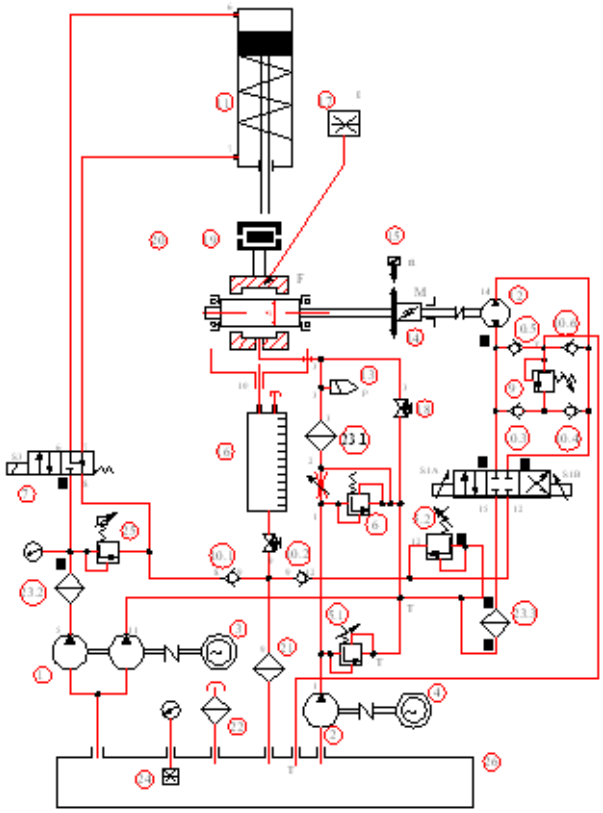
Fig. 12 The complex graphics for piston sealing at pressure of **100 bar.**

4. The testing device for radial hydrostatic bearings and radial sealing systems

In the **Research Laboratory for Tribology and Lubrication Equipments,** there is an electro-mechanical-hydraulic testing device for radial hydrostatic bearings and radial sealing systems, which enables the development of research for industrial applications, regarding measuring of the friction couple/moment which appears in the working regimes of the machinery and equipments. This testing device is presented in the **Figures 13,** where it can see, also, the Hydraulic action scheme.

–Side view-

–Top view-



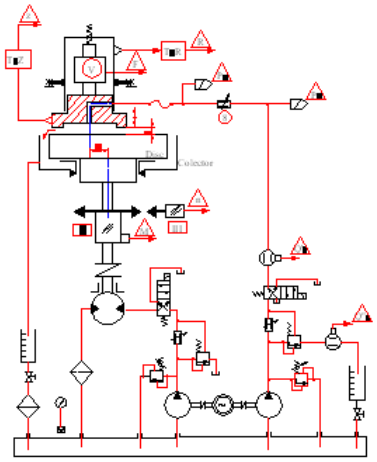
Hydraulic action scheme

Figure 13: The testing device for radial seals and radial hydrostatic bearings

5. The testing device for frontal hydrostatic bearings and axial sealing systems,

A second device, also, an electro-mechanical-hydraulic device, which is in the Research Laboratory for Tribology and Lubrication Equipments, allows to develop the experimental researches of the axial/frontal hydrostatic bearings and frontal sealing systems, belonging from industrial applications. The testing device is presented in **Figure 14.**

The physical testing device



Hydraulic action scheme

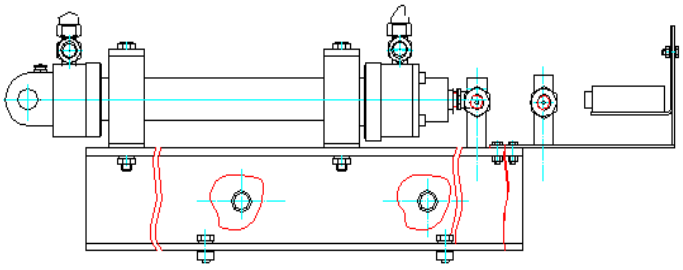
Figure 14. The testing device for frontal seals and frontal hydrostatic bearings

6. The durability Testing of the translational seals systems from the hydraulic cylinders

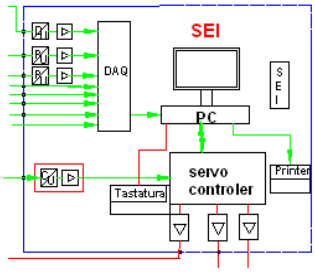
Other testing device is for durability testing for the transnational seals system from hydraulic cylinders, which is presented in the **Figure 15**.

The phisical testing device

The aquisition system



The design of testing device



The scheme of aquisition system

Figure 15: The testing device of seals durability

7. Classical, modern and modernized lubrication systems

In the Tribology Laboratory was **effectuated o lot of studies** regarding the basic and modern lubrication systems used in the industrial equipments, in order to create new technical solution and for improve the used now on the old machineries.
The laboratory has a **number of functional panels,** for the main systems of centralized lubrication, namely for volume dosing systems, **Figure 16**, progressive dosing systems, **Figure 17,** the lubrication systems with two lines, **Figure 18**, the recirculation system with electronic monitoring, **Figure 19**, and, also, the micro lubrication systems and spray lubrication systems..
These functional panels are used in **training activities** of our institute, which are developed with the **industrial companies, in order to transfer the basic knowledge**

Figure 16: The volumic dosing lubrication systems,

Figure 17: The progressive dosing lubrication systems

Figure 18: The lubrication systems with two lines

Figure 19: The recirculation lubrication system with electronic monitoring

These **functional panels materializing**, at small scale, **the real lubrication systems** of the machines and technological equipment from the industry, and can be used for testing for specific lubrication components, for the training activities in the lubrication field, and, also, for functional demonstrations of the main/based lubrication systems.

8. Conclusions

The paper presents a series of tribological research which have developed in Tribology and Lubrication Systems from Hydraulics & Pneumatics Research Institute-INOE 2000-IHP, regarding the increasing of the performances of the fluid power equipments.

- The paper presents, in detail, the measurement device and the stand for measuring frictional forces in rod seals and in piston seals of hydraulic cylinders and there are shown graphic examples of their variation.
- Valid measurements of frictional forces are obtained in downward stroke, due to the phenomenon of natural alignment of the piston rod and the force transducer that eliminates the occurrence of additional jamming forces.
- It is shown that the three graphs for two consecutive cycles, which are almost identical, demonstrate *repeatability* of the process.
- In the paper are presented examples of complex graphical variation, for 100 bar and 200 bar, two examples for rod friction forces and two for piston friction forces.
- The measurement system, based on advanced transducers and electronic and computerized data processing, guarantees the accuracy of measurements performed on the stand.

The paper presents diferent researching devices for radial and frontal hydrostatic bearings and sealing systems, and, also, some classical, modern and modernized lubrication systems
Finally, considering all the above, it can say that the **Tribology and Lubication Systems Laboratory** from INOE 2000-IHP has an important endowment and can develop interesting research works on tribology and lubrication industrial equipments.
The development of large scale works, needs integrated research strengths, that can be achieved through cooperation between universities and institutes with expertise in the field, from different countries, which is posible only on one European research projects

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