

MODELING THE HIGH-SPEED PROCESS FOR SMOOTHING OF HOLES

Assoc. Prof. Dr. Evstati Lefterov, Assist. PhD. Student Eng. Tanya Avramova
Technical University of Varna

Abstract: The article considers modelled and analyzed combined tools for drilling and boring with simultaneously smoothing. The contact stresses and deformations of details used for hydraulic cylinder are defined. A new construction of fulcrum-smoothing elements is analyzed. The obtained results serve for designing of tools that work on the principle of sliding friction. These tools are an important part of technological processes for producing hydraulic cylinders.

Keywords: HIGH-SPEED PROCESS, SMOOTHING OF HOLES, HYDRAULIC CYLINDER

1. Introduction

The production of hydro- and pneumo-cylinders is mostly related to deep openings treatment, separated in two groups:

- Mechanical treatment by swarf take down (drilling or rasping of an opening); [3, 7]
- Surface treatment - mostly related to plastic deformation (SPD). [1, 2, 4, 5, 6, 8, 9]

The final form of the treated surface is done according to two principles:

- Sliding friction (burnishing), accomplished by one rectilinear movement [10, 13, 15, 17, 18, 19];
- Friction at rolling on the generant of the treated opening, executed by instruments based on rollers and pellets [10, 17, 18, 19]. In this case the treatment is done by two movements - rotary and rectilinear.

The above mentioned operations are mostly performed by particular instruments with complex construction and the deformations in the surface layer of the treated openings are a result of rolling rollers with compulsory variation of the tension [20, 21, 22, 23, 24, 25, 26, 27, 28].

A basic disadvantage of the constructions which work simultaneously (cutting and smoothing) is the difference in the dynamics of the two processes. This requires the mounting of several lines of supporting elements for both the cutting and the rolling part. In order to function as supports, in most cases there are six elements (evenly distributed on the treated diameter) in two lines, and it is necessary to have the option to adjust the diameter of the outside line of supporting elements.

Hence, their other disadvantage, namely the limitation in the diameters of the treated openings.

2. Model of instruments

In the present work we show results of theoretic research related to combined instruments for drilling, rasping and smoothing of openings. We use a scheme of sliding friction of static stable elements with different shape and dimensions (fig.1) which also serve as guide supports.

The instrument works in the following way: there are two methods to ensure the normal performance of the instruments. In the first case, the normal and tangential forces, which act on the supports, should be approximately equal, and in the second case the stability coefficient S toward each support should be higher than 1.

It is well known that when drilling or widening openings, the guides smooth the treated opening under the effect of cutting forces, which lead to reactions in the guiding elements.

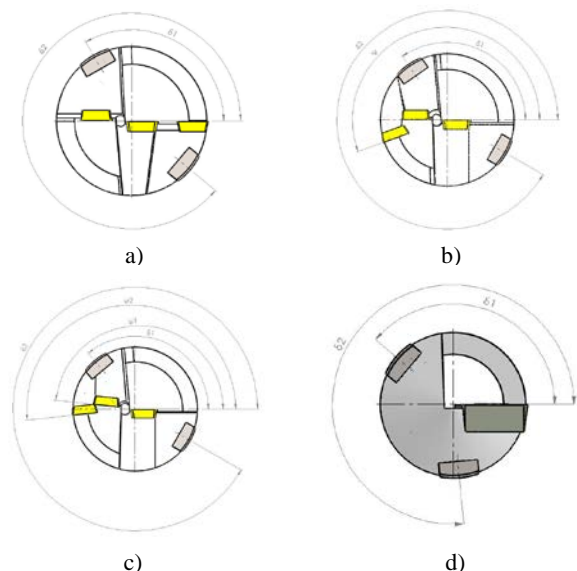


Fig. 1 Analyzed instruments constructions
a, b, c – drills for treatment of deep openings with different position of the cutting plates (angles ψ_1 and ψ_2); d – instrument for boring of openings.

Different constructive and geometric parameters can change the forces in the supports through the cutting forces (Table 1). The effect on the treated detail (pipe) is also very important.

Table 1: Factors influencing the forces in the contact zone

Parameters of the cutting part	- Geometry of the cutting plates – $\gamma^\circ, \alpha^\circ, \kappa^\circ$ - Dimensions of the cutting plates - 1 [mm]
Parameters of the cutting hub	ψ_1 and ψ_2 – angles of mutual position at the cutting plates
Parameters of the guide part	δ_1 and δ_2 – angles of position at the guide plates

The design and assembly of the instrument is created by SolidWorks software. Preliminary static linear analysis is made to determine the tensions and deformations which occurred in the cutting hub and the detail. The loading of the instrument is achieved experimentally by measurement of the cutting powers which act on each cutting plate.

Three types of drills for treatment of deep openings are considered, differing in the position of the cutting plates (angle ψ) and the angles of the position of the guides (fig.1 a, b, c). In addition, we also review an instrument for widening of openings (Fig. 1 d).

By changing the angles ψ_1 and ψ_2 , the solid system of forces, which loads the instrument, is changed and different reactions in the supporting smoothing elements can be created.

The mould constructions differ in the shape of the guiding elements (Fig. 2 a, b). On Fig. 2 a) is shown the most commonly used shape of guiding plate, and Fig. 2 b) presents a guiding element, which allows a considerable increase of the contact load.

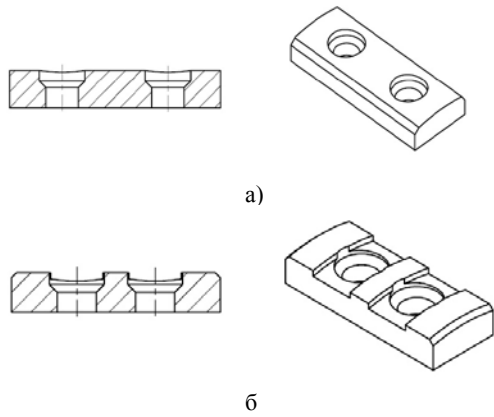


Fig. 2 Guiding elements of the analyzed instruments constructions a – smooth guiding plate; b – intermittent guiding plate

3. Results of the research

The resulted tensions and deformations of the instruments and details are shown in Table 2, 3, 4 and 5.

Table 2: Tensions and deformations of the cutting hub for drilling (at $\psi=0^\circ$) and the detail.

Variant with smooth guiding plate	General shape	General shape
	Tensions on the hub	Tensions on the hub
	Deformation of the hub	Deformation of the hub
	Tensions on the detail	Tensions on the detail
	Deformation of the detail	Deformation of the detail
	Deformation of the detail	Deformation of the detail
Variant with intermittent guiding plate	General shape	General shape
	Tensions on the hub	Tensions on the hub
	Deformation of the hub	Deformation of the hub
	Tensions on the detail	Tensions on the detail
	Deformation of the detail	Deformation of the detail
	Deformation of the detail	Deformation of the detail

Table 3: Tensions and deformations of the cutting hub for drilling (at $\psi=20^\circ$) and the detail.

Variant with smooth guiding plate	General shape	General shape
	Tensions on the hub	Tensions on the hub
	Deformation of the hub	Deformation of the hub
	Tensions on the detail	Tensions on the detail
	Deformation of the detail	Deformation of the detail
	Deformation of the detail	Deformation of the detail
Variant with intermittent guiding plate	General shape	General shape
	Tensions on the hub	Tensions on the hub
	Deformation of the hub	Deformation of the hub
	Tensions on the detail	Tensions on the detail
	Deformation of the detail	Deformation of the detail
	Deformation of the detail	Deformation of the detail

Table 4: Tensions and deformations of the cutting hub for drilling (at $\psi_1=6^\circ$ and $\psi_2=-6^\circ$) and the detail.

Variant with smooth guiding plate	General shape	General shape
	Tensions on the hub	Tensions on the hub
	Deformation of the hub	Deformation of the hub
	Tensions on the detail	Tensions on the detail
	Deformation of the detail	Deformation of the detail
	Deformation of the detail	Deformation of the detail
Variant with intermittent guiding plate	General shape	General shape
	Tensions on the hub	Tensions on the hub
	Deformation of the hub	Deformation of the hub
	Tensions on the detail	Tensions on the detail
	Deformation of the detail	Deformation of the detail
	Deformation of the detail	Deformation of the detail

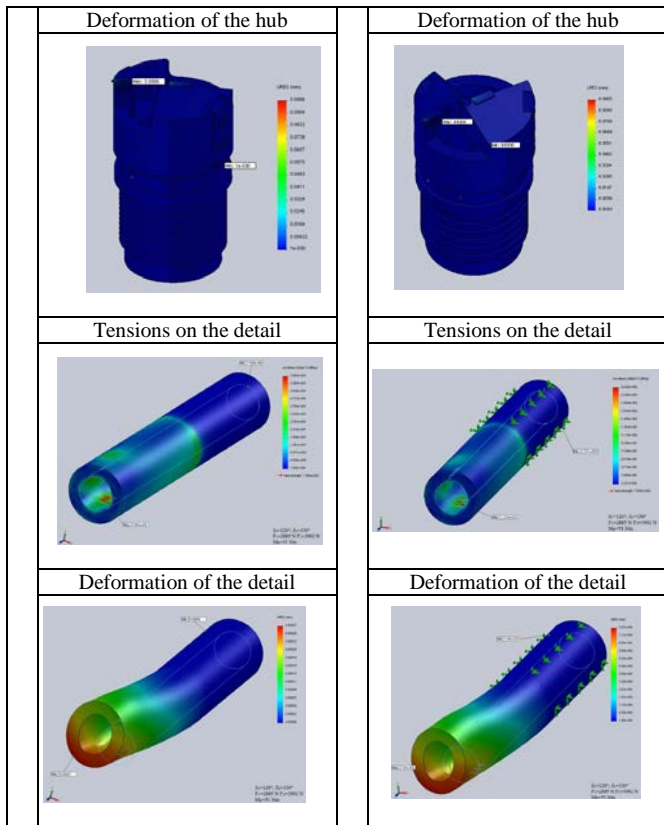
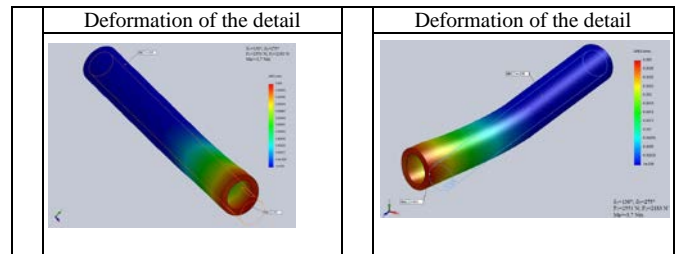
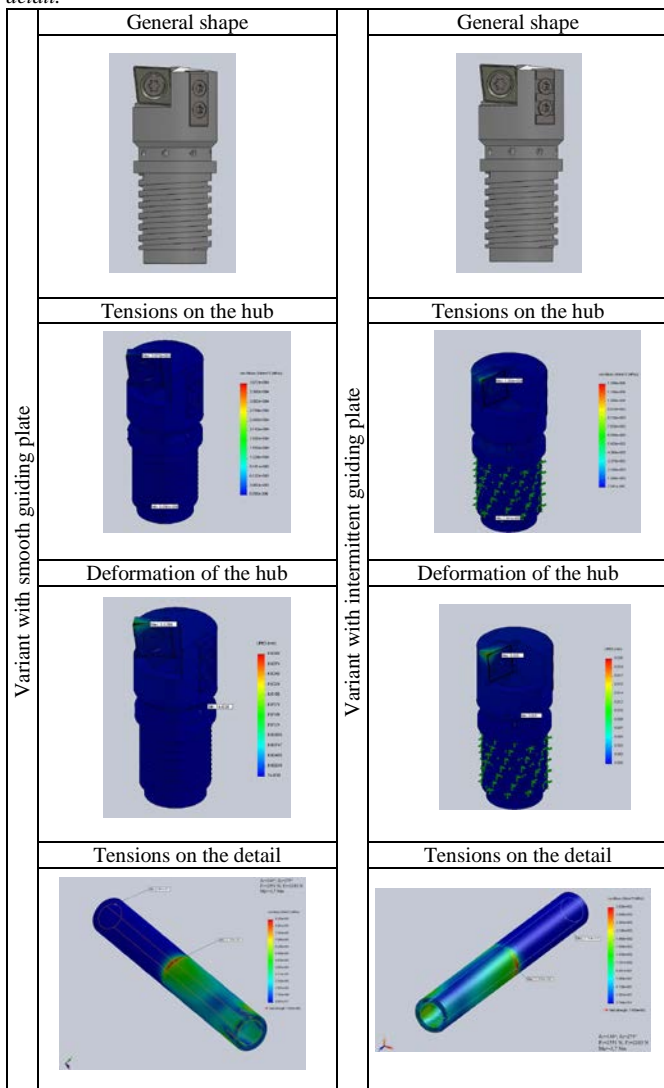


Table 5: Tensions and deformations of the cutting hub for boring and the detail.



In Table 6 are given the results of the tensions and deformations which occurred at the change of the angles of the position of the guiding-smoothing elements and their shape, at the condition that the treated detail is set in a chuck. The diameter of the drills is $D = 30$ mm, and the diameter of the instrument for widening of the openings is $D = 22$ mm, and the material of the treated detail is hydraulic steel S355.

Table 6: Tensions and deformations of the details at treatment with smooth and intermittent guiding plate.

Variant №	$\delta_1, [^\circ]$	$\delta_2, [^\circ]$	$F_1, [N]$	$F_2, [N]$	Maximum tension, [MPa]	Maximum deformation, [mm]
Drilling with smooth guiding plate - $\psi=0^\circ$	120	320	-11581	-4488	106,4	0,0007
	130	320	-8840	-23520	199,6	0,0016
	140	310	4904	23515	274,8	0,0022
	150	300	285	7917	125,3	0,001
	160	290	-755	4847	93,2	0,0007
Drilling with intermittent guiding plate - $\psi=0^\circ$	120	320	-11581	-4488	476	0,0021
	130	320	-8840	-23520	772,4	0,0047
	140	310	4904	23515	812,2	0,0063
	150	300	285	7917	369,5	0,0029
	160	290	-755	4847	274	0,0022
Drilling with smooth guiding plate - $\psi=-20^\circ$	125	330	3176	-4867	60,1	0,00026
	110	340	1099	-3365	55,3	0,0003
	120	330	2685	-4497	58,2	0,00027
	130	320	10378	-10656	85,4	0,00027
	150	300	-5089	-1800	72,9	0,00031
Drilling with intermittent guiding plate - $\psi=-20^\circ$	125	330	3176	-4867	256,6	0,00074
	110	340	1099	-3365	220,3	0,00087
	120	330	2685	-4497	238,3	0,00078
	130	320	10378	-10656	350,1	0,00077
	150	300	-5089	-1800	303,4	0,00089
Drilling with smooth guiding plate - $\psi_1=6^\circ$ и $\psi_2=-6^\circ$	130	330	4217	4670	58	0,00024
	110	340	1280	3047	53,5	0,00031
	120	330	2885	3992	55,6	0,00027
	130	320	10710	9198	79,1	0,00034
	150	300	5029	1336	73,2	0,00032
Drilling with intermittent guiding plate - $\psi_1=6^\circ$ и $\psi_2=-6^\circ$	130	330	4217	4670	230	0,00071
	110	340	1280	3047	214,6	0,00091
	120	330	2885	3992	223,2	0,00079
	130	320	10710	9198	340	0,00099
	150	300	5029	1336	304,1	0,00093

Variant №	δ_1 , [°]	δ_2 , [°]	F_1 , [N]	F_2 , [N]	Maximum tension, [MPa]	Maximum deformation, [mm]
Boring with smooth guiding plate	140	275	2069	2313	101,6	0,0011
	130	275	2551	2183	93,4	0,001
	150	275	1786	2405	116,2	0,0013
	160	275	1614	2476	134,1	0,0014
	170	275	1514	2537	150,4	0,0016
Boring with intermittent guiding plate	140	275	2069	2313	302,8	0,0033
	130	275	2551	2183	283,5	0,003
	150	275	1786	2405	353,5	0,0038
	160	275	1614	2476	398,5	0,0043
	170	275	1514	2537	449	0,0048

4. Conclusions

1. The angles of reciprocal position of the cutting plates ψ_1 and ψ_2 have a considerable impact on the forces F_1 и F_2 , which act in the guiding supports. These angles provide different conditions for smoothing of the treated surface (Table 6).

2. The impact of the coefficient of friction between the guiding plates and the walls of the treated opening is taken into account indirectly by the tangential component of the forces F_1 и F_2 , and its value is $\mu=0,1$.

3. The usage of guiding plates with intermittent shape (Fig. 2b) increases the contact tensions from 4 to 5 times, and maximum deformations from 2 to 4 times. This allows considerably better smoothing impact on the micro relief of the treated openings.

4. The tensions and deformations of the detail, which occurred during the simulation moulding of the instruments, are within the admissible limits and can be used for design and operation of instruments for treatment of openings with combined effect.

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