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STUDY OF FREE BENDING VIBRATIONS FOR TEXTILE MACHINES SPINDLES

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ABSTRACT
This paper is a part of a large study made by the authors in the domain of bending vibrations of the textiles spindles of the cotton ring spinning frame and twisting machines. The free vibrations of an SKF spindle are analyzed by the Finite Element Method. The natural frequencies are calculated for a large range of rotation speeds and the normal modes are determined. The calculation is made by using MSC/Nastran computer program, for different mesh sizes and for different types of finite element. The natural frequencies values resulting for each case are compared, to establish the best model approaching the actual spindle.
Keywords: *vibration, textile spindle, Finite Element*

1. INTRODUCTION
Textile spindles are basic subassemblies of ring spinning and twisting machines which greatly influence the quality of processed yarns. Their proper operation requires low vibrations and noise values, low energy consumption, long working life of bearings and increased reliability. The researches in this field and solutions proposed did not entirely solved the vibration related problems occurring during operation. The feedback from the users, as well as the new models of spindles exhibited at International Fairs further the preoccupations in the direction of perfecting the spinning and twisting mechanism in which the spindle is contained. This concern is also manifested by the large Companies manufacturing textile equipment and components.

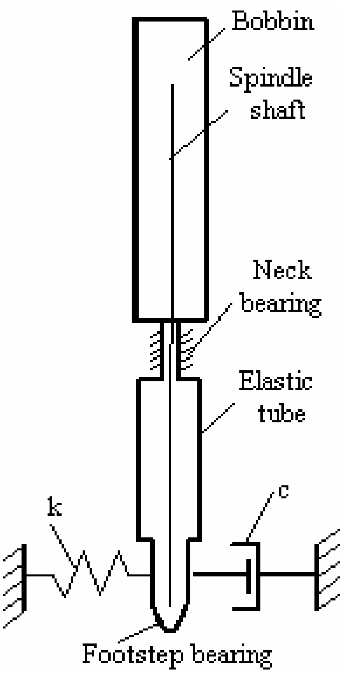

Figure 1. Schema of textile spindle

The present paper is a part of a larger investigation carried out by the authors on bending vibrations of textile spindles, the cotton ring spinning frames are fitted with.

The investigations commenced with the study of a SKF-type spindle free vibrations, extensively employed in the spinning mills from all over Europe (fig.1).

The natural frequencies of the spindle and its critical speeds were determined by means of transfer matrix method [1].

2. THE STUDY OF FREE BENDING VIBRATIONS OF THE SPINDLE BY MEANS OF FINITE ELEMENT METHOD
The analysis of the free bending vibrations of spindles has been further carried out by Finite Element method, two objectives being aimed at: the calculation of natural frequencies over a wide range of speeds, on one hand, including running conditions as well, and on

the other hand, the determination of normal bending vibration modes of spindle.
For this purpose, the MSC/Nastran programme was used [3, 4] observing the specific working phases corresponding to the method:

- drawing-up a geometrical model appropriate to the actual spindle of dimensions from figure 1 and from technical documentation [2];
- meshing;
- defining material properties (elasticity modulus, volumic mass of steel and aluminum);
- introduction of boundary conditions (limiting the possibilities of translation and rotation);
- running of programme.

2.1. Beam elements

In the first stage, meshing was effected with linear beam-type elements of full circular section. The programme was run at various mesh sizes such as:

- spindle made similar to the model equivalent with 17 beam-type elements and 18 nodes (I);
- spindle made similar to the model equivalent with 384 beam-type elements and 385 nodes (II).

The natural frequencies are recorded in table 1.

Table 1. Natural frequencies of spinning frame spindle

Order Freq.	Transfer Matrix		FEM. (I)		FEM. (II)	
	(Hz)	(rad/s)	(Hz)	(rad/s)	(Hz)	(rad/s)
1	55,34	347,71	54,55	342,74	55,33	347,64
2	639,60	4018,72	640,42	4023,87	635,84	3995,10
3	1328,22	8345,45	1268,10	7967,70	1321,11	8300,77
4	-	-	1588,03	9977,88	1688,75	10610,72

For determining the normal vibration modes of the spindle, the same programme was used and the results were reported in graphical forms. Figure 2 shows the normal modes obtained with beam elements for meshing the spindle geometric model in 17 fields and figure 3 presents the normal modes obtained with same types of elements for meshing geometric model in 384 fields.
Analyzing the values from table 1 and from the graphs, the following conclusions could be drawn:
The results obtained by using linear finite elements are very close to those obtained through the transfer matrix method [1]. The spindle under consideration has four natural frequencies within the theoretical range, but only the basic one lies within the working domain, around the value of 55 Hz (3300 r.p.m.).

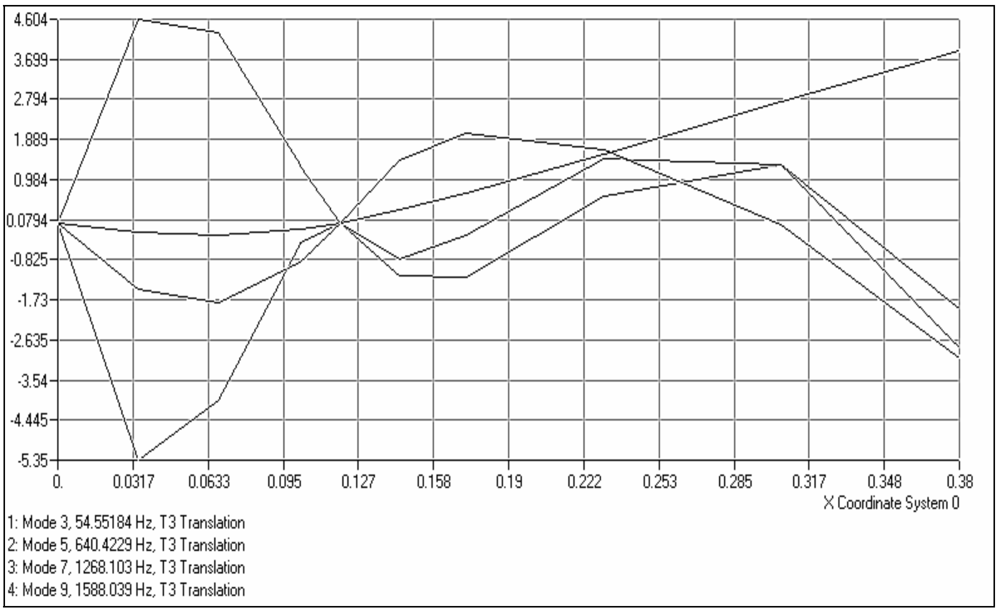

Figure 2. Normal modes of bending vibrations for textile spindle (beam elements I)

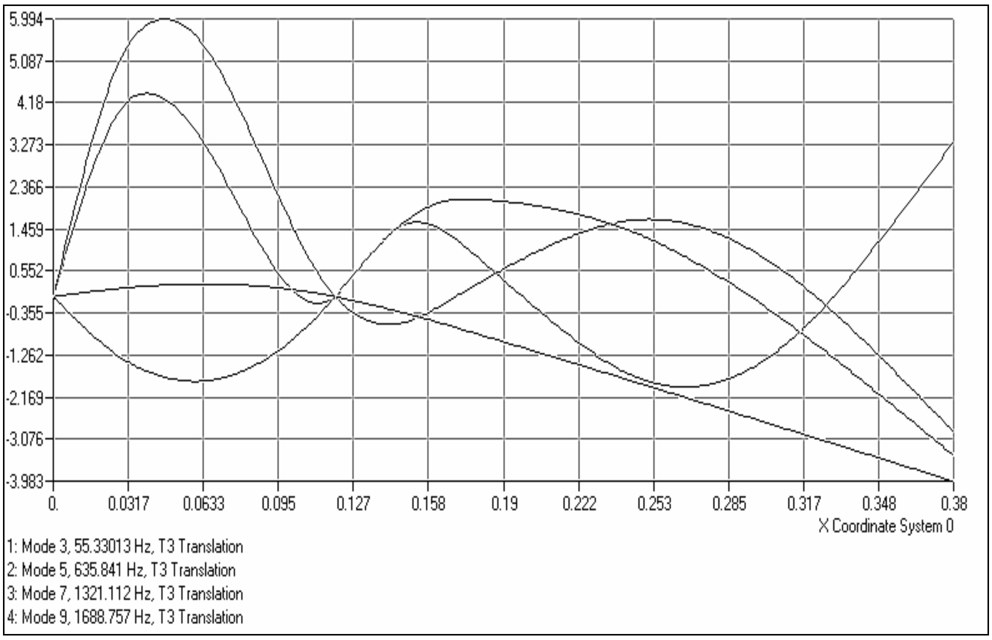

Figure 3. Normal modes of bending vibrations for textile spindle (beam elements II)

The normal modes highlight tendencies of angular or linear displacements of spindle axis during bending vibrations. Thus, the thinner end of spindle shaft has a maximum displacement bringing about the need of damping within the area. This information can be used for the constructive changes occurring within the optimization process.

2.2. Volumic elements

The study of vibrations was continued with other types of finite elements, in order that the results be compared and the optimum variant could be established, so that the simulation be closest to the dynamic behavior of actual spindle.

Meshing was effected with tetrahedral volumic elements, the following were simulated:

- spindle geometrically modeled in accordance with the actual spindle, with 6656 elements and 4191 nodes (I);
- spindle geometrically modeled in accordance with the actual spindle, with 39299 elements and 10729 nodes (II);
- spindle geometrically modeled in accordance with the actual spindle, with 106659 elements and 25894 nodes (III);

Table 2 contains natural frequencies of spindle, calculated for various mesh size. Likewise, for determining the normal vibration modes of spindle, the same programme was run. The results were obtained in the form of graphs.

Figures 4, 5 and 6 show the normal modes for spindle obtained with volumic elements.

The natural frequencies have values higher than with beam-type elements, but they drop with the increase of number of elements, tending to get stabilized. From the table one can observe that the natural frequencies are pairs of appropriate values, they correspond to vibrations in plane xOz, more exactly in the direction x, and in the plane yOz, direction y, respectively.

From the normal modes of vibrations reported the first two which are within working domain have a special significance.

Table 2. Natural frequencies of spinning frame spindle (volumic elements)

Order freq.	Natural frequencies (Hz)		
	I	II	III
1	77,6	72,5	68,78
2	79,2	72,8	68,82
3	899	850,6	823,98
4	906	851,3	824,59
5	1481	1338,5	1244,68
6	1487	1383,2	1325,19
7	1507	1388	1326,5
8	1580	1587	1524
9	2170	2003	1892,7
10	2269	2013	1895,8

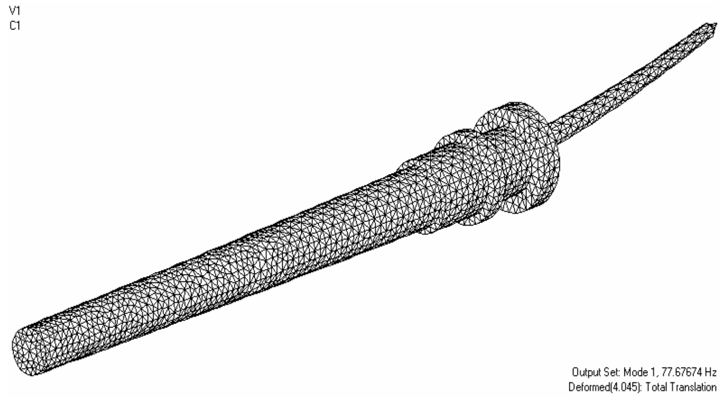

Figure 4. The first normal mode of spindle vibration (volumic elements)

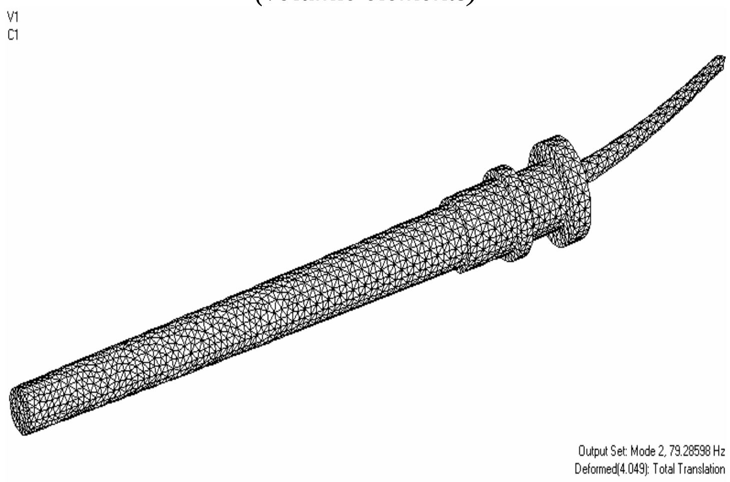

Figure 5. The second normal mode of spindle vibration

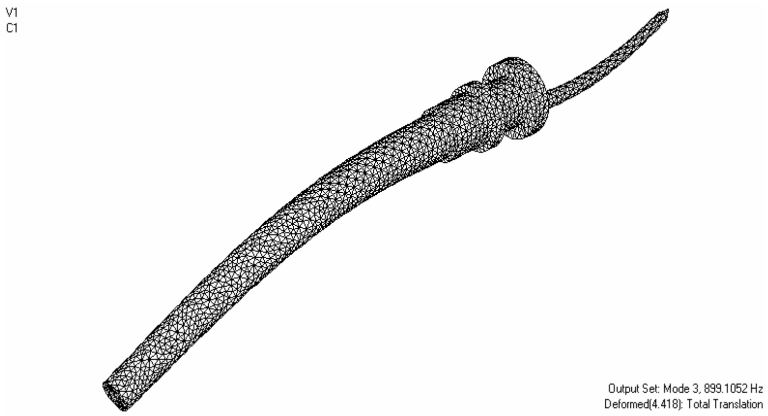

Figure 6. The third normal mode of spindle vibration

3. CONCLUSIONS

The study of bending vibrations of spindles through the agency of finite element method has the advantage of rapidly obtained results. These are close to those obtained by transfer matrix method, thus the usefulness of the models proves to be correct.

Modeling with volumic elements offer supplementary suggestive informations with regard to normal modes of spindle vibrations.

Researches could be continued for forced vibrations, with special attention on critical zones. The investigations could conclude with the practical application of the results.

4. REFERENCES

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