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IMPLEMENTATION OF THE PC MODEL OF LOCKED CONNECTION

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ABSTRACT: This paper deals with a proposal of device for measurement of clamped joints. A computerized model of clamped joint is proposed. In the experimental part shaft surface roughness is measured and finally, values of the friction torque depending on twisting moment are evaluated.
KEYWORDS: friction torque, dynamometer, 3D model, jaws, shaft

❖ INTRODUCTION

One of the basic construction elements for construction production either in engineering or building and construction industries are clamped joint claws. From the point of view of working life and criteria on the clamped joint jaws, the main importance belongs to stating the correct clamping power, as well as stating the correct friction torque in the joint. If there is a small clamping power on this joint, it can cause an insufficient friction torque and subsequently damage the clamped joint and thus damage the whole mechanism. On the contrary, high clamping power can cause a big deformation either on the hub or clamped joint claws, which can lead to cracks in the claws or disabling the mutual re-assembling and disassembling of the hub and claws [1].

❖ BASIC REQUIREMENTS ON JOINTS

In appliances, there are two types of binding between components and knots – movable and non-movable. The type of movable binding results from the required function and kinematics scheme. The non-movable bindings ensure a constant position of components and knots. The non-movable bindings are obtained by linking the components and knots.

The binding elements and methods are to ensure sufficient resistance and required constant position of the components and knots. In precise mechanics, a higher number of binding methods is used. Reasons:

- Power and deformation ratios,
- Requirements on simple assembly and disassembly,
- High requirements on precision,
- Simultaneous use of heterogeneous materials in one knot,
- Requirements on outward form [2].

❖ PROPOSAL OF 3D DEVICE FOR FRICTION JOINT MEASUREMENT

Fig. 1 shows the solution of proposed device. The device consists of following components: frame 1, to which bearing shell sliding surface 14 is screwed. Holder 8 is welded to the frame and there are pegs 11 screwed in it. Via screw 4, through collar 13, dynamometer 5, peg holder and peg, the clamping power is transferred on claws 3. Weight 12 slides axially along lever 6. Shaft 2 is from both sides placed in bearings 9, which are in shell 10. Screw 7 serves to ensure the shaft position.

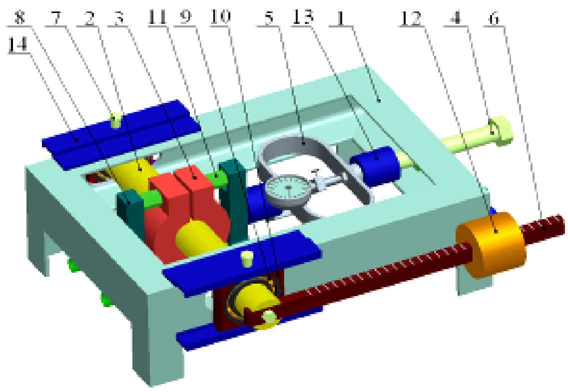

Figure 1. 3-D model of the proposed device

PROCEDURE OF THE MEASUREMENT

By the screw rotation, clamping of the shaft by means of claws is generated. From the dynamometer, the clamping power is acquired. By means of the weight, it slides axially in the direction from the shaft axis along the lever until the clamped joint is broken. From the weight mass and the distance from the shaft, twisting moment of the clamped joint breach is calculated. The friction torque is determined from the equations for transfer of the twisting moment. The disadvantage of this device is measurement scope restriction by the lever length and relatively complicated construction, which, however, eliminates former shortcomings.

EXPERIMENTAL DEVICE SET-UP

Device was proposed using normalized semi-finished product according to constructional principles. The machinery passed through process of evaluation in accordance with safety needs. The main unit for measurements was selected force strength on screw that was measured by dynamometry and twisting moment of lever. Moment of friction can be calculated using the medium formula for transmission torsion moment. Moment of friction has been calculated using the medium formula for transmission torsion moment.

Firstly, 8 holes were drilled into the construction frame, into which coils M8x1.25 were cut. Into these holes, sliding surfaces of bearing shells were screwed by means of screws with fixed head and internal hexagon. The bearings were inserted into shells and ensured by snap rings 68.

The pegs were screwed into the peg holders either into the external holes for big claws or into the internal holes for small claws. The holder with the sliding surface and collar were inserted into the tubes with the internal diameter of on the construction frame.

The claws were put on the pegs according to the peg distribution. The shaft was forced into the bearings and subsequently ensured against drop-out by snap rings 40. The lever was screwed by a screw with a washer. Afterwards, a locking element against lever fall was screwed into the frame. The weight was put on the lever. The dynamometer was screwed into the collar on the peg holder and on the opposite side of the dynamometer the collar with bearing was screwed. The frame was supplemented by screw M24 x 2, which presses on the dynamometer collar and serves for generation of the axial power. Finally, the whole construction was fixed to the worktable.

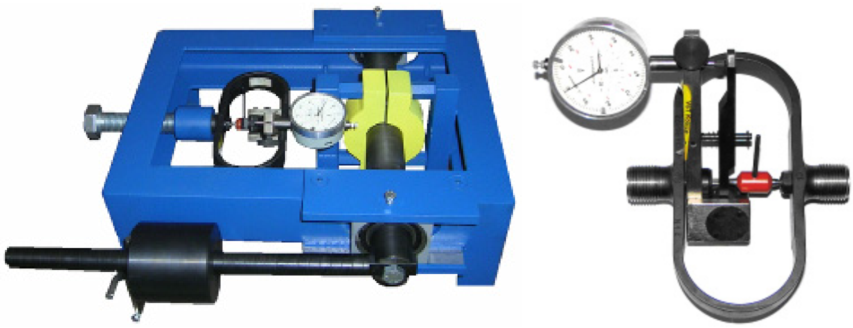

Figure 2. Complete clamped joint device (left). Dynamometer with range 2 kN (right)

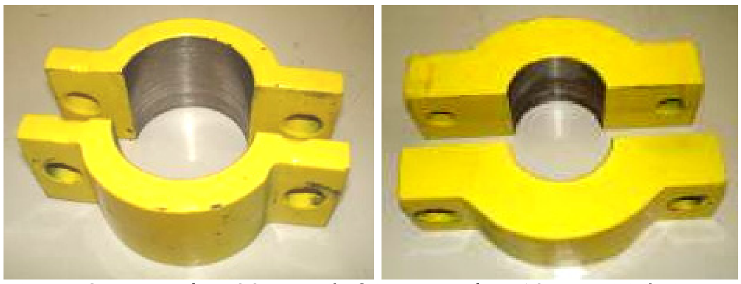

Figure 3. Jaws Φ = 90 mm (left). Jaws Φ = 60 mm (right)

Important parts of locked connection are displayed on Figs. 2-4.

The sample for the measurement with shaft diameter Φ = 40 mm and two types of jaws were used:

a. For uniform distribution of pressure around the hub of the jaw with an outer diameter Φ = 90 mm,
b. For the cosine distribution of pressures around the hub of the jaw with an outer diameter Φ = 60 mm.

Examples of manufactured components (Fig. 4) comprise: a) the sleeve bearing dynamometer b) shaft, c) sleeve bearing with bearing d) pin e) weight; f) lever.

The sample for the measurement was a shaft with the diameter of Φ = 40 mm and one type of claws. For equal pressure distribution on the claw hub perimeter with external diameter of Φ = 90 mm.

Figure 4. The completed frame (left). Examples of manufactured components (right)

❖ METHODS OF MEASUREMENT

Measurements began by clamping the joint by power of 2 kN using a screw. On the lever, the weight was set on 33 divisions, whereas every division corresponds to a different twisting moment and afterwards the screw was slowly loosened until the clamped joint was broken. The breach occurs if the lever moves. When the lever moves, we read the number of divisions from the dynamometer. Gradually, the weight moves towards the rotation axis by two divisions up to 9 divisions.

Subsequently, the measurement was performed from 9 divisions to 33 divisions. After these measurements, measurements of the surface roughness using Mitutoyo SJ 301 (Fig.5) were carried out with consequent soft regrinding of claws by brush paper and repeated measurement.

SURFACE ROUGHNESS MEASUREMENT

Fig. 5c presents resulting surface of the finished part after roughness measurement. On this surface is present one part with the more worn zone. Fig. 5d illustrates the record of measured roughness of the shaft surface with diameter of 50 mm.

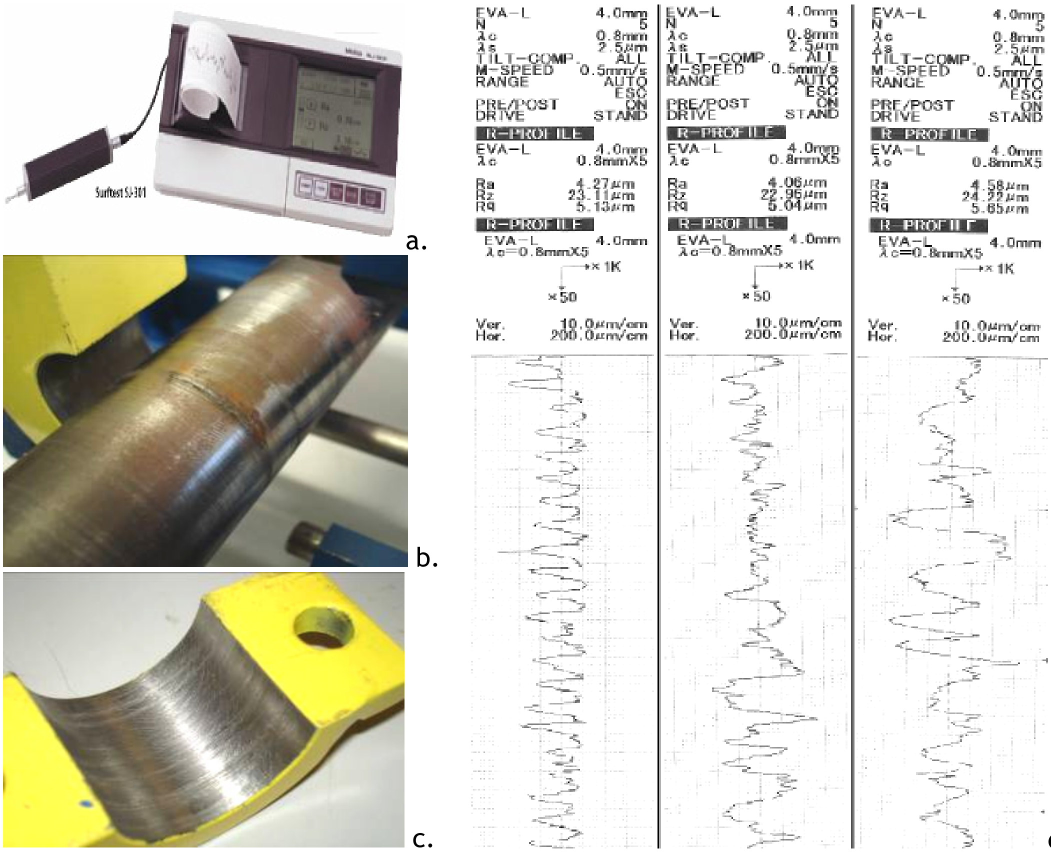

Figure 5. Mitutoyo SJ 301 (a) used for measurement of surface roughness of shaft (b) and jaws (c)along with the measured surface roughness (d)

MEASUREMENT OF UNIFORM PRESSURE DISTRIBUTION ON HUB PERIMETER

For this measurement, we used big claws of the clamped joint, which were put on the pegs and subsequently tightened by the screw to 2 kN. The measured values of the clamped joint breach, as well as the calculated clamping power are summarized in Table 1. Conversion of the number of dynamometer divisions to power F was performed according to the equation (1)

$$F = 2000/552{,}1.n_{divisions} \tag{1}$$

The calculation of the friction torque for equal pressure distribution was performed according to equation (2), where *f* ranges from 0.15 to 0.2.

$$M_T = F_N.f'.d = F_N.\frac{\pi}{2}.f.d \tag{1}$$

Table 1. Measurement on claws with external diameter of Ø = 90 mm.

Lever division	33	31	29	27	25	19	17	15	13	11
Dynamometer division	155	145	131	122	120	71	56	43	40	32
F [N]	561,5	525,3	474,6	441,9	434,7	257,2	202,9	155,8	144,9	115,9
Lever division	13	15	17	19	21	27	29	31	33	
Dynamometer division	55	55	78	80	81	101	105	109	110	
F [N]	199,2	199,2	282,6	289,8	293,4	365,9	380,4	394,9	398,5	

Table 2. Calculated friction torques for claws of Ø = 90 mm.

F [N]	561,5	525,3	474,6	441,9	434,7	257,2	202,9	155,8	144,9
M_T [N.m]	5,2920	4,9508	4,4730	4,1648	4,0970	2,4241	1,9123	1,4684	1,3657
F [N]	289,8	199,2	282,6	289,8	293,4	365,9	380,4	394,9	398,5
M_T [N.m]	1,0923	1,8774	2,6634	2,7313	2,7652	3,4485	3,5852	3,7218	3,7558

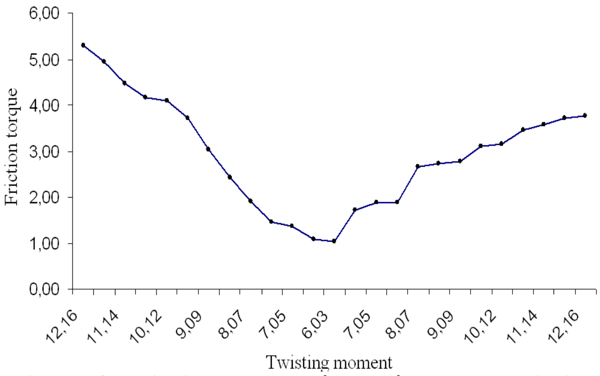

Figure 6. Friction torque dependence on twisting moment

Fig. 6 summarizes the friction torque dependence on twisting moment, which results in the fact that the measurement on the device was with minor errors during the first measurement, when the weight was moved from the end of the lever towards the axis of rotation. During the measurement from the axis, a bigger dispersion arose.

❖ CONCLUSIONS

The calculated values of the friction torque dependency are distorted. They depend on many factors, among which there are e.g.: precision of clamped joint performing; surface roughness; clamping power; conditions that can influence the measurement; number of measurements etc. This causes the fact that when more measurements are carried out, the value of friction torque varies, which causes the dispersion in measurements. Finally, for the purpose of application demands, it is suitable to recommend modern hydraulic tightening machines to ensure higher precision and precise digital torque wrenches for performing the clamped joint breach.

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