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INVESTIGATION OF THE PRESS FIT JOINTS BY THE TRIBOLOGY ASPECT

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Abstract. *The strength of a press fit joint represents static friction force that is the biggest force that can be transmitted by means of this joint. The real strength of a press fit joint can only be determined by loading the joint up to the moment of parts separation. However, in projecting phase of engineering practice calculation of the press fit joint strength is often necessity. In order to reliable estimate the press fit joint strength it is necessary to know real value of static friction coefficient. Calculation method of press fit joints as specific tribomechanical systems with experimental investigation of their friction coefficient values is given in this paper.*

Key words: *tribology, press fit joints, friction force, friction coefficient.*

1. INTRODUCTION

Press fit joints have simply form and way of assembling and because of that they have application in projecting of transport vehicles. A press fit joint represents a bond between two parts in contact and it is realized by the static friction effect that is caused by mutual pressure acting on their contact surfaces.

The strength of a press fit joint represents static friction force. In fact this is the biggest force which can be transmitted from one to another part in contact. Because of that, a press fit joint represents a specific tribomechanical system. The most important feature of this tribomechanical system is it's real strength.

Press fit joints such as gear-shaft, bearing-shaft, wheel-axle, brake disc-axle and so on are very important mechanical parts. This is because the strength of a press fit joint directly has influence on safety of transport vehicles.

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2. THE STRENGTH OF A PRESS FIT JOINT

The real strength of press fit joint can only be determined by loading the joint up to the moment of parts separation. The value obtained in this way is different from the one obtained theoretically by means of calculation. This is the cause of the unreliability in choosing the coefficient friction value, estimating the real joint interference and calculating the contact pressure.

In Fig. 1. is given an overview of parameters and features that have influence on contact pressure and friction coefficient and in that way on the strength of a press fit joint.

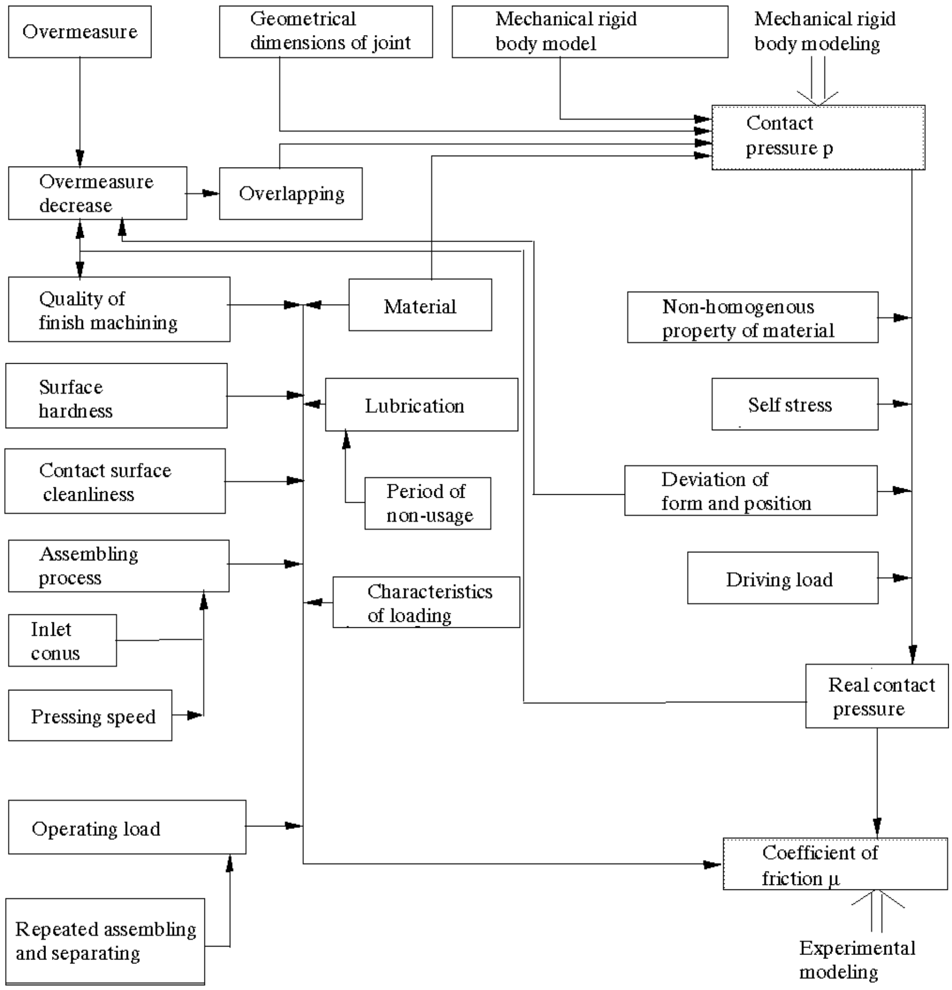

Fig. 1. Influencing parameters and features on press fit joint strength

The next formula is in use for the press fit joint strength calculation:

$$F_{\mu} = \mu F_N = \mu p A = \mu p \pi d l \quad (1)$$

It can be seen that increasing in press fit joint strength can be obtained by the increase of the joint diameter (*d*), length of the press fit joint (*l*), contact pressure (*p*) and friction coefficient (μ). The increase of the joint diameter and length causes the increase of the volume as well as the weight of the unit and in this way the increase of the whole construction proportions. On the basis of the previous an engineer must avoid the increase of the press fit joint strength in this way.

The contact pressure can be increased by performing larger joint interference or by increased stiffness of parts in a joint. The increase of the contact pressure is limited by material yield strength point of parts in a press fit joint.

The friction coefficient value has large interval of possible values and depends on a lot of parameters. These are: nature and properties of used material, value of the contact pressure, lubricant film properties, contact surfaces roughness, contact time, presence of the extraneous bodies in contact zone and so on. Friction coefficient can be increased using some technological acts and surfaces treatment. However, the friction coefficient value must be limited for the purpose of assembling and separating press fit joint parts without performing damages on parts contact surfaces.

There is unreliability in defining the strength of a press fit joint. This comes mainly from unreliability in defining the value of coefficient of friction for the concrete instance. An investigation has been carried out at the Faculty of Mechanical Engineering in Ni{ in which static friction coefficient has been studied.

For example, taking into account recommendations for choosing the interference values in the case of press fit joints for railway vehicles the larger contact pressure value can have mostly two times bigger value then the smallest one. If different kinds of lubricant and different condition of pressing to make a press fit joint are taken into account, the biggest value can be five times bigger than the smallest one (6). Therefore, the strength of press fit joint can be change greatly with frictional features changing.

3. Calculation of a press fit joint

In calculation of press fit joints start point is working load. This load is very important because it causes tangential and/or axial forces on parts surfaces in contact in a press fit joint. With the purpose to transfer these forces from one part to another it is necessary to obtain existence of a force that can resist sliding between the parts in contact. The force between parts in a press fit joint that does that is called friction force. Elastic deformations on parts in contact caused by the existence of interference cause contact pressure that than produces this force. Calculation of a press fit joint should give the interference value that ensures mentioned conditions that is nominal values and parts tolerances of a press fit joint.

An algorithm in Fig. 2 shows the calculation method of elastic loaded cylindrical press fit joints. Some input data for the calculation depend on the construction demands. The others are obtained by measuring or adopted from the recommendations.

A computer program for press fit joints calculation has been made on the basis of the shown algorithm. Faculty of Mechanical Engineering as well as Mechanical Industry find this program very useful for this purpose.

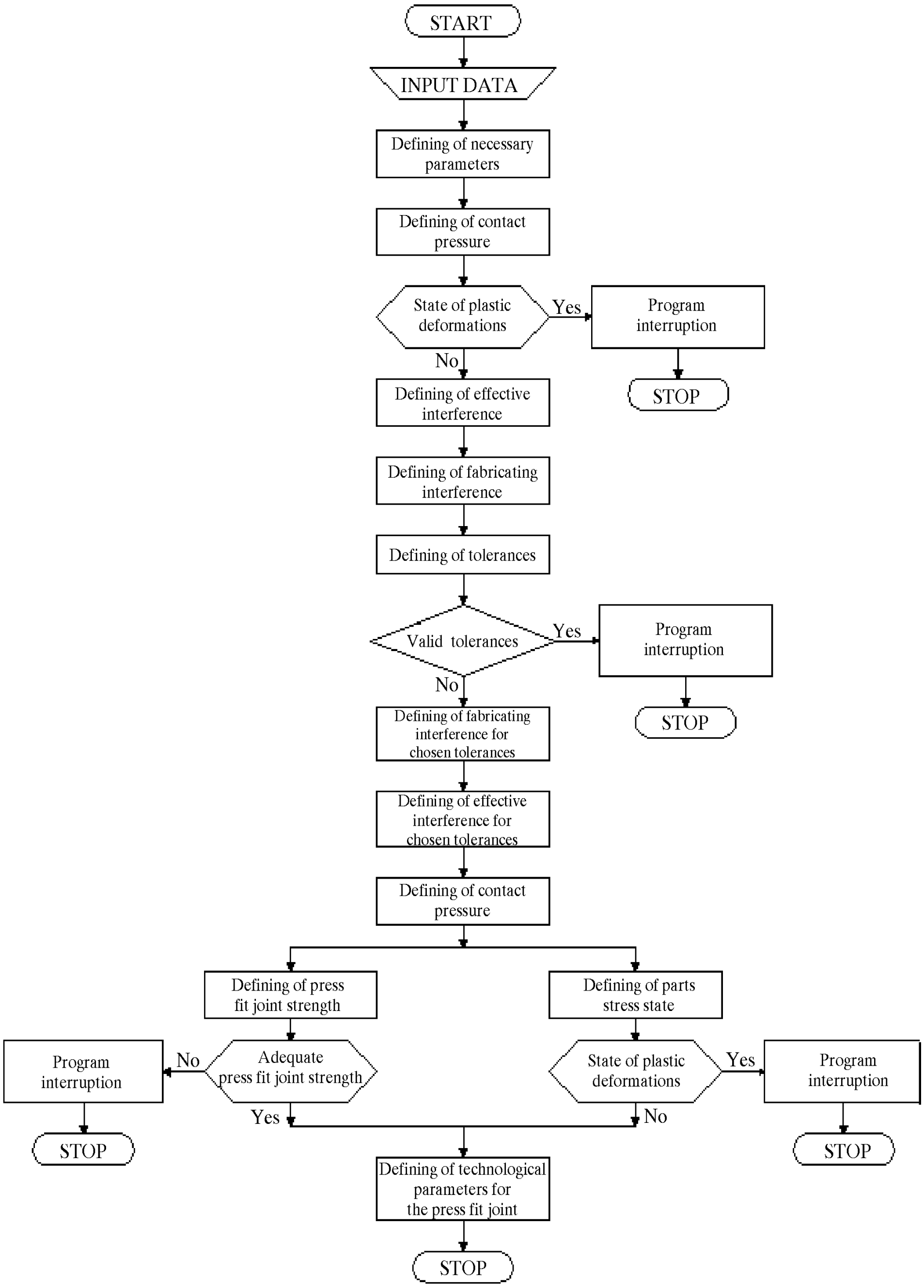

Fig. 2. Press fit joints calculation algorithm

4. THE EXPERIMENTAL INVESTIGATION

In the case of static friction establishing the friction coefficient value can be done only in very short period of time, that is in the very start moment of sliding. The static friction force is tangential resistance force that appears during so-called boundary relative displacement. The relative displacement proceeds to the visible, macro displacement. Taking into account this fact, static friction force can be measured only in the very moment of sliding beginning. This is for the reason that in the next moment, after sliding has started, this static friction force changes into kinetic one. This process can be explained by conditions of forming micro-connections and it has stohastical (accidental) character.

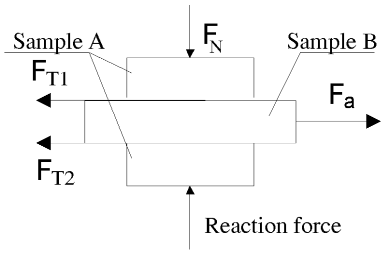

Fig.3. Schematic review of experimental model

Experimental model for establishing static friction coefficient, projected specially for this type of investigation, is shown on Fig. 3. On this base, the measuring equipment was made and investigation was done with samples in the form of plates.

Taking into account this experimental model static friction coefficient can be established by formula:

$$\mu = \frac{Fa}{2F_N} \quad (2)$$

In this way static friction coefficient is established by two measuring force values (F_a and F_N) and because of that this value is very reliable. On the other hand, the next formula is often used for friction coefficient calculation for cylindrical press fit joints:

$$\mu = \frac{F}{p\pi dl} \quad (3)$$

The values obtained by this formula are somewhat unreliably because of the fact that the contact pressure value is not measured but just approximately calculated.

Experimental investigation was executed in two separate parts. The aim of the first experiment was examining the influence of the surface roughness and hardness on the static friction coefficient. This was done with samples in the form of plates by the measuring equipment specially made for this occasion, as it is shown on Fig. 4.

This measuring equipment should offer conditions for measuring vertical load force (F_N) and longitudinal force (F_a). The last force represents friction force in the beginning of the sample parts sliding. Except forces it should be enabled to measure displacements of sample parts too. This is important because it is necessary to record force just in the moment when the sample parts begin mutually moving.

The method named measuring mechanical values by electrical way is used. This method is reliable and respectable in modern metrology. For this purpose program BEAM 3.1 is especially useful and it was used for this experiment.

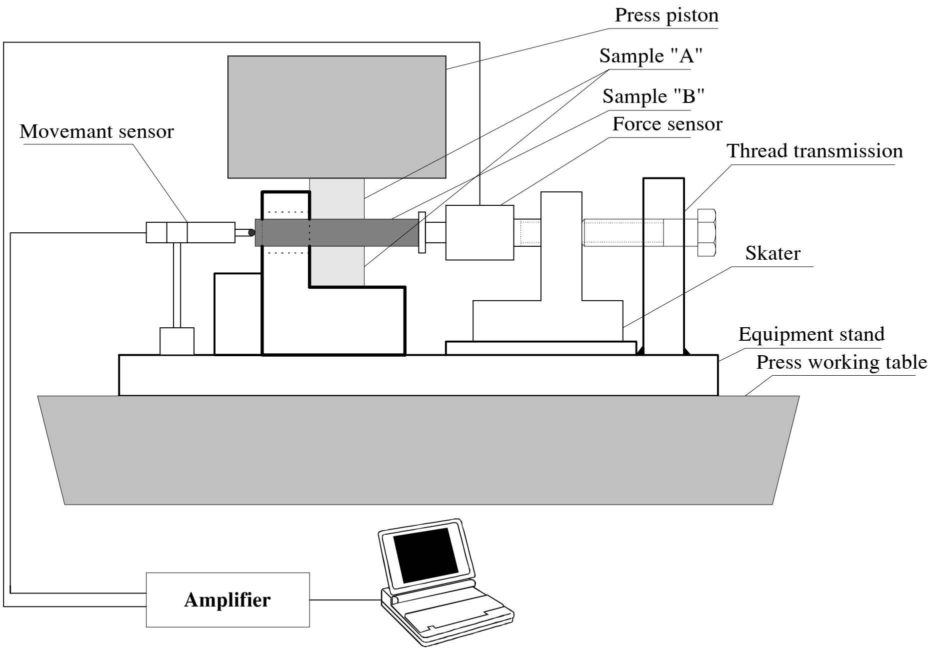

Fig.4. Schematic review of measuring place for measuring static friction force

Force-movement diagram obtained in the experimental process is shown on Fig. 5.

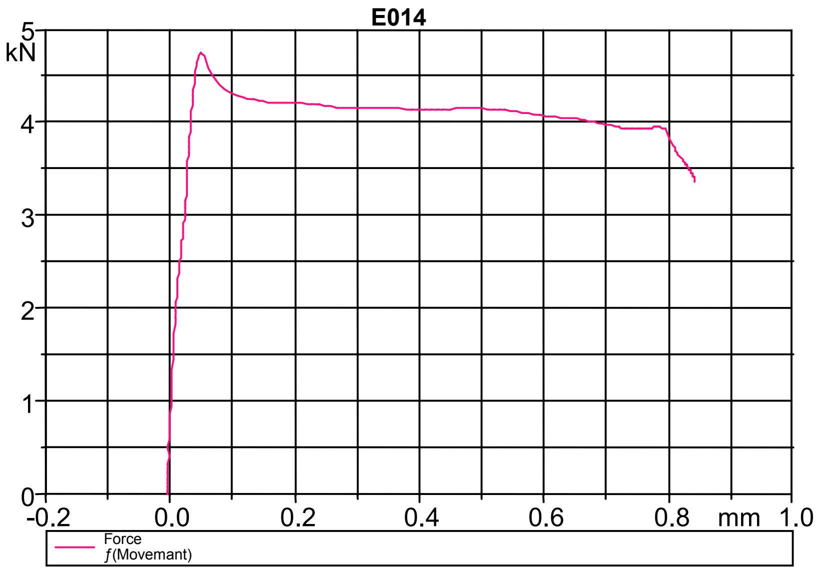

Fig.5. Force-movement diagram of sample plates sliding process

The second part of the experiment is performed with press fit joint samples. First, press fit joints were assembled as force fit joints and, a few days after, samples were separated by means of press force. The friction force and the displacements of sample parts were recorded during the process of assembling and separating.

The separating process of a press fit joint sample continued about 40 seconds. However, the sliding beginning moment happened in very short period of time, such as it was in the case of plates sliding in the first part of the experiment.

Typical experimental force-movement diagram at the beginning of a press fit joint parts separating process is shown on Fig.6.

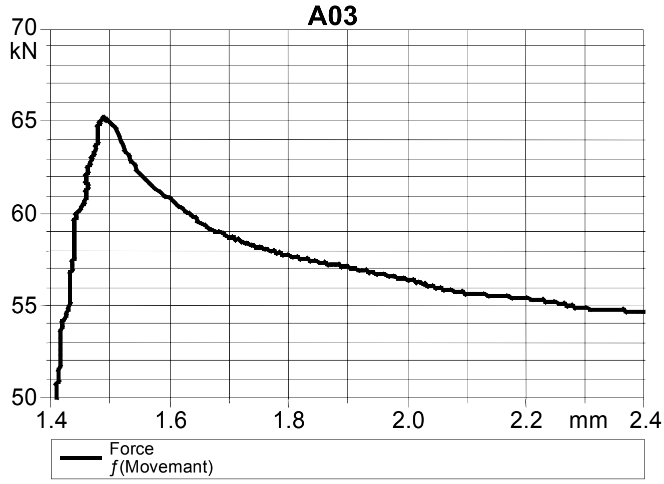

Fig.6. Force -movement diagram at the beginning of a press fit joint parts separating

The experimental investigation has shown that properties of applied lubricants and contact surfaces roughness have specially great influence on the static friction coefficient value as well as on the real strength of press fit joints [6]. With different lubricants that were applied on press fit joint samples with similar contact surfaces roughness of parts static friction coefficient values were in an interval from 0,047 up to 0,259. The values of static friction coefficient obtained with press fit joint samples that were lubricated with the same lubricant together with changing in contact surfaces roughness were between 0,123 and 0,226. Moreover, when samples in the form of plates with varying in contact surfaces roughness and lubricated with the same lubricant were used the range 0,051 to 0,126 was obtained for the values of static friction coefficient.

5. CONCLUSION

On the basis of the results obtained in the experiment it can be generally concluded that press fit joints must be treated as specific tribomechanical system. It is very important to have knowledge of tribological parameters that can influence strength of a press fit joint and in this way to ensure good loading transmit.

The strength of a press fit joint, that is the static friction force, is very difficult to identify precisely. That is because it depends on plenty parameters and features that have stohastical (accidental) character. Performed investigation indicates that for the responsible press fit joints that are loaded with huge loads and produced in high series it is necessary to perform an experiment for testing the friction coefficient value for the concrete tribological circumstances (the way of assembling the press fit joint, the way of machining contact surfaces, applied lubricant, surface hardness and so on).

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ISTRAŽIVANJE PRESOVANIH SPOJEVA SA TRIBOLOŠKOG ASPEKTA

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Nosivost presovanih spojeva predstavljena je silom statičkog trenja koja predstavlja najveću silu koja se može preneti ovim spojem. Stvarna nosivost presovanog spoja se može jedino odrediti opterećivanjem spoja do trenutka razdvajanja delova u spoju. Međutim, u inžinjerskoj praksi je veoma često neophodno u fazi projektovanja sračunati nosivost presovanog spoja. U cilju da se što pouzdanije proceni nosivost presovanog spoja potrebno je poznavati stvarnu vrednost statičkog koeficijenta trenja. U ovom radu je dat tok proračuna presovanih spojeva kao specifičnih tribomehaničkih sistema zajedno sa eksperimentalnim istraživanjem vrednosti njihovih koeficijenata trenja.

Ključne reči: *tribologija, presovani spojevi, sila trenja, koeficijent trenja.*