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APPLICATION OF 3D SOFTWARE PACKAGES FOR DESIGNING TRIBOMETER OF MODULAR TYPE

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Abstract: *In this paper is presented advantages of modular type of tribometers using various types of softwares, especially for modelling. Designing this type of tribometer allows significant saving regarding time, space, people, raw materials as well as financial resources. Design of tribometers followed with testing and verifying, which implies simulation using various types of softwares, significantly improve the way and standards of tribometer contruction. Selection of the desired parameters which would be used in the experiments is very important and the first step in designing of the tribometer. Testing and verifying is the last step when scientists and researchers get the result of the final evaluation whether or not to proceed to construction of the tribometer.*

Keywords: *tribometer design, rapid construction, CAD software, simulation*

1. INTRODUCTION

The machines and equipment for various tribology experiments need to be maximal versatile. The versatility is reflected through possibility of providing variety of experiments. These types of equipment are specific and mostly designed, constructed and used by researchers and scientists for very complex measurements and experiments. These equipment need to be, not just versatile but very precise, providing accurate results which are used as an input for further experiments or calculations.

Tribometers are widely used for experimental research for measurement of friction characteristics under laboratory conditions. This laboratory conditions have to be pre-defined, before measurements are performed. Also, equipment and measurements are designed for conducting different types of experiments, to obtain results for further experiments. Laboratory conditions mean various parameters are constant, for example normal force, velocity, temperature and humidity [4]. Because of different types of the contact [5] versatility of equipment is the most important characteristic which is required.

There are many different types of tribometers for different use [1] [2] [3] [6]. Different use means different structure of tribometer, different processes followed with different parts of tribometer. So, rapid development of tribometers based on software for 3D modelling is required. The modular tribometer will be able to speed up process of design and construction of tribometers depending on type of experiment. Today, there are commercial universal tribometers which are not the same as modular we want to present. Universal tribometers offer the various options and different types of experiments on the same equipment. The main difference between universal and modular tribometer is that on the universal all necessary parts are already mounted on the same equipment and just small corrections in software enables working on test equipment. Also, the additional parts can be added for desired experiments [7]. On the modular tribometers researchers can choose which of the tribology parameters wish to monitor. So, after calculations and simulations of properties of equipment structure, constructors can proceed with equipment construction.

Modular tribometers are suitable for rapid construction of equipment and what is the most important, for performance evaluation and conformance to researchers' requirements. Software for 3D modelling allows that before construction of the equipment to check, test, verify and validate successful experiment's output. This means there is a possibility of predicting success/failure of the experiments. The results of this prediction provide valuable significant data which could save, on the first place, financial resource and then time, space, people, raw materials, etc.

The aim of this paper is to propose methodology of using software for modelling tribometer which have to be designed and tested performing simulation for selected parameters. The whole process of testing, quality checking and final adjusting of modular tribometer need to be conducted before construction. Every part of tribometer is compact in size, having the best possible characteristics for selected parameters, overcome technical difficulties and the end checking is the tribometer functional.

The paper is structured as follows: Secton 2 present importance of using software for 3D modelling. Section 3 describes one example of modular tribometer and what type of experiment can be carried out. The conclusions are given in Section 4.

2. BENEFITS OF 3D TRIBOMETER MODELLING

CAD technology is ubiquitous for diverse array of fields, particularly engineering and manufacturing [9]. It is integral part of the every process where is needed to meet some goals such as reducing design to production lead time, better engineering analysis, additional flexibility and faster response for design modification [8]. All these benefits are reflected to manipulation with designing parts necessary for final construction. The greatest attention is given to:

- dimensioning of critical parts, which are necessary for conducting successful experiments resulting to relevant outputs;
- dimensioning of measurement parts;
- possibility to construct various equipment for different experiments mean that modules have been already designed for rapid design;
- simulations which are very important to see if all parts of the tribometer are properly assembled, if all system is functional or not to react in time before spending resources, before construction.
- simulations have another advantage, researches can see and conclude is there any overlapping of the work areas, some errors, mistakes and fault decisions which are made during equipment and process design;
- predicting values of the parameters which are selected for experimental research (normal load, viscosity, stress generated in the contact zone due to the given force, etc.).

All steps in design and construction depend on requirements from researches and scientists what parameters would be considered. Also, conceptual development of modules is dependant of requirements.

In our case, the most important parameters were linked with basic parameters typical for hydraulics and its components which can be found in real industrial systems. Also, we monitor processes which appear between selected pin and plate in oil environment. Based on this we could simulate and calculate if the required processes are possible to monitor and get relevant results. The most important parameters for our research were:

- liquid resistance (in our case liquid is oil) inside the container and
- stress in the contact zone due to given load.

In the next section will be presented one modular tribometer designed, tested and constructed for tribological phenomena in hydraulic components (pumps, motors, cylinders and valves).

3. EXAMPLE OF EXPERIMENTAL EQUIPMENT

The first step is defining the type and concept of the tribometer. In our case, whole concept is based on analysis of hydraulic components and characteristics of wear processes which are occur in that kind of industrial equipment. From the literature [10] [11] linear sliding movement and abrasive wear mechanism are the most common and the most important in the hydraulic components. Regarding this fact, pin-on-plate tribometer was selected to be designed and constructed because we had wear process between pin and plate in oil environment. Also, it can be able to control some of the basic tribology parameters such as load in contact, slide length, sliding speed, liquid resistance, etc.

On the figure 1 is shown model of tribometer which is divided in 3 bigger units:

- experimental unit (positions: 1, 2 3 4 and 7);
- control unit (positions: 6 and 8) and
- pneumatic drive unit (position: 5)

All units need to be well connected and functional. Potential problems with the first starting up of the constructed tribometer can be prevented using number possibilities of 3D modelling software packages.

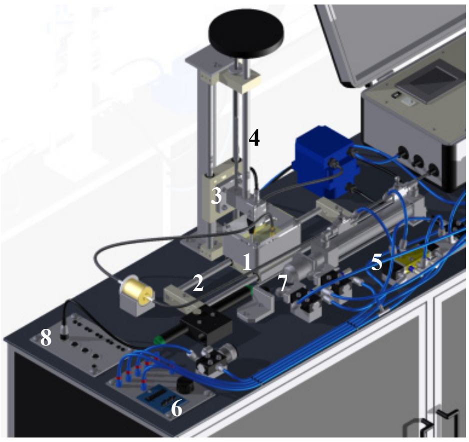

Figure 1. Sub-divided components of tribometer model

First of all, whole design of the tribometer is based on container with a plate and oil (1), placed on a horizontal linear guides (2), moving alternately, while pin is stationary. Pin bracket (3) is set to vertical linear guides (4) and given loads on the pin passed through the bar, which is also a dynamometer for measuring of friction force. Drive system for reciprocation motion is pneumatic (5) with pneumatic cycle counter (6).

On container with a plate (1) displacement transducer is fixed (7), with function to measure, in real time, container position and thus enable the accurate determination of velocity and moments when container change movement direction. On a tribometer base plate surface there is a connection panel for this transducer (8).

Now will be described the most important part of the tribometer, the contact zone where tests are performed (figure 2).

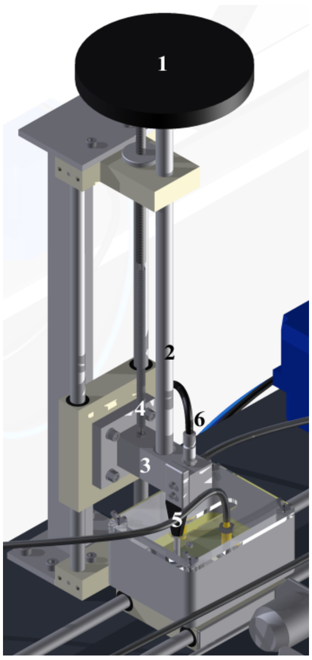

Figure 2. System for setting load and force measurement

Value of normal load in the contact zone is defined by calibrated weights (1) where the forces transferred through the shaft (2) with a spherical end are to the pin bracket (3). Compensation of own mass elements which are located on the pin bracket is performed through a spring with a threaded spindle (4). On pin bracket (3) set the single-axis piezoelectric vibration sensor (6) which measures vibrations in the tribological contact in the vertical direction.

The close-up view of the above described contact zone is shown in figure 3.

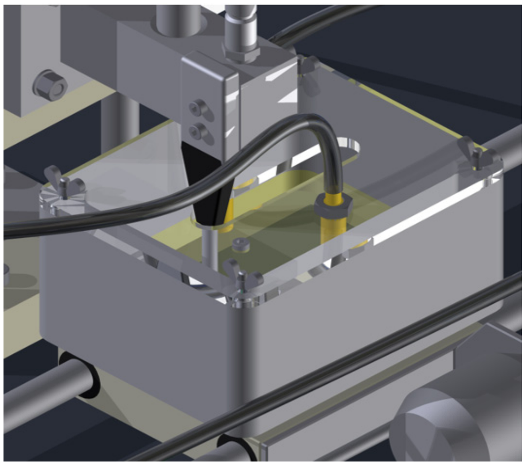

Figure 3. Close up view of contact zone

There is a plate attached at the bottom of aluminium container. Pin has cone top that fits into a spherical end of the dynamometer bar and thus carries the normal force evenly over the entire surface of contact. Container has a volume of 500 ml and is filled oil up with oil to about 1/3 of its height. Container is covered with a transparent cover on which there are connections for oil circulation - suction and return. Suction line takes oil from the bottom of container on one side and returns oil back to the surface on the other side of container. This is to ensure adequate oil mixing during circulation.

And, at the end the third part of the tribometer is pneumatic system (figure 4).

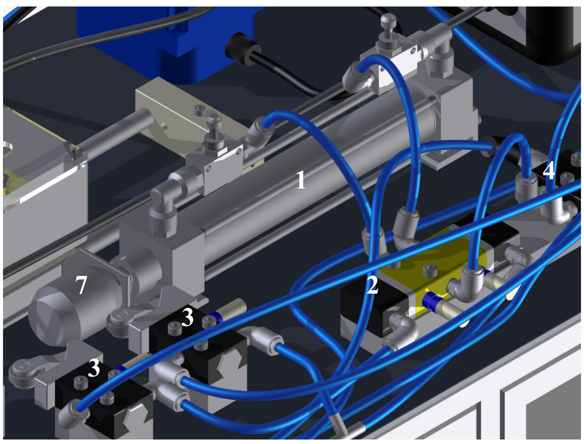

Figure 4. Pneumatic drive unit

This part is assembled of pneumatic cylinder (1), air-operated distribution valve 5/2 (2), two pneumatic limit switches (3), pneumatic logic valve 3/2 (4), pneumatic cycle counter and the reset button. Limit switches limit stroke of cylinder piston which is fixed to container. Switches are fixed and the stroke length is determined by varying the length of a cylindrical end part of cylinder (7) which activated limit switches. At both command lines, which bring compressed air to the cylinder, set of throttle valves that regulate the speed of the cylinder in both directions.

4. CONCLUSION

In the times where financial savings are more important than results, there need to be the way which will satisfy both conditions. Besides that, there is a constant need for various types of experiments which need to be precise and its results need to be accurate. Development of modular tribometers could be good solution for issues related for rapid construction of tribometer and obtaining accurate results for selected parameters. Tribometer which is designed from modules tested and verified through simulations it is very simple to proceed to the next step regarding construction. Desired and requested parameters are also important because software could obtain possible mistakes and failures in design before construction.

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