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FITS MODELLING OF AXIAL-SYMMETRICAL SHAPED JOINTS

Стаття присвячена моделюванню осе-симетричних фасонних шарнірів. Були сформовані обчислювальні моделі МСЕ для стаціонарного вала. Ці моделі дають змогу повністю оцінювати стан зв'язку і показують різницю результатів між подібними підгонками.

Ключові слова – фасонний шарнір, обчислювальна модель, МСЕ

Actual paper is devoted to the fits modelling of axial-symmetrical shaped joints. FEM Computational models of stationary shaft were developed. These models allow to estimate completely state of connection and show the difference of results between similar fits.

Keywords – shaped joint, computational model, FEM

Introduction

Axial-symmetrical shaped joints are the most popular type of connections in general machine construction. Bolts, pins, rivets, screws and splines belong to these elements.

During design of connection of new machine part one must determine function, which must be satisfied. Depending on designed function and loads designer selects geometrical parameters, which have to guarantee a proper cooperation, i.e. fit.

In order to get a designed function of connection we can use many tolerance pairs of hole and shaft. However, it is recommended to use privileged fits according to principle of stationary hole or shaft. In tables 1 and 2 there are presented recommended fits according to above principles with marked fits, which are privileged.

If we need a slide fit than we should use the recommended fit H7/f6, which is compatible with principle of stationary hole. For the same function of connection we can use fit F8/h6 according to principle of stationary shaft.

Using principle of stationary shaft we can apply also non-privileged fit F9/h8 and get a similar utility functions. There occurs a question: What is the difference between fits of this same types? In order to show this difference there were built computational models of fits of connections. For analysis there were selected clearance fits F8/h6 and F9/h8.

Table 1

Generally used fits on the basis of principle of stationary hole (for the range of dimensions up to 500mm) according to PN-EN 20286-1

Basic hole	Shaft dimensional deviation																		
		b	c	d	e	f	g	h	js	k	m	n	p	r	s	t	u	x	z
	Clearance fits								Transition fits				Clear fits						
H6						H6/f6	H6/g5	H6/h5	H6/js5	H6/k5	H6/m5	H6/n5	H6/p5	H6/r5					
H7			H7/c8	H7/d8	H7/e7, H7/e8	H7/f7	H7/g6	H7/h6	H7/js6	H7/k6	H7/m6	H7/n6	H7/p6	H7/r6	H7/s6, H7/s7	H7/t6	H7/u6	H7/x6	H7/z6
H8			H8/c8	H8/d8, H8/d9	H8/e8, H8/e9	H8/f7, H8/f8, H8/f9		H8/h7, H8/h8, H8/h9	H8/js7	H8/k7	H8/m7	H8/n7			H8/s7		H8/u8	H8/x8	H8/z8
H9				H9/d9	H9/e8, H9/e9	H9/f8, H9/f9		H9/h8, H9/h9											
H10				H10/d10				H10/h9, H10/h10											
H11	H11/a11	H11/b11	H11/c11	H11/d11				H11/h11											
H12		H12/b12						H12/h12											

Generally used fits on the basis of stationary shaft (for the range of dimensions up to 500mm) according PN-EN 20286-1

Basic shaft	Hole dimensional deviation																
	A	B	C	D	E	F	G	H	JS	K	M	N	P	R	S	T	U
	Clearance fits								Transition fits					Close fits			
h5						F7/h5	G6/h5	H6/h5	JS6/h5	K6/h5	M6/h5	N6/h5	P6/h5				
h6				D9/h6	E8/h6	F7/h6 F8/h6	G7/h6	H7/h6	JS7/h6	K7/h6	M7/h6	N7/h6	P7/h6	R7/h6	S7/h6	T7/h6	
h7				D8/h7	E8/h7	F8/h7		H8/h7	JS8/h7	K8/h7	M8/h7	N8/h7					U8/h7
h8				D8/h8 D9/h8	E8/h8 E9/h8	F8/h8 F9/h8		H8/h8 H9/h8									
h9				D9/h9 D10/h9	E9/h9	F9/h9		H8/h9 H9/h9 H10/h9									
h10				D10/h10				H10/h10									
h11	A11/h11	B11/h11	C11/h11	D11/h11				H11/h11									
h12		B12/h12						H12/h12									

Computational Models

Designer during creating a new connection does not know what influence of values of fits on connection elements is. For complete identification of connections with the same types of fits there were built two computational models for selected fits: first one for upper deviation of hole and for lower deviation of shaft, second one for lower deviation of hole and for upper deviation of shaft. Shaft and hole deviations for individual fit models were presented in table 3.

Table 3

Values of upper and lower deviations [μm] for modelled fits

Fits	**I**	F8/h6	B = +64	a = -16
	II	F8/h6	A = +25	b = 0
	III	F9/h8	B = +87	a = -39
	IV	F9/h8	A = +25	b = 0

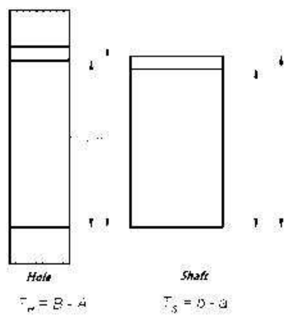

Fig. 6 Shaft and hole with marked tolerance range and size limits.

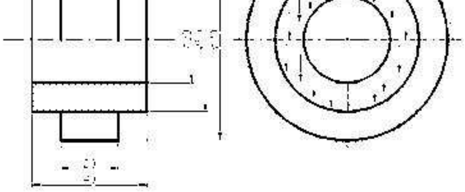

Fig. 7 A scheme of analysed computational model.

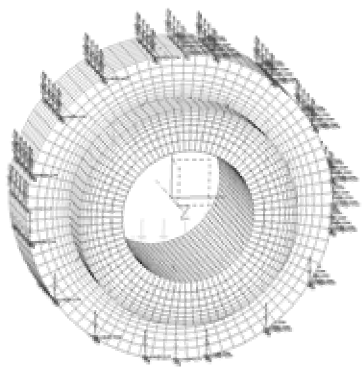

Fig. 8 A view of FE model.

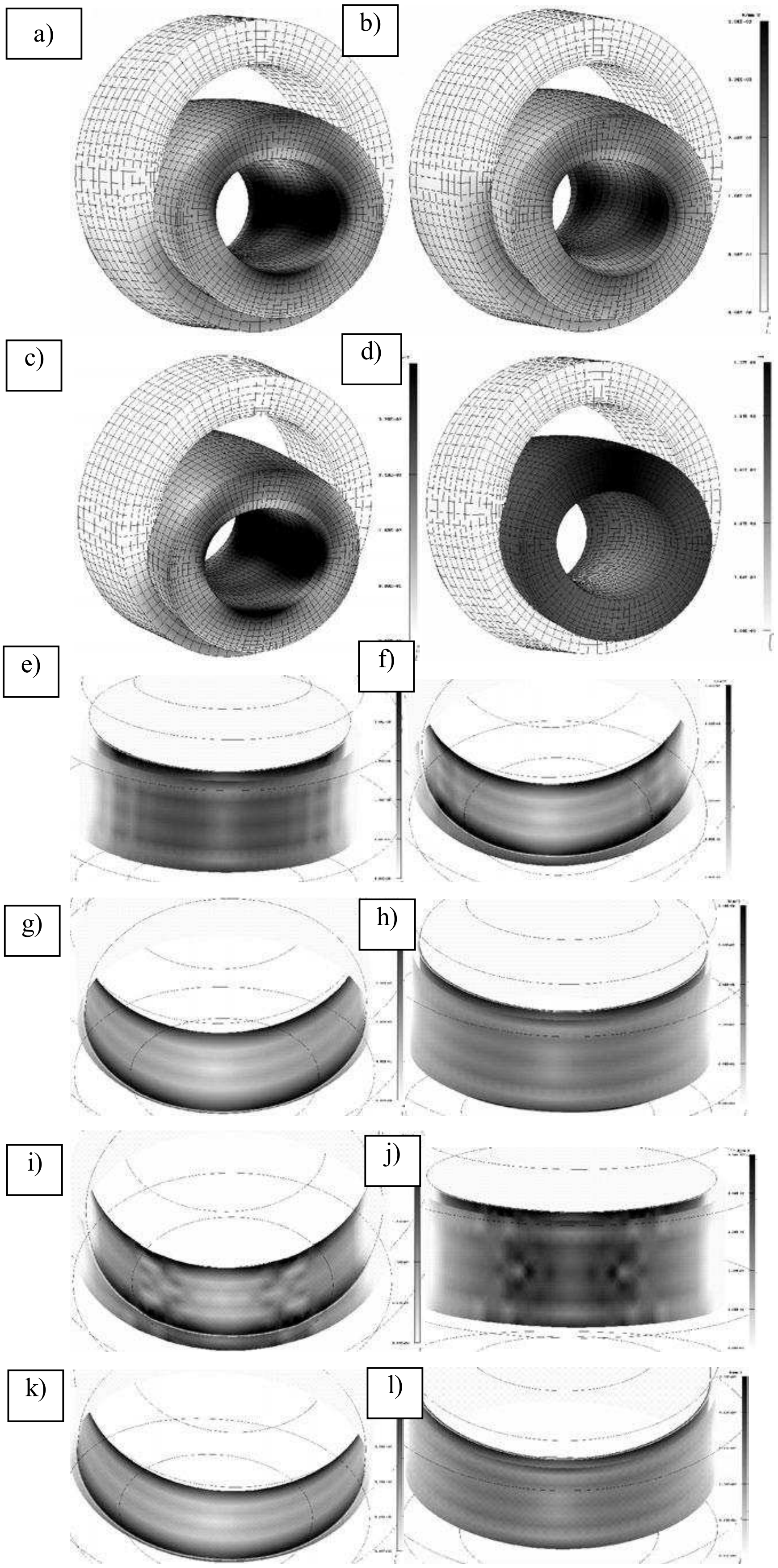

Fig. 9 Results of FEM analysis: a),b), c) – reduced stresses according to Huber-Misses hypothesis for models I, II and III d) – displacements of model I, e) – l) – distribution of contact stresses of hole and shaft for models I, II, III and IV.

There was selected piston's spigot joint. Sleeve with hole cooperates with floating pin. Mating surfaces of connection (diameter □ 50) are manufactured with proper dimensional deviations. End faces of pin are loaded with transverse force.

Table 4

Parameters of FEM computational model

Node Label Range	1 - 19602, 18720 Total
Element Label Range	1 - 15360, 15360 Total
Element Types	solid linear brick : 15360
Physical Properties	1 - SOLID1 : 15360
Materials	GENERIC_ISOTROPIC_STEEL : 15360

Outer surface of hole has no degrees of freedom. There were generated contact elements on mating surfaces.

On the basis on computations we can get a few sets of results. Designer is interested in getting reduced stresses according to Huber- Misses hypothesis, displacements in construction and distribution of contact stresses on the mating surfaces. In table 5 there are presented maximal values of selected magnitudes. Geometrical dimensions of hole and shaft are given in first column, in brackets.

Table 5

Parameters of FEM computational model

Fits	**Stress [MPa]**	**Displacements [mm]**	**Contact stresses [MPa]**
F8 B(+64)/h6 a(-16)	486	0,1570	427
F8 A(+25)/h6 b(0)	413	0,0999	332
F9 B(+87)/h8 a(-39)	590	0,1870	544
F9 A(+25)/h8 b(0)	413	0,0999	332

Summary

Performed analysis of fits has confirmed the known relationships. Models show the difference between similar fits. Models allow to estimate completely state of connection and show the difference of results between similar fits. The highest differences are visible in distributions of contact stresses. Analysed models did not take into account roundness and cylindricity deviations, what should be considered during further works.

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