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The mobile tribotester design in roller-block and roller-roller system using in sliding and rolling-sliding contact

Projekt mobilnego tribotestera w układzie rolka-klocek i rolka-rolka, wykorzystywanego do badań w skojarzeniu ślizgowym i toczno-ślizgowym

HENRYK BĄKOWSKI
ZBIGNIEW STANIK
MAREK JASIOK *

The paper presented an experimental study to estimation surface layer wear in sliding and rolling-sliding contact using in different operational conditions of study, such as extremely low temperatures, low or high pressure, presence of lubricant or sand whether high rotational speeds.
KEYWORDS: sliding and rolling-sliding contact, tribotester

In each sliding or roller-sliding combination, tribological wear occurs, which results from the friction process. Wear is the condition of the machine or its individual parts at the designated wear stage. Wear, on the other hand, is such a change in the condition of the part or machine that causes the loss of functional properties. A wear depends on the type of friction, presence of lubricant, loading of machine parts, slip or rolling speeds and temperature. As a result of the friction, there is a loss of material from the contact surface, change of the surface layer's properties and deterioration of the friction surface quality – thereby increasing roughness and cracks, cracks and defects after torn material particles. Therefore, it is important to conduct research in the area of assessment of the surface layer in a slip combination in order to delay changes occurring in the wear process [1].

Previously, laboratory tests were carried out on an Amsler type device (fig. 1) in a roll-block or roll-roll arrangement. The main limitation in these tests were operating parameters (ie slips) and high purchase costs of the device, so that not every user had access to it (in contrast to the constructed position described in the article).

The slip values were selected depending on the geometrical dimensions of the cooperating rollers. Proposed position is devoid of this limitation, therefore during the tests, the slip values can be changed depending on the changing operating conditions. The main idea that guided this undertaking was to obtain results similar (or identical) to the results obtained on a professional Amsler type stand in the roll-roll or roll-block layout [2].

* Dr inż. Henryk Bąkowski (henryk.bakowski@polsl.pl), dr hab. inż. Zbigniew Stanik (zbigniew.stanik@polsl.pl) – Wydział Transportu Politechniki Śląskiej; mgr inż. Marek Jasiok (serwis@inter-turbo.pl) – Inter Turbo

Fig. 1. Amsler stand for wear test

The aim of constructing an experimental station for the assessment of the surface layer in a rolling-sliding association was to allow any user to carry out tests under different conditions, e.g. at extremely low temperatures, in the presence of lubricant or sand and at high rotational speed. Thanks to the developed solution, the operating costs of the device have been reduced. In addition, both the device and its systems are easily accessible and the costs of replacing them are low [6, 7].

Position and materials

The main premise for designing the testing machine was the economic aspect. By the way, it was shown that even a small financial effort can be made to build a station corresponding to a professional device [4]. The basic elements necessary to make a tribotester are:

- PMT-24V500 W power supplies,
- DC electric motors with planetary gear,
- 500 W motor controllers
- speed controllers
- extensometer beam,
- self-aligning bearings in housings,
- drive shafts,
- research rollers (counter-sample and sample).

The use of a DC motor equipped with a planetary gearbox allows to obtain high torque at a rotational speed of 500 rpm.

The most important feature of the presented position is the possibility of independent control of the rotational speed of two separate drive shafts (fig. 2). In practice, any slip values regardless of the size of the sample or counter-sample can be obtained.

Roller bearings in housings were used for bearing bearings. By placing the bearings in the housing, it was possible to attach the rollers to the base of the station. Bearings in the cast iron housing allowed easy assembly and disassembly of rollers on the stand. The advantage of the set is its own supply of grease, which can be supplemented with a special valve if necessary.

Fig. 2. View of the tribological node of the experimental station

In order to measure the friction force between the cooperating rollers, a tensometric bar connected on one side to a raised electric motor was used, and on the other – to the position plate. As the frictional resistance increases, the engine tries to rotate around its own axis. Before this rotation, it is stopped by a measuring system consisting of a strain gauge beam, recording the value of the force that is trying to turn the motor (fig. 3). Fig. 4 and fig. 5 present a 3D model and a view of the test stand for wear tests, and in fig. 6 – a schematic diagram of connecting all systems necessary for the correct experimental work of the tribological stand.

Fig. 3. View of mounting the extensometer beam to the plate and drive motor

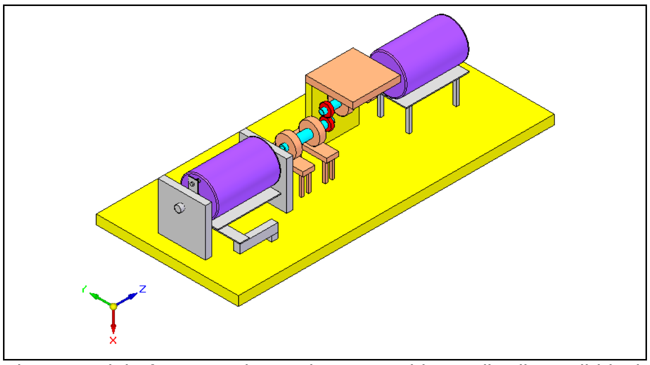

Fig. 4. Model of an experimental test stand in a roll-roll or roll-block system

Fig. 5. View of the actual position

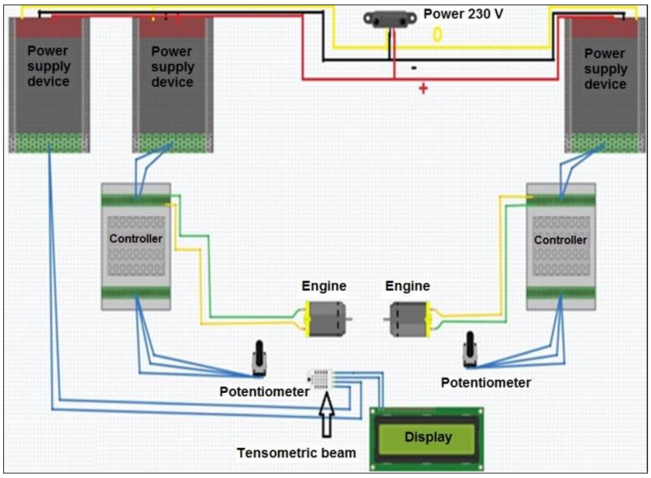

Fig. 6. Connection diagram of the system

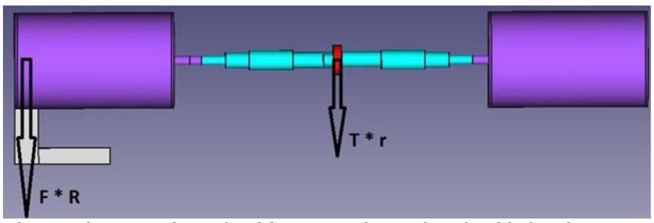

Fig. 7. Diagram of a pair of forces to determine the friction forces at the station

To determine the coefficient of friction (friction force T) a pair of forces was used (fig. 7). The radius R is the distance from the extensometer beam to the motor axis, while r is the radius of the roller.

The friction force was determined from the transformation of the formula $T \cdot r = F \cdot R$:

$$T = \frac{F \cdot R}{r}$$

Tribological and simulation tests

The tests were performed on an experimental stand for tribological tests in a roll-roll system and in a roll-block system [5].

The main advantage of the universal testing station is the possibility of changing the rotational speed of the shaft (and thus the slip) with both the deposited counter sample and the sample. In order to show the similarity of the wear process in the experimental station (fig. 5) in relation to the course of this process on the standard Amsler station in the roll-roll system (fig. 1), fig. 8 shows the wear of the top layer in the rolling-sliding combination. This similarity was confirmed by metallographic examinations of the surface layer [3, 4].

a)

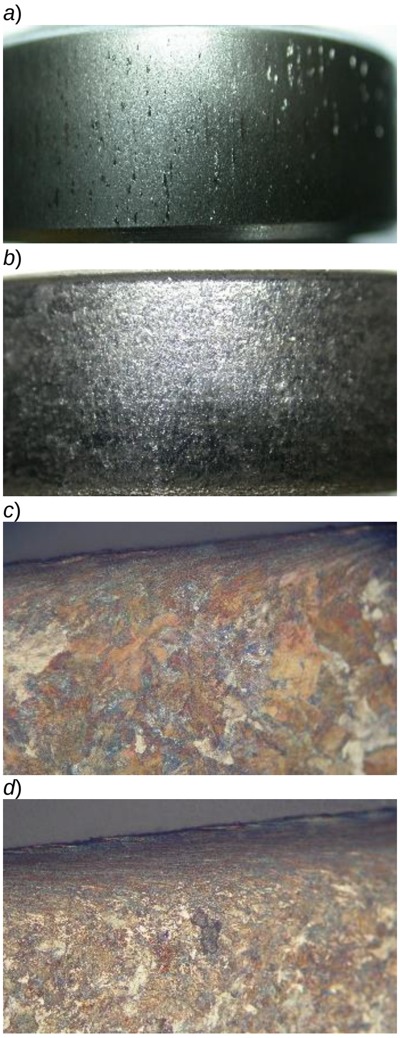

Fig. 8. View of the friction surface and top layer of the roll after cooperation at the Amsler station (*a*, *b*) and in the experimental stand (*c*, *d*)

Simulation research using the finite element method presents stress distribution and safety coefficient in relation to the entire station [8]. The greatest stresses occur between the plate and the attached arm, pressing the upper roller against the lower one, and at the end of the roller on which the roller is mounted, which may lead to cracks (fig. 9).

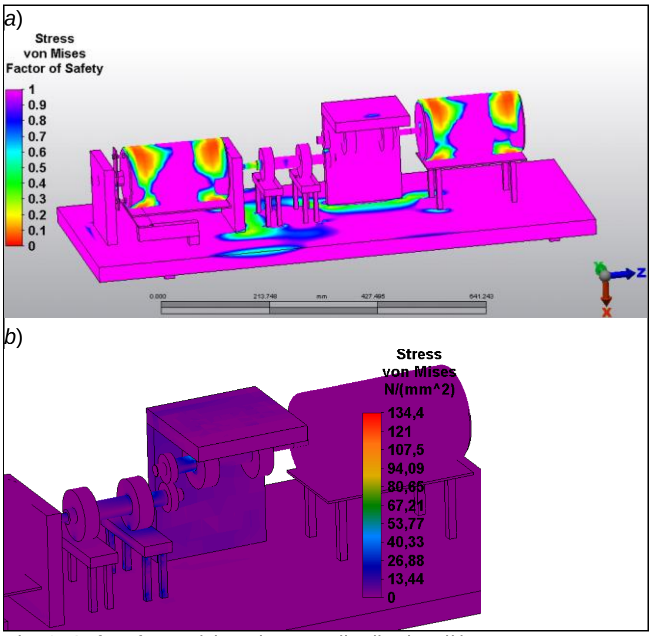

Fig. 9. Safety factor (*a*) and stress distribution (*b*)

Conclusions

So far, research has only been carried out on an Amsler type device. They were limited to tests in selected operating conditions. It should be emphasized that the Amsler type device is expensive, and thus it is not available to any user – in contrast to the built experimental station [6, 7]. The results of the research conducted on it are similar to the results obtained on a professional Amsler type stand in the roll-roll system. Due to this, the mechanism of wear in both cases is identical, as confirmed by metallographic tests (fig. 8).

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