CONSIDERATIONS REGARDING THE FUNCTIONALITY OF THE CHUCK COLLETS

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Abstract: *In this paper the authors aim to present the theoretical study of functionality of clenching mechanisms such as chuck collets, abbreviated MBE. For these chuck collets to function properly, a value for the angle of the collet needs to be set, as well as a range of values for the relative roughness of the contact surfaces.*

Keywords: *chuck collets, efficiency of MBE, clamping force.*

1. Introduction

Collet chucks are self-centered technological equipment used in automation mechanisms of machine tools and flexible manufacturing systems. Constructively, the main element of a collet chuck (MBE) is a collet provided with longitudinal grooves equidistant on its circumference and a tapered portion through which radial deformation occurs. With radial deformation, the collet can center parts (maneuvering axle in automated systems, cutting tools, control tools, etc.), possibly tightening/fixing parts during a technological process (machining, assembly, inspection, etc.).

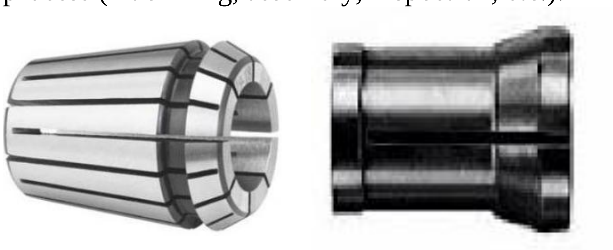

Figure1. *Examples of usual chucks*

The MBE functionality of a mandrel in a technical system, is subject to the efficiency with which the raising/cross function is carried out, eventually, the efficiency with driving force is carried out in the MBE. Functionality, and so the effectiveness of an MBE is reflected by:

- Self-locking condition of the system, determined by the value of α angle collet,
- Return efficiency of MBE.

2. Physical study model

The efficiency calculation is the ratio between the real purpose function and the ideal purpose function. In the case of MBE, fig.2, output function from the system is represented by the clamping force, S:

$$\eta = \frac{S}{S_{id}} \quad (1)$$

Where: S_{id} is the ideal operational clamping force, that is, in the absence of friction forces.
$\mu_1 = \mu_2 = \mu_3 = 0$

Dependence relations between driving forces Q and total tightening torque, developed by MBE mechanism are:

$$Q = S\,[\mu_2 + tg(\alpha + \varphi_1)] \quad (2)$$

$$S = \frac{Q}{\mu_2 + tg\left(\frac{\alpha}{2} + \varphi_1\right)} \quad (3)$$

$$i_S = \frac{S}{Q} = \frac{1}{\mu_2 + tg\left(\frac{\alpha}{2} + \varphi_1\right)} \quad (4)$$

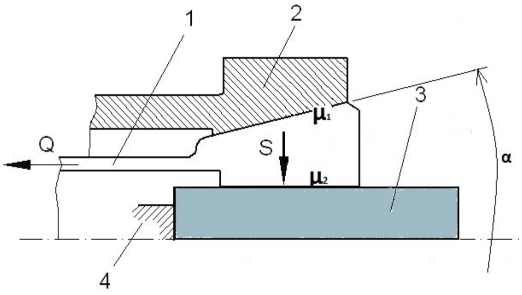

Figure 2. *Physical model of request: 1-collet, 2-conialc sleeve, 3-study object, 4-stopper*

From (2) and (3) comes the relation of the force transmission ratio $\mathbf{i}_S$, and the relation of efficiency η, for MBE:

$$\eta = \frac{tg\frac{\alpha}{2}}{\mu_2 + tg\left(\frac{\alpha}{2} + \varphi_1\right)} \qquad (5)$$

Where: μ= tgφ, is the coefficient, and the friction angle.

Condition of functionality of the MBE is established for the case the value of force transmission ratio i_S, and the mechanism efficiency is sufficiently high, convenient from the point of view of efficiency.

3. Experimental stand

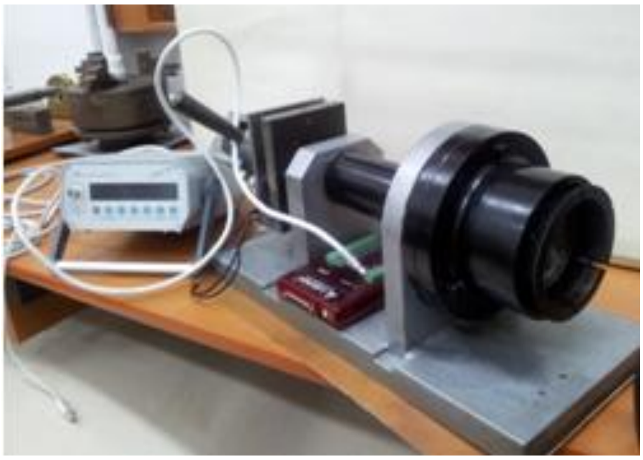

Figure 3.*Experimental stand [1]*

Experimental stand, fig.3, for efficiency research of MBE uses a data acquisition software [1], where the collet , fig.4, is made out of alloy steel , with contact surfaces in relative motion of the counterpart (parts 1, 2, 3 of fig.2) and rectified variables of roughness *Ra*, μ.

For signal processing, a software was used, Fig.5, and strain gauges.

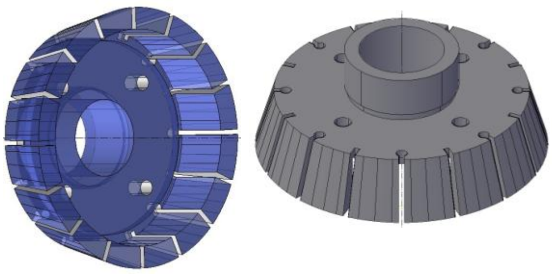

Figure 4. *Collet for experimental study*

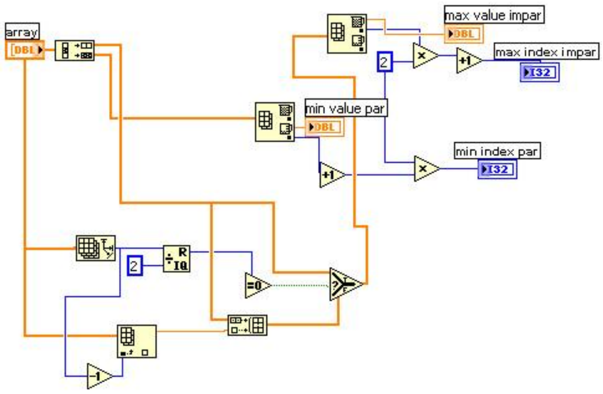

Figure 5 – *Scheme of data aquisition soft*

4. Processing of experimental data

In paper [1] the relationship between the effective clamping forces S_{ef} at the collet jaws was represented, which was compared with the computing force S_c predicted by model (3).

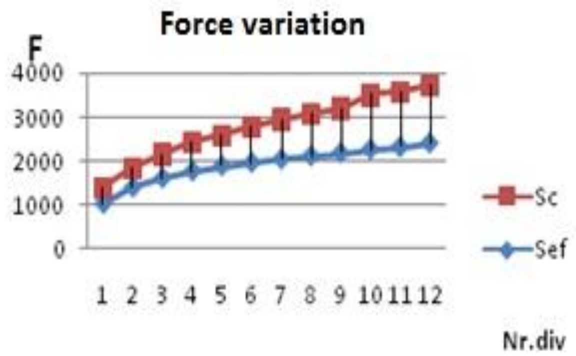

Figure 6 *Graphic variation of* S_{ef} *and* S_c

It was found that for a collet with an angle α = 30°:

- Experimental forces are smaller than those obtained by calculation, because of the friction forces that appear between conical sleeve μ_1, and study object, μ_2.
- An efficiency domain for using mechanisms in technical systems can be set.

The experimental results are summarized in Tabel 1.

Tabel 1 Experimental results of tightening/fixing MBE

Nr. crt.	Nr.div. (V)	K_f	S_i (N)	S_{Sc} (N)	E_{ef} (N)	$i_S = S_{ef}/S_{Sc}$
1.	1,74	1385	2409,9	1025,05	388,88	0,32
2.	2,481		3436,18	1401,58	435,18	0.31
3.	2,743		3799,05	1615,92	555,55	0,34
4.	3,014		4174,39	1775,58	657,4	0,37
5.	3,218		4456,93	1895,75	712,96	0,376
6.	3,345		4632,82	1970,57	842,59	0,427
7.	3,480		4819,8	2050,1	916,6	0,447
8.	3,605		4992,92	2123,74	981,48	0,464
9.	3,724		5157,74	2193,84	1018,51	0,465
10.	3,862		5348,87	2275,14	1250	0,54
11.	3,951		5472,13	2327,57	1268,51	0,544
12.	4,105		5685,42	2418,23	1314,81	0,546

The study was extended to different values of the α angles, as well as a friction coefficient corresponding to a roughness R_a=0,4÷0,32mm. Results are presented in Tab. 2.

Synthesis of processed and calculated values with mathematical models for MBE are shown in Tab. 3.

Tabel 2 Dependence between roughness and the angle of friction between elements of MBE

R_a, (mm)	**3,2**	**1,6**	**1,2**	**1,0**	**0,8**	**0,1**	**0,05**
≈φ (°)	73	58	50	45	38	6	3

Tabel 3 MBE – Synthesis of calculations

α	**70**	**60**	**50**	**40**	**30**	**20**	**10**
i_{SC}	1,423	1,732	2,144	2,747	3,732	5,671	1,143
i_S	1,22	1,38	1,72	2,14	2,81	3,81	5,08
η(R_a=0.05mm)	0,81	0,801	0,781	0,758	0,702	0,624	0,476
η(R_a=0.1mm)	0.805	0.794	0.776	0.747	0.698	0.615	0.448

Graphical representation of $\mathbf{i_S}$, $\mathbf{i_{SC}}$ and $\boldsymbol{\eta}$ depending of $\boldsymbol{\alpha}$ angle – according to figures 7 and 8.

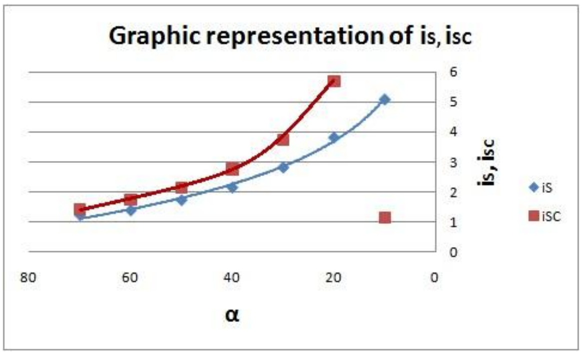

Figure 7 *Graphic of i_S and i_{SC} depending of α angle*

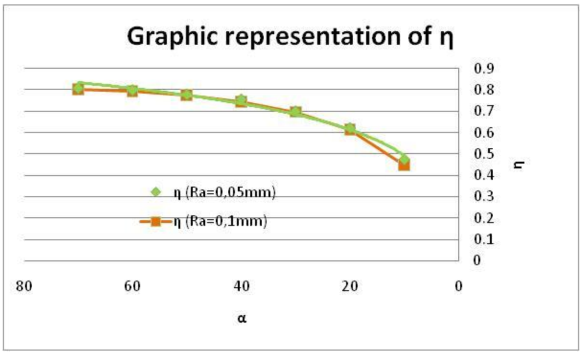

Figure 8 *Graphic of η depending of α angle*

5. Conclusions

The analysis of experimentally obtained charts show that:

- The smaller the value of $\boldsymbol{\alpha}$ angle is, the higher the force transmitting ratio;
- The values of $\boldsymbol{\alpha}$ angle, for which yield and the $\mathbf{i_S}$ ratio is efficient, should be between 20° - 50°;
- For mechanical systems in automated structures ,corrections are in order so that errors could be eliminated.

References

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