EAN 2017
55th conference on experimental stress analysis

Modal analysis of composite ram

Ing. Milan TANČIN, Ing. Luboš Limberg
University of West Bohemia, Univerzitní 22, 306 14, Plzeň, Czech Republic
University of West Bohemia, Univerzitní 22, 306 14, Plzeň, Czech Republic
milax@rti.zcu.cz, limbi@rti.zcu.cz

Keywords: modal analysis, composite ram, eigenfrequency, composite

Introduction

This topic relate to comparing modal analysis on composite tubes, which are constituent parts the composite ram. These modal analysis are based on modal analysis performed on real part. Three types of modal analysis were performed: 1) modal analysis for freely placed ram, 2) modal analysis for fixed ram on one side, 3) modal analysis for fixed ram on one side with additional mass. The main goal is to create virtual model, which will have almost the same boundary conditions (dimensions, layers, orientations, etc.). Obtained results will be compared with results obtained from real analysis.

Preparing the model

For preparing the model were available 3D models of whole ram, data from modal analysis [1], including their placement [2] and properties [3] and weight of each part [4].

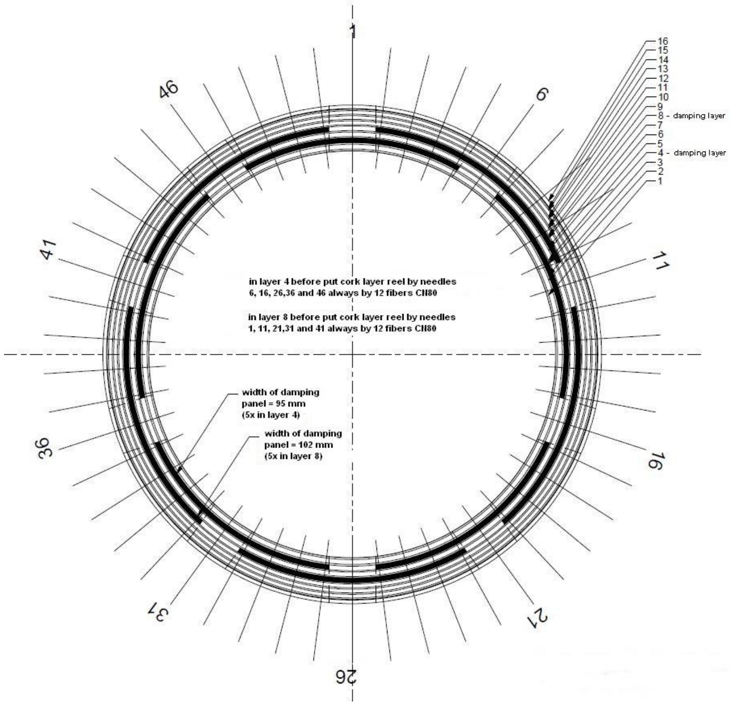


Fig. 1: Tube cross-section with shown layers [2]

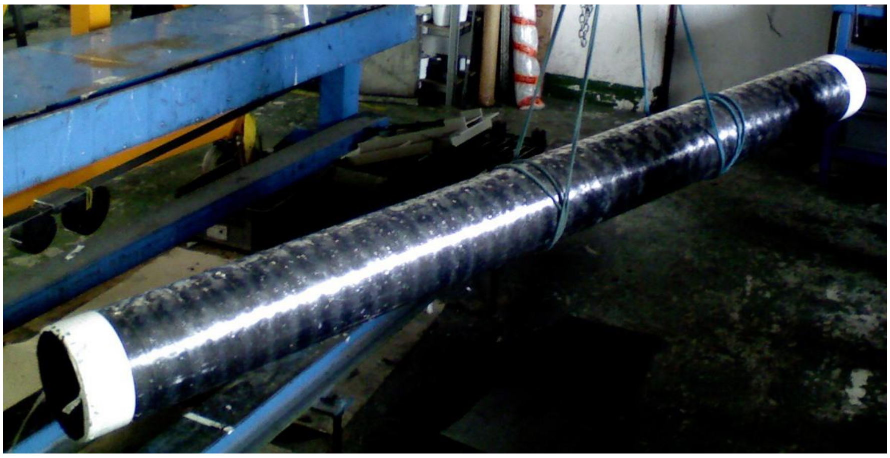


Fig. 2: Measuring free oscillation the ram

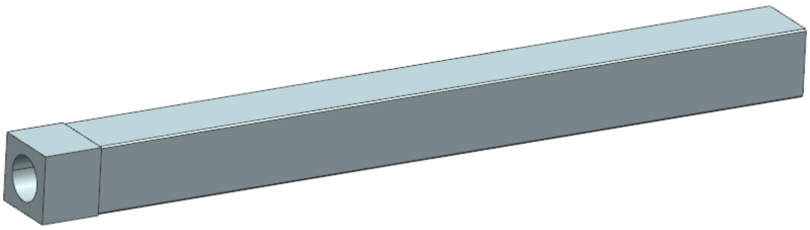


Fig. 3: 3D model of whole ram

For next operations, only some parts were necessary, concretely model of tube, which is divided into two pieces, further named as *ground tube* and *middle tube* with bigger diameter.

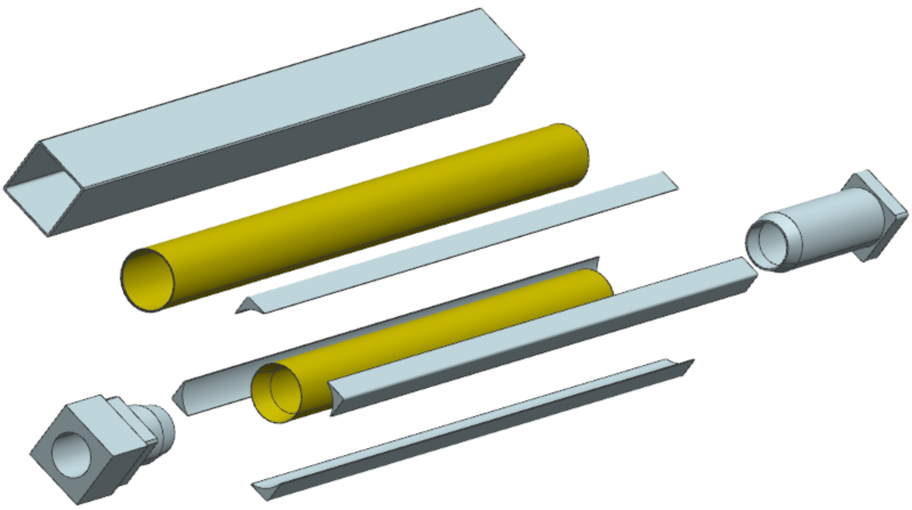


Fig. 4: Exploded view with marked parts (yellow colour), which will be solved

Selection computational model

Before preparing computational model is needed to select the best model type for this task type. Exist two main ways, how to model the ram. First way is to model the ram as 3D solid for each composite layer. It means, that individual layers are modelled, meshed and connected to each other. Each layer have defined its properties separately. This way wasn´t prefer, due to demanding preparing the model and connecting layers to each other. In additional, some layers are very thin and this computational model wouldn´t have to be too stable. Second way is to create the model as 2D task and define each layers by laminate modeler. This way was prefer for synoptic layers definition and for better and easier potential future adjusts.

Model creation

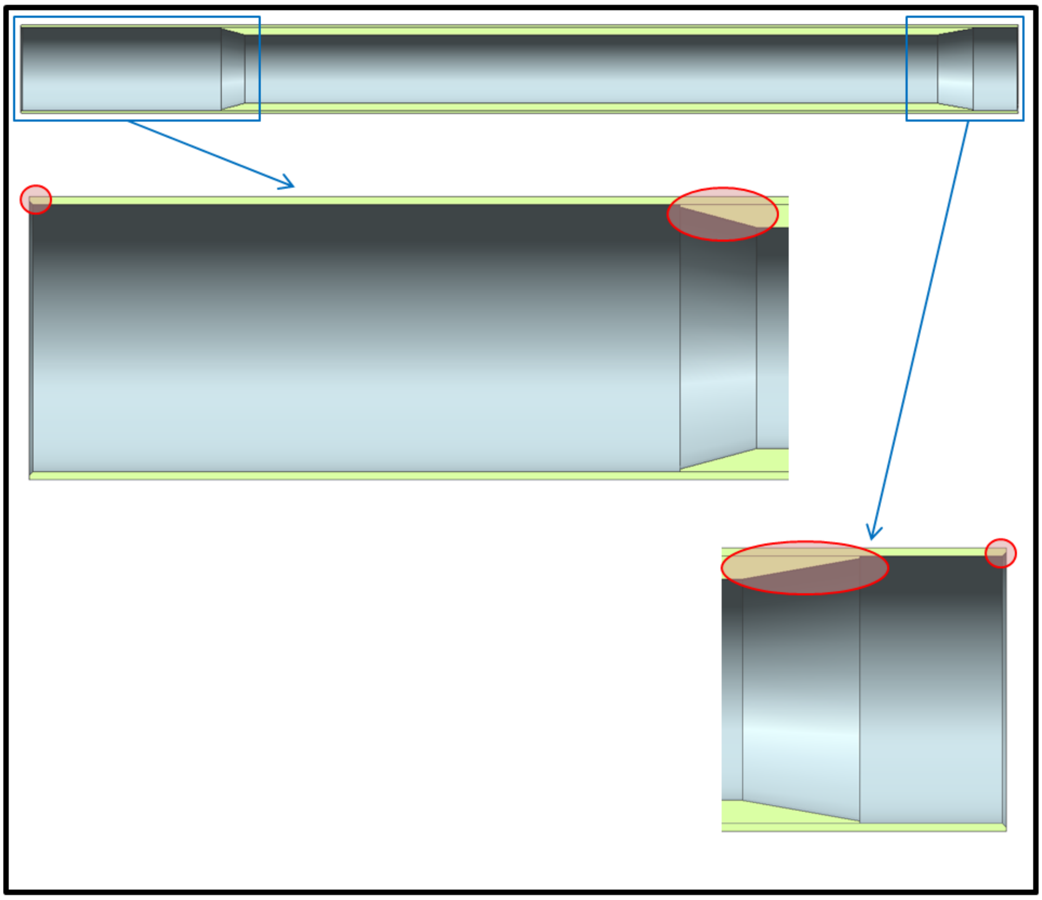


Fig. 5: 3D model of the ram – cross-section with details of chamfers (red marked)

After selection of computational model is possible to model tubes of the ram, which will be computed. This task was a little simplified and certain faces was adjusted to following layer definition. As can be seen on Fig. 1, in certain sectors (black filled), there are cork panels, which have influence on time costs and correct computational approach. Whole 2D model was cut into smaller faces and for each face was defined appropriate layer composition. This approach was selected due to simplify chamfers, which are shown on Fig. 5, where is shown initial model. Consequently, chamfers were represented by cut face, like on Fig. 6.

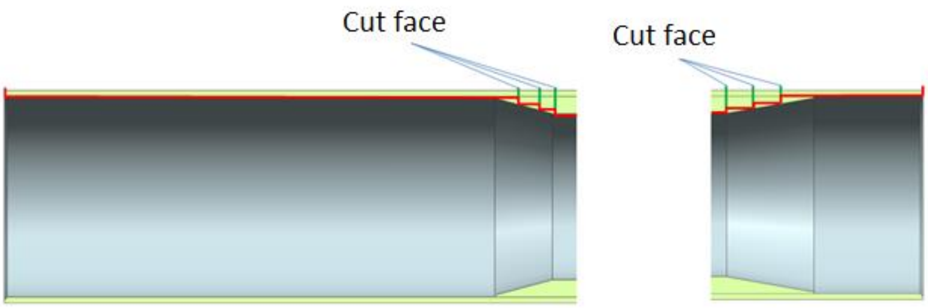


Fig. 6 Simplified chamfer areas – places, where computational 2D model was cut (green marked)

Thanks to these simplifying conditions, 2D model were created, prepared to assign mesh and single layers by laminate modeler. All cut faces will have assign appropriate number of layers.

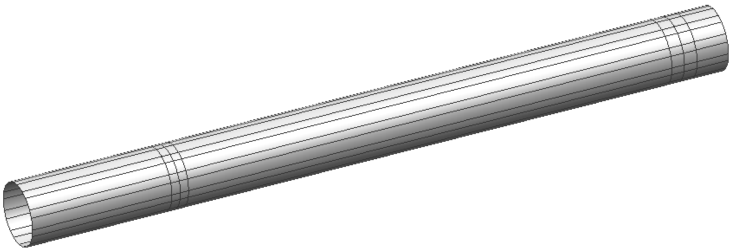


Fig. 7 Final 2D model

Mesh creation, layer definition

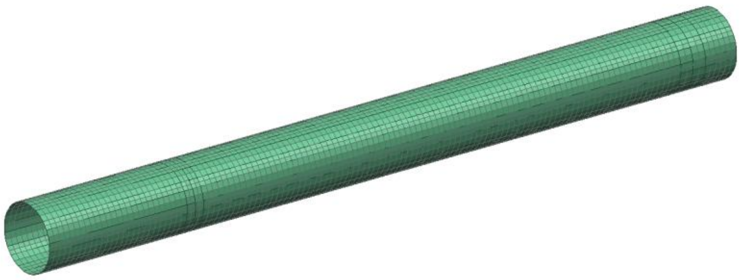
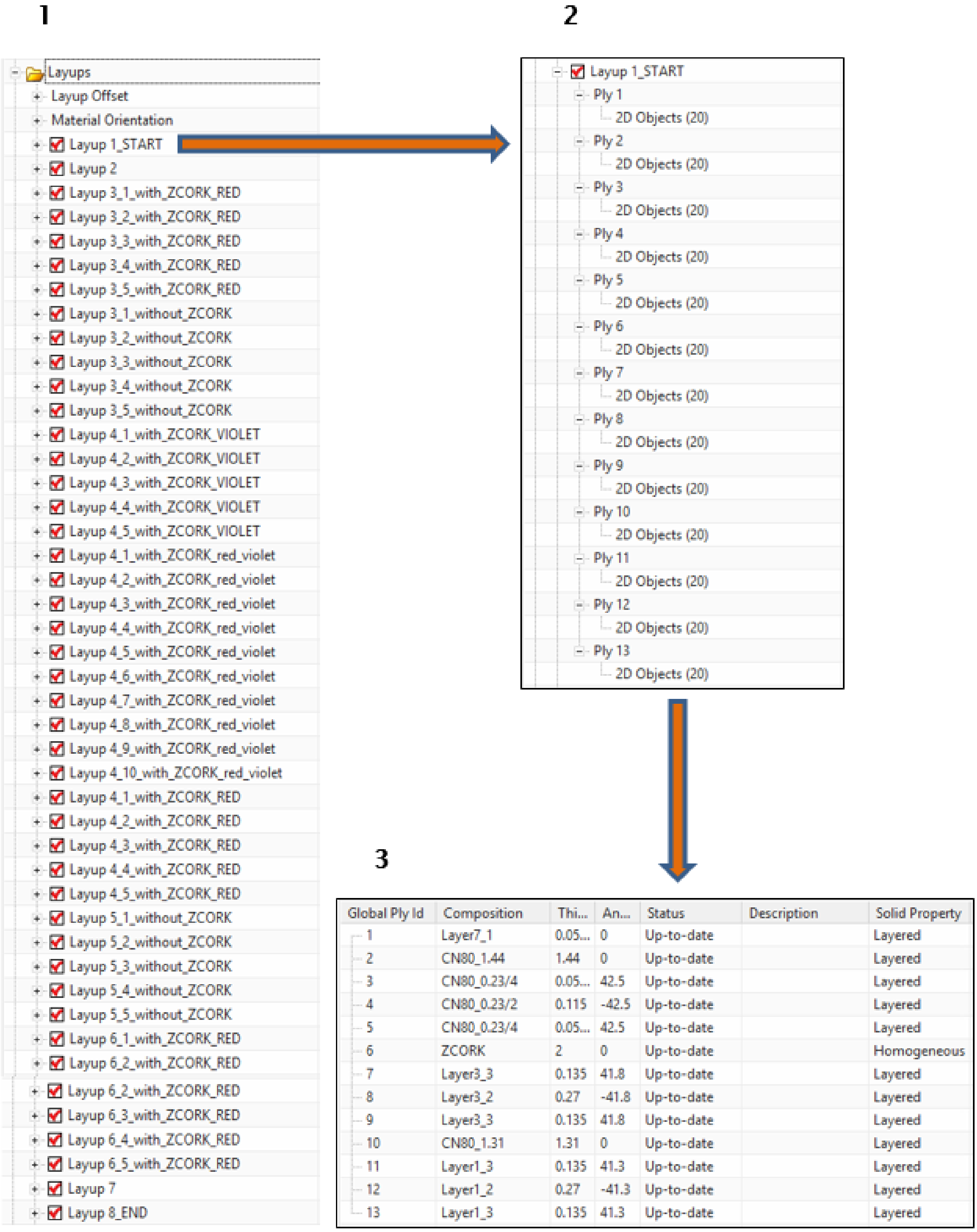


Fig. 8: 2D model of the composite tube

Fig. 9: Layer definition - demonstration example for angle 45°

After creation of computational model, mesh definition follows. Thanks to previous adjustments on 2D model, is it possible to define properties for each face separately, in relation to real layer composition. As was mentioned, this approach was selected mainly due to cork layers. As mesh was selected CQUAD4 with element size 20mm and this mesh was used for all 2D faces. After mesh definition was define layer properties for each face. This stage of definition have the biggest time costs, because by cut caused new 140 faces and each face must be defined separately. It is given due to type of fiber winding, mainly for different angle than 0 and 90 degrees. Fig. 9 describing layer definition for different layers. As it can be seen, each layer with different angle from 0 and 90 degrees must be defined three times. Layers with angle 0 and 90 degrees, are winded completely with this angle. Layers are defined by so-called *layups*. These layups have all information about particular layer. Layups can be united for faces with same properties.



Global Ply Id	Composition	Thi...	An...	Status	Description	Solid Property
1	Layer7_1	0.05...	0	Up-to-date		Layered
2	CN80_1.44	1.44	0	Up-to-date		Layered
3	CN80_0.23/4	0.05...	42.5	Up-to-date		Layered
4	CN80_0.23/2	0.115	-42.5	Up-to-date		Layered
5	CN80_0.23/4	0.05...	42.5	Up-to-date		Layered
6	ZCORK	2	0	Up-to-date		Homogeneous
7	Layer3_3	0.135	41.8	Up-to-date		Layered
8	Layer3_2	0.27	-41.8	Up-to-date		Layered
9	Layer3_3	0.135	41.8	Up-to-date		Layered
10	CN80_1.31	1.31	0	Up-to-date		Layered
11	Layer1_3	0.135	41.3	Up-to-date		Layered
12	Layer1_2	0.27	-41.3	Up-to-date		Layered
13	Layer1_3	0.135	41.3	Up-to-date		Layered

Fig. 10: Created layups – demonstration example for definition one face

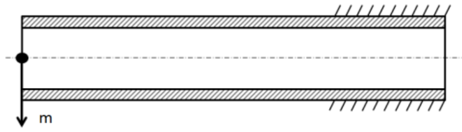
Computing, results

After that material properties was defined, computing can start. Modal analysis was solved by NX NASTRAN solver a type of solver was SOL 103 Real Eigenvalues. Lower border for looking for real eigenvalues was set-up on 1Hz. Totally 3 tasks were solved.

- Freely placed ram

- Fixed ram on one side

- Fixed ram on one side with additional mass



Last two cases have informational character, due to lack of information about length of fixation and size and position the additional mass. For freely placed ram, this set – up is enough and computing can start. For fixed ram on one side is necessary define this fixing, it means, remove degrees of freedom in this place. For fixed ram on one side with additional mass is necessary to define this mass and location.

Freely placed ram

In case of freely placed ram, results were in compare with experiment about 7 - 38% different. This difference can be caused by simplifying conditions for chamfered faces. Another influences can cause lack of information about real thickness a real ratio between fibers and resin for each layer. This influence can be caused by winding layer on winded previous one. Lower layer can be pressed under nominal value and its properties could be different from reference data.

Mode	Experiment	Simulation	Difference (%)
	Frequency (Hz)	Frequency (Hz)	
1	383	356	-7.0
2	476	359	-24.6
3	713	575	-19.4
4	747	578	-22.6
5	792	590	-25.5
6	947	592	-37.5
7	982	663	-32.5
8	1060	663	-37.5
9	1120	734	-34.5
10	1170	735	-37.2

Table 1: Results for freely placed ram

Fixed ram on one side

In modal analysis for fixed ram on one side, most modal frequencies were lower than 15%. Fixed area was determined approximately, due to lack of accurate information. Different results can be caused by factors mentioned in chapter above.

Mode	Experiment	Simulation	Difference (%)
	Frequency (Hz)	Frequency (Hz)	
1	273	256	-6.2
2	392	256	-34.7
3	400	357	-10.8
4	572	359	-37.2
5	606	577	-4.8
6	653	578	-11.5
7	684	614	-10.2
8	775	738	-4.8
9	809	741	-8.4
10	970	755	-22.2

Table 2: Results for fixed ram on one side

Fixed ram on one side with additional mass

Last case, modal analysis for fixed ram on one side with additional mass had similar results in compare with experiment mainly for higher frequencies. For lower frequencies were results more different. As in previous case, there was lack of information about fixing and additional mass. For simulation was used smaller ending. Weight of the ending was known. It was 43kg. On the picture, ending was most probably a little bit moved out from ram. This boundary condition wasn´t taken into consideration. Mass is defined as 1D element connected to ram in area, where ending is really placed. On the table 3, it can be seen, that for higher modes, diffence is about 5%, but for lower modes, results are very difficult.

Mode	Experiment	Simulation	Difference (%)
	Frequency (Hz)	Frequency (Hz)	
1	703	102	-85.5
2	858	102	-88.1
3	976	628	-35.7
4	1070	737	-31.1
5	1160	738	-36.4
6	1310	959	-26.8
7	1450	959	-33.9
8	1540	1241	-19.4
9	1570	1491	-5.0
10	None	1491	

Table 3: Results for fixed ram on one side with additional mass

Conclusion

This topic related about realized modal analysis of composite ram. Model was created as divided 2D face and then composite layers were defined. Certain areas of the ram were simplified. After obtain result was shown, that simulation corresponds with experiment only for certain modes. Reasons, why some modes are different, can be more. At first, bottom layers can be stiffer (about 10%), due to way of manufacturing, when each following layer can cause stiffening to previous layer. Some influence can cause not accurate storing layers in little different angle, than reference. Finally, for precise modal analysis is necessary to have more information about precise boundary conditions. This simulation partly confirmed it. To possible improve these results, mainly for modal analysis of freely placed ram, Ansys solver will be used for comparing these results between themselves. For this step should be used shell elements and these new results will be compared with actual ones. Suitable aspect to take into consideration is change material properties for winded layers, placed on lower diameters in the structure. After modal analysis in Ansys, larger model of machining machine and also whole model of the ram (including outer frame, sides and endings) will be created.

References:

[1] f. a. v. Z. v. P. Katedra mechaniky, „Modální analýza vřeteníku,“ Plzeň, 2010.

[2] R. Poul, „Smykadlo-TrubkaZaklad-RozvrzeniVrstev-1,“ 2010.

[3] Unknown, „kompozitni_skladby“.

[4] Unknown, „VahyDilu-1“.