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Experimental Approach of the Torque Bearing Capacity Regarding the Sectional Clamp Assemblies

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Abstract

The torque bearing capacity of sectional clamp assemblies was in detail approached in both paper works [2] and [7], written on this subject. Authors got there by analytical method the dependence between axial clamping force of threaded elements and the torque bearing capacity of the sectional clamp assembly. This boarding refers both to sectional clamp or clamp and cap assemblies.

The authors have deliberately got the experimental results in order to give the credibility to these analytical results.

This demarche is a part of extensive plan of experimental approach, regarding a various kind of removable assemblies.

Key words: *removable assembly, elastic tightening, sectional clamp assembly, torque bearing capacity of the clamp assembly.*

Introduction

The clamp tightening assemblies are practically achieved by stronghold contact of joint surfaces put in connection. These assemblies are functional based on frictional force generated between interlinked surfaces under the action of a contact pressure [1], [4], [5], [8].

If contact surfaces get still elastic strain, the assembly is a removable kind; on the contrary, if there are some plastic deformations, the joint may become solid (detachable) joint.
The elastic tightening clamp assemblies gets some certain advantages:

- A great bearing capacity for static or variable load;
- The joint brings a convenient centering for any cylindrical or conical fit.

There are also a few disadvantages to be mentioned:

- The possibility of tight fit loosing in running time;
- Some surface deteriorations on mounting operation;
- The severe pieces selection before mounting.

The flexible clamp (collar clamp, bracket) assembly achieves an elastic tightening between an outer piece (such as a wheel, mount, stem or crank) on a shaft-piece (such as a shaft, bar, strap, column etc.).

The most frequent case of usually removable connection is that of shaft-hub joint, using a bolt and nut threaded joint for tightening it [2], [6].

Functionally, the sectional clamp assembly has a limited domain of pretty reduced load whenever frequent mounting-dismounting moments are required, when tightening needs adjusting or loosening of shaft section is not allowed.

Experimental Equipment, Tools and Instruments in Use

The system for testing

The system of assembly testing (stand) has the following structure:

- Sectional clamp assembly (fig.1);
- Special stand for assembly torque tests (fig. 2 and 3);
- Instrumentation (dynamometer, click-type torque wrench (fig.3), slide calliper rule).

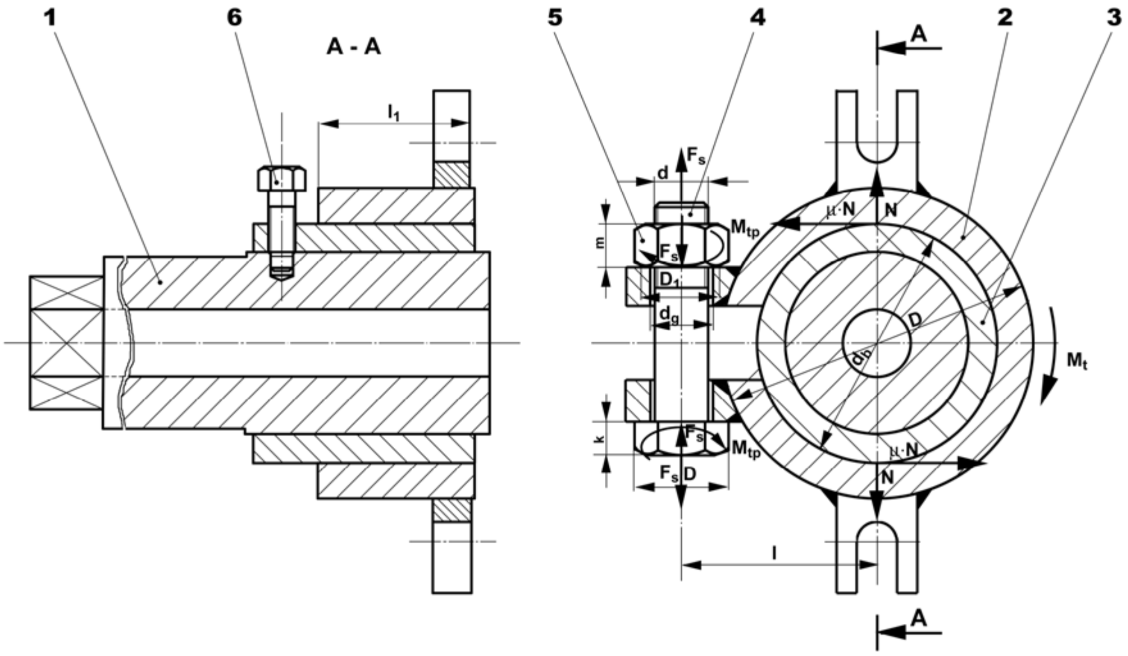

Fig. 1. The tightening sectional clamp assembly

The tightening sectional clamp assembly, presented in figure 1, has the following structure:

- The shaft (1) having one end finished with a cylinder surface and the other end with a portion hexagonal outline required to mount it into the twisting test device;
- The tightening sectional clamp (2) made by a welded structure;
- The threaded assembly with nut-bolt (5, 4) for tightening purpose;
- The intermediate bush (3), preliminary mounted on the shaft body, brings in a higher interchangeability for test series; the bush (3) fits on the shaft by the special bolt (6) in the working position.

This special way to secure by bolt makes possible to determine the torque bearing capacity for any type of shaft-hub pair – meaning different alloys couple, different roughness stage – by inter-changing a special bush set.

The axial tightening force (F_s) develops by nut (5) screwing, using a torque wrench. The torque moment (M_{tp}) is gradually increased for each experimentally step and separately recorded; the torque is carefully applied by dynamometric wrench.

Finally, the sectional clamp assembly has to be fitted on the special stand for assembly torque tests (fig. 2 and fig. 3.5).

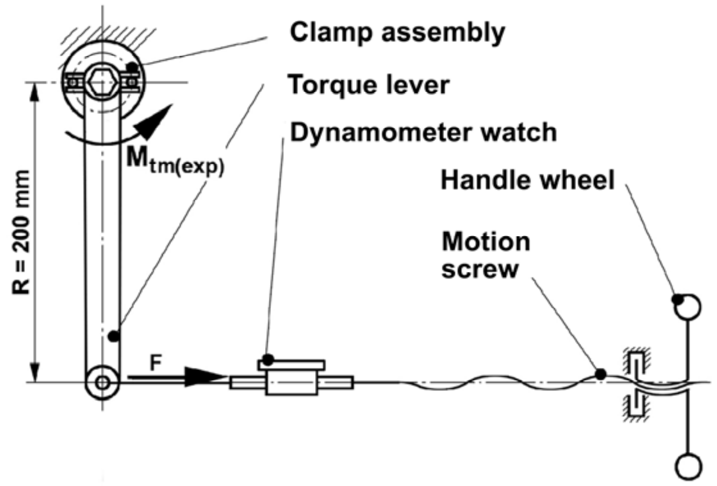

Fig. 2. The cinematic scheme of the special stand used for various assembly torque tests

Figure 3 shows the different steps of sectional clamp assembly mounting, than fitting it on the special stand for torque experiments:

- First, positioning and fixing the bush (3) using the bolt (6) (fig. 3.,1);
- Than positioning the clamp on the shaft, with a soft screwing of elements 4-5 (fig. 3.,3);
- Mounting the assembly on the stand and fixing its ends for torque testing (fig. 3.,2);
- Applying the M_{tp} torque, using the dynamometric wrench (fig. 3.,4);
- The dynamometer regulation for F force application by rotating the handle wheel, to charge the torque (fig. 3.,5).

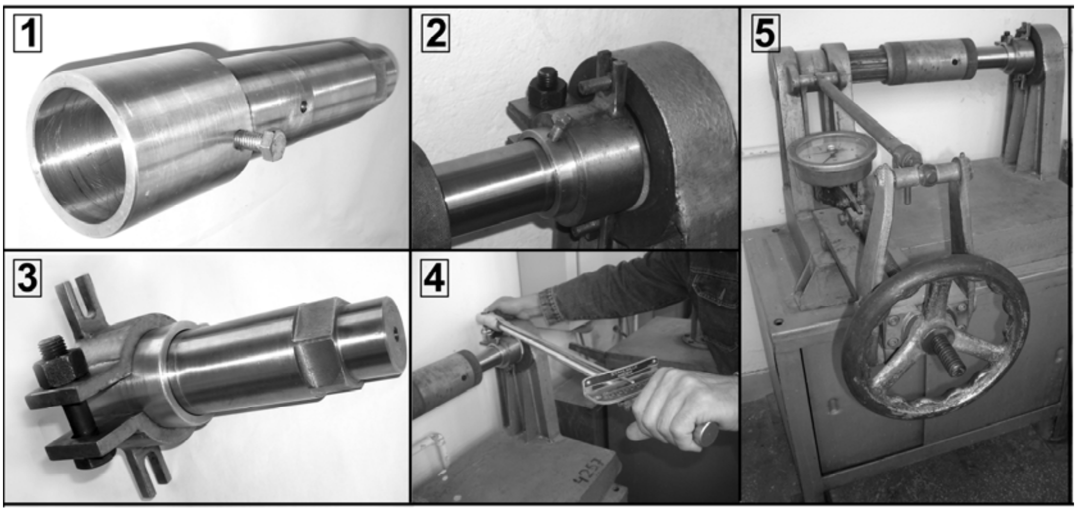

Fig. 3. The main steps of mounting and acting on the sectional clamp assembly during the experiments

The structural characteristics of the sectional clamp assembly

The main dimensional characteristics of the sectional tightening clamp assembly are the following:

- Dimensional elements of the bolt (4) and its thread:
  d=16mm d_1=13, 835mm d_2=14,701mm
  k=10mm p=2mm α_2=arctg $p/\pi d_2$
- Dimensional elements of the nut (5):
  m=13mm
  S=24mm
  $D_1 \approx 0{,}95 \cdot S$=22,8mm
- Other dimensions of the components (fig.1)
  d_b=65mm l=54mm
  D=85mm l_1=50mm $d_g=1{,}1 \cdot d$=17,6mm

Experiments for determining the torque bearing capacity of the sectional clamp assembly

The torque bearing capacity of the sectional clamp assembly can be determined using the special stand for torque tests. The torque applied on the assembly (M_{tm}) is generated by a motion screw which acts on the lever (of length R). The axial force of the motion screw (F), is shown on the dynamometric watch and, using it, we can express the experimental value of the torsion moment:

$$M_{tm,(exp)} = F \cdot R \cdot \eta_d \,, \tag{1}$$

where:
F is the force registered to dynamometer dial;
R=200 mm – the length of the lever (fig. 2);
η_d – the mechanical efficiency of lever system of the stand (η_d=0.95).

Experimental results

The experimental determination of the torque bearing capacity for the tightening sectional clamp assembly was performed for the couple of alloyed bronze-steel:
- bronze – the piece (3) (fig.1);
- steel – sectional clamp, piece (2) (fig.1).

The piece (3) is safely not to spin using the bolt (driven-in pin, 6), screwed in the special threaded box of the shaft.
This interchangeable system makes possible to sequentially determine the bearing capacity for any pair of (2)-(3) pieces and roughness, such as:
- straight turning steel/long grinding steel;
- fine turning steel/cast iron etc.

When experimentally determine the torque bearing capacity of a tightened sectional clamp assembly (or clamp and cap assembly too), there are the following steps to be done [2], [6]:
- All the sectional clamp assembly components have to be correctly positioned and mounted, than the threaded components (4) and (5) softly preload by hand;
- The first preload torque M_{tp} has to be applied on the (5) nut, recording the value seen on the scale of the dynamometric wrench; using it, the axial preload (F_o=F_s) can easily get, than bearing reaction (N); these can be used also for analytical torque bearing capacity determination (M_{tm}) [2], [6];

- If rotating the handle wheel of the stand, the maximal axial force (F) remains registered on the dynamometer, as evidence, and can be used to determine the experimental value of the torque ($M_{tm(exp)}$), applying equation (1);
- The same steps have to resume than, for some other higher (M_{tp}) values; for each level, we have to register the corresponding axial force of the dynamometer, to determine the experimental torque.

All the experimental results are successively shown in table 1.

Table 1. Experimental results and processed data

No. att.	Preload torque applied to the nut, M_{tp}	Registered values of the dynamometer force, F				Lever lenght, R	Estimated mechanical efficiency of the stand, η_d	Experimental torque bearing capacity, $M_{tm,(exp)}$
		Sequentially registered values			Average value			
	[N·m]	[N]				[m]	[%]	[N·m]
1.	20	500	550	540	530	0.2	0.95	**100.7**
2.	40	1020	1500	1600	1370			**260.9**
3.	60	1400	2100	2080	1860			**353.4**
4.	80	2500	2400	2000	2300			**437**

After registering all the experimental results, the torque bearing capacity can be determined by calculus and a graphical variation can be added (figure 4).

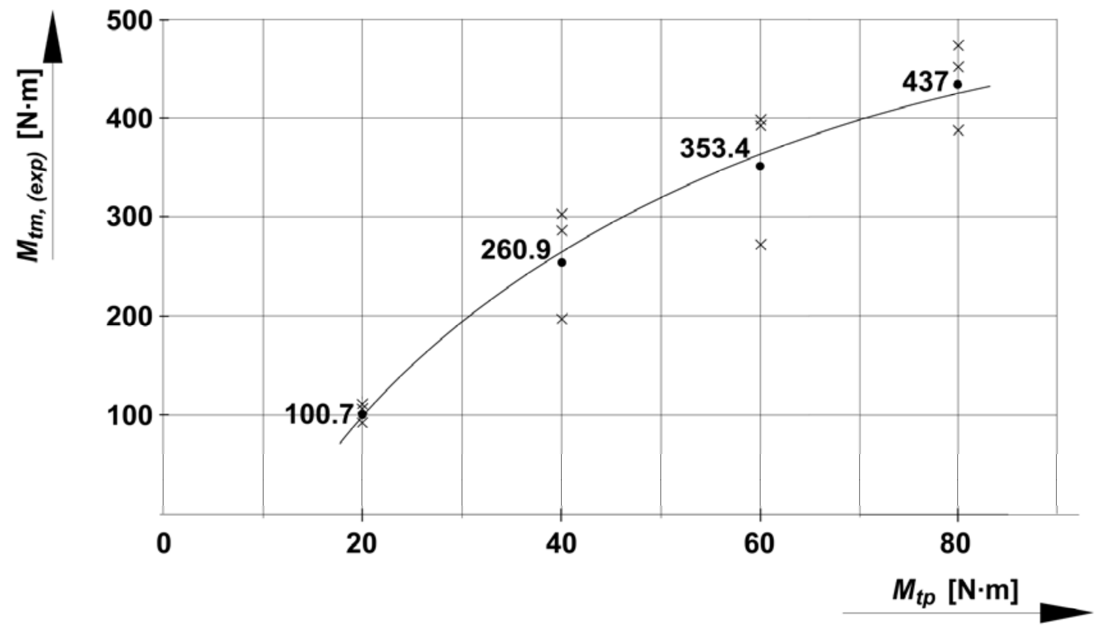

Fig. 4. The final diagram of experimental processed determination

Conclusions

Analyzing the results of these experiments and all processed tabular and graphic results, there are a few conclusions to highlight:

- This paper presents the main steps of experimental torque bearing capacity determination, dedicated to the tighten sectional clamp assembly; certainly, the experimental results can be compared by analytical ones, which were theoretically determined before such as a dependence between threaded preload torque and torque bearing capacity.

- The original assembly device use for this experiment has a simple and robust structure, created to easily use for any material couple, as different alloys or different roughness surface structure; here, the tightening sectional clamp assembly was performed for the couple of alloy bronze-steel.
- The assembly torsion loading used here some lineal increasing values (table 1); the limitative torque results for the torsion bearing capacity seem to have a pretty non-linearity, as the figure 4 shows.

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Determinarea experimentală a capacităţii portante a asamblărilor cu brăţară de strângere secţionată

Rezumat

Determinarea capacităţii portante a asamblărilor cu brăţară de strângere a făcut obiectul analizei abordate în lucrările [2] şi [7]. Autorii au determinat pe cale teoretică dependenţa dintre forţa axială dezvoltată în asamblarea cu piese filetate şi momentul de torsiune transmis de asamblările cu brăţară – în ambele variante, brăţară secţionată şi brăţară cu capac.

Pentru a confirma credibilitatea rezultatelor obţinute pe cale teoretică, autorii şi-au propus să determine şi experimental capacitatea portantă a asamblărilor analizate.

Prezentul demers face parte dintr-o mai amplă abordare experimentală pusă la punct de autori, în încercarea de verificare practică a determinărilor analitice anterior dezvoltate.