Considerations Concerning the Oil Viscosity Influence on Textile Spindles Dynamic Response

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Dynamic complex phenomena due to specific running conditions for textile spindles such as speeds, unbalanced yarn bobbins, their attachement to the ring frame, types of spindle bearing units, are the main causes of significant modification in time for running parameters with important implications in unwished efect appearance. In this way, the paper presents some aspects concerning the oil viscosity influence both on rotative spindle+yarn bobbin system dynamic response with the help of double amplitude measuring for spindle rod and on running power consumption of textile spindles. The experimental researches make evidence on textile spindles vibration amplitudes increasing with oil viscosity decreasing, but power consumption increasing in corellation with oil viscosity increasing too; these aspects have a negative influence on running dynamic stability. The experimental results presented as influence diagrams contribute to establish an important data base which will help in taking adequate decisions for oil viscosity selection necessary to textile spindles.

Keywords: oil, viscosity, textile spindle, dynamic response, power consumption

During the operation period, a textile spindle must work with rod vibration amplitudes as small as possible able to be mentioned in a centered position towards the ring. This condition is very difficult to be realized when the spindle speeds and the bobbin imbalance increases. All deviations from this condition will lead to increase frequency of yarns breaking, low yarns quality and productivity. In the same time it is necessary to have a reduced spindles power consumption, a high bearings durability (8 - 10 years) and economic maintenance (oil change at 1500….20000 operating hours). In this way it must be taken into consideration the oil viscosity influence from spindle support on the power consumption.

All the aspects mentioned above are strongly connected with the oil viscosity, bearing execution solutions for the textile spindle rod, elastic and dumping proprieties, constructive tolerances.

The achieving of the main objectives regarding an adequate textile spindles functioning requires fulfillment of conditions of particular importance which are specific for textile spindles vibrations, such as:

- the fundamental critical speed must have significant lower values than the operating textile spindle speed in order to benefit of self-stabilization phenomenon; in this situations there are obtained low values for rod amplitude vibrations during the operating process;
- the resonance curve from the critical speed area must have a flat aspect in order to obtain amplitude low values with the best results especially for machine stop-running to avoid unwished touches between bobbin and traveler;
- under-harmonics resonance phenomenon specific for the operating speeds zone must be avoided; these kind of situations would appear due to the non-linear proprieties specific for elastic elements of bearings;
- the textile spindle rod axis trajectory must be very closed by circle during the operating process for an unbalanced bobbin; to realize such a condition it is necessary a radial symmetrical system with elastic support for bearings and damping proprieties against the textile spindle support; in this case it will be obtained minimum tension forces for yarns due to the uniform traveler run on the ring;
- the capacity to keep low values for textile spindle rod vibration amplitudes with unbalanced bobbins;
- stability for textile spindle rod vibrations under the influence of external perturbation factors such as textile belts joining, their vibrations and stretcher rolls;
- obtaining low loadings of upper bearing even higher levels of bobbin unbalance in order to reduce energy consumption, noise level and to increase bearings durability at high speeds.

In the theoretical studies on the textile spindles dynamics, oil viscosity influence on the dynamic response during the operating process is put t in to evidence through the damping coefficient ***c***. In this way there were developed original mathematical models for two specific situations encountered in practice concerning types of support for rotating system structured by textile spindle and yarn bobbin [3, 4, 6, 7, 13 15]:

- elastic support to the cup's lower bearing;
- elastic support to the cup for both textile spindles bearings.

For example there is presented the motion equation system corresponding to a theoretical study that refers to the situation of an elastic support to the cup lower bearing (fig. 1) [13]:

$$\begin{cases} \ddot{\psi} - \dfrac{c \cdot l_1^2}{J} \cdot \theta^2 \cdot \dot{\psi} = -\dfrac{J^*}{J} \cdot \omega_r^2 \cdot \theta \cdot \sin(\omega_r \cdot t) \\ \ddot{\theta} - \dfrac{c \cdot l_1^2}{J} \cdot \dot{\theta} + \dfrac{k_e \cdot l_1^2}{J_o} \cdot \theta = -\dfrac{J^*}{J_0} \cdot \omega_r^2 \cdot \cos(\omega_r \cdot t) \end{cases} \quad (1)$$

in which ***c*** is the damping coefficient.

Experimental part

The experimental researches have been conducted using a test rig originally designed [11] presented in figure

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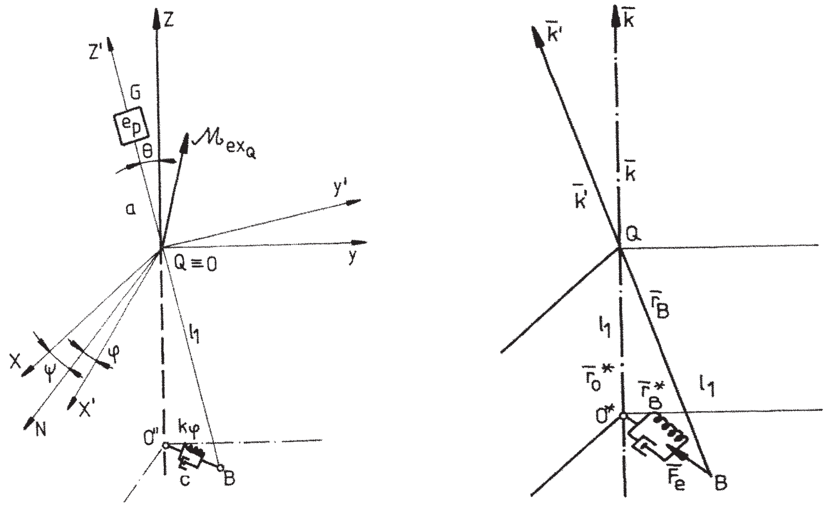


Fig. 1. Theoretical model for a textile spindle with an elastic support to the cup's lower bearing

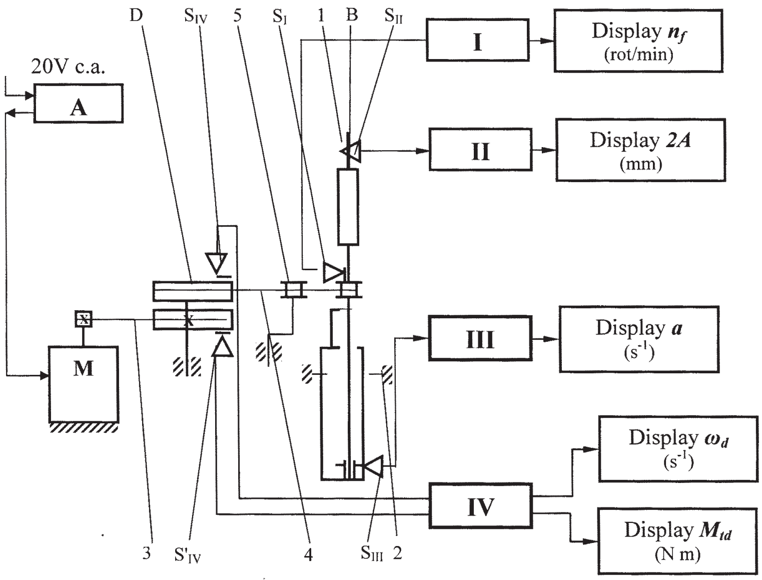


Fig. 2. Test rig for experimental researches on textile spindles

2, which allows determination of speed for the whole rotating system (textile spindle+yarn bobbin), double amplitude ***2A*** for the vibrations of the rotating ensemble, accelerations ***a*** of textile spindle cup, angular speed of dynamometer ω_d and torsion moment of the dynamometer M_{td}. With the help of ω_d and M_{td} where obtained the power consumption values. There are mentioned in this figure: **A** – command electronic device; **M** – variable speed device for textile spindles with range between 0 … 25000 rpm; **D** – torsion dynamometer; **1** – rotating ensemble (textile spindle+yarn bobbin); **2** – machine supprot for textile spindles; **3**, **4** and **5** - belt transmisions; SI - speed sensor for textile spindle; SII - amplitudes sensor; SIII - accelerations sensor for the cup of textile spindle; SIV and SV magnetic sensors for dynamometer; I, II, III and IV -electronic devices for prelevation and transfer of signals.

The vibrations source is realised with the help of an equivalent bobbin from metal which is able to replace the real yarn bobbin; it permits to obtain different excentricity values for its own mass center. This bobbin is fixed to the real bobbin mass center and it has the same mass and the same inertial moments calculated according to the main inertial axis. It is possible to be fixed on the equivalent bobbin (initial balanced) different masses whose values are established according to the experimental research program; the maximum value of the unbalancing mass is determined in connection with the value for this parameter specific to the real operating process.

This equipment for experimental researches has created the adequate conditions to realize a very large number of determinations in different conditions able to establish the main effects of oil viscosity from the textile spindle cup on the amplitudes values of the rotating ensemble, on the cup accelerations and on the power consumption. The tests were made for different values of oil viscosity between 16.....65 cSt. For experimental researches were tested textile spindles both from the last generation produced by Texparts Company from Germany based on HF and HZ support types and an original model of textile spindle HL type [12].

In figures 3 and 4 are presented two special mechatronics systems for testing textile spindles which were concepted based on the general schema of the test rig mentiond above. These two testing equipment include original elements which are able to offer a high precision for the experimental measurements.

Based on experimental data there were built the diagrams for double amplitude variation of rotating ensemble, for cup's accelerations and for textile spindles power consumtion in different operating process conditions; there were selected the diagrams from figures 5-10.

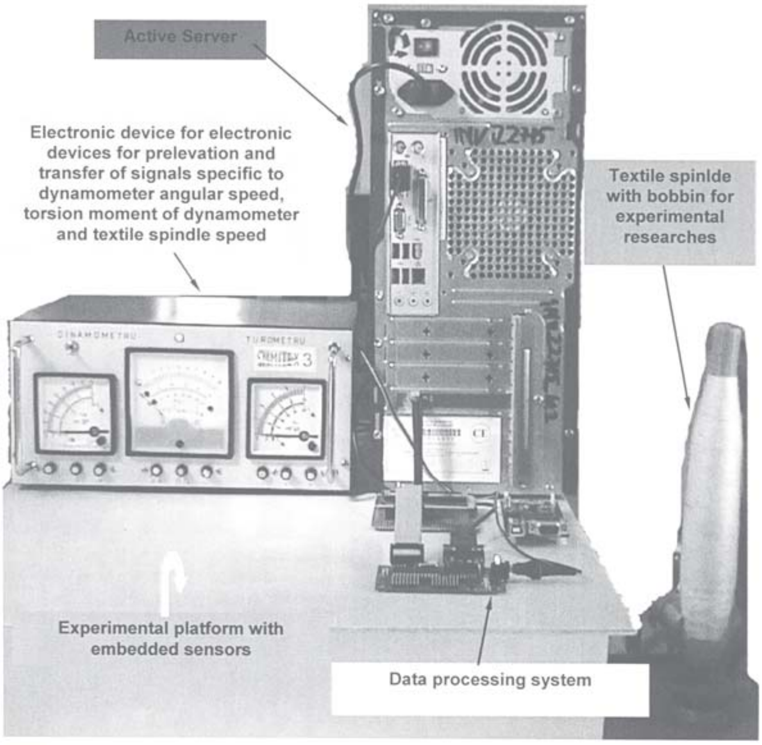


Fig. 3. Mechatronic system designed for experimental researches concerning power consumption of textile spindles

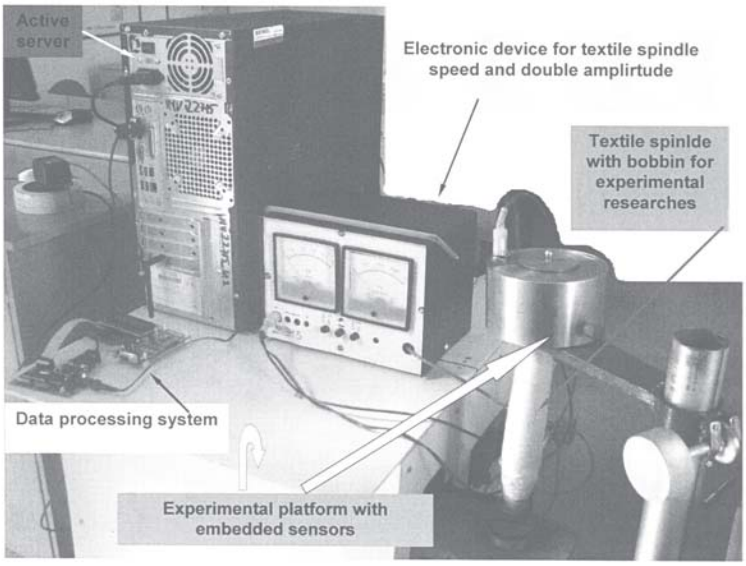


Fig. 4. Mechatronic system designed for experimental researches concerning double amplitudes of textile spindles

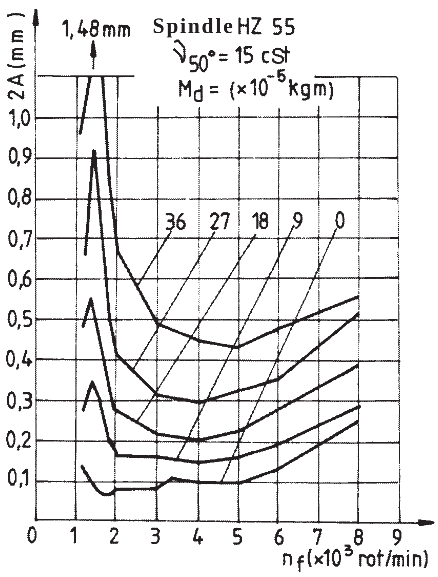


Fig. 5. Double amplitude variation of rotating esemble specific to HZ textile spindle

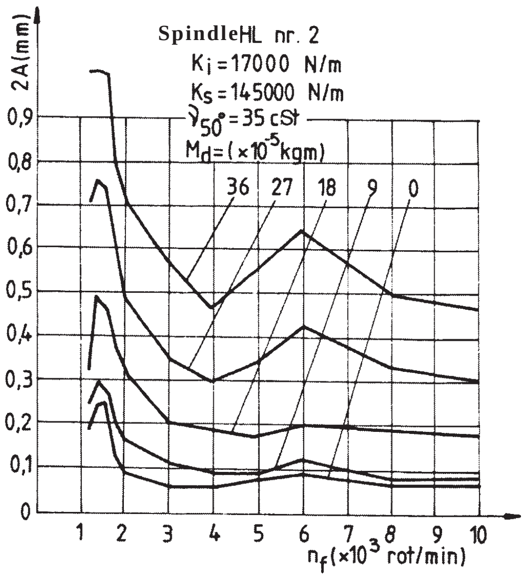


Fig. 6. Double amplitude variation of rotating esemble specific to HL textile spindle

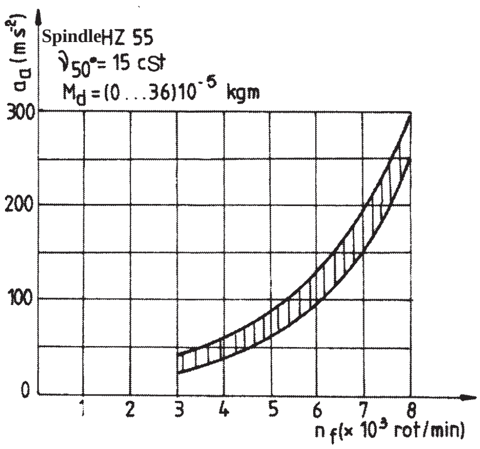


Fig. 7. HZ textile spindle cup accelerations

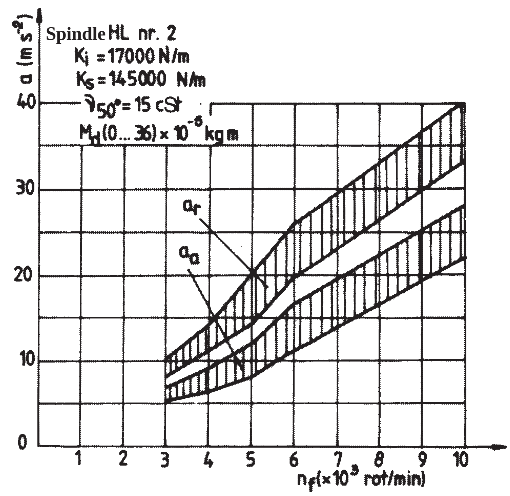


Fig. 8. HL textile spindle cup's accelerations

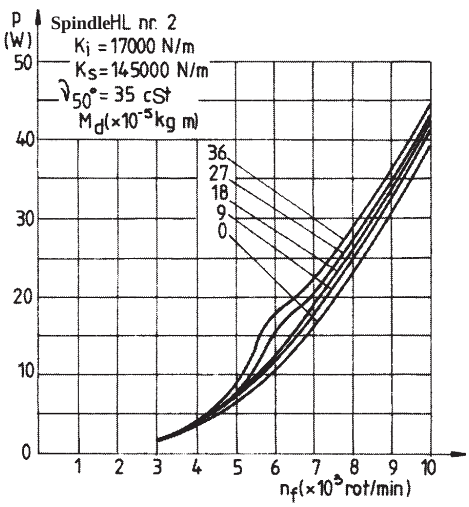


Fig. 9. HZ textile spindle power consumtion

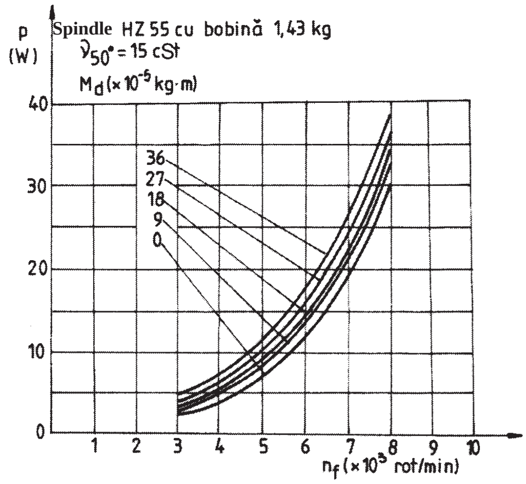
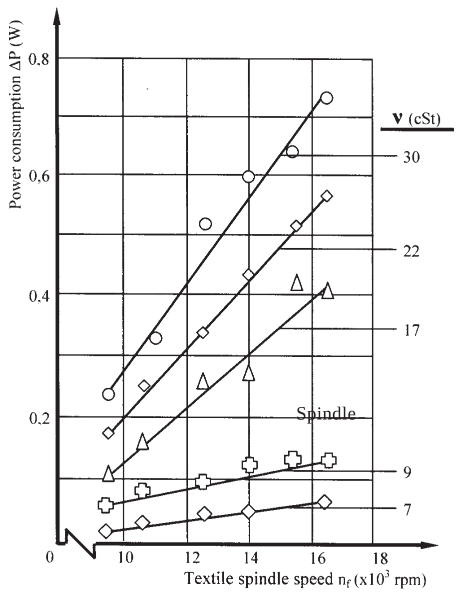


Fig. 10. HL textile spindle power consumption



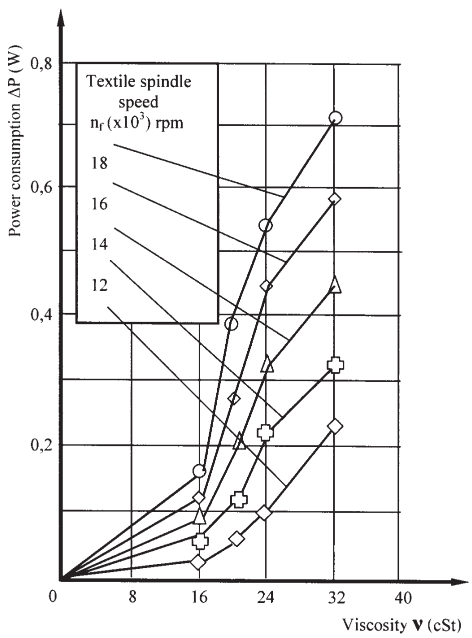


Fig. 11. HF textile spindle with bobbin unbalanced by 1.5 . 10^{-4} Nm

In figures 11 and 12 are presented the specific aspects of textile spindles HF and HZ types concernig thier response under the influence of oil viscosity on the power consumption [18, 19, 20]. It must be mentioned that for two values of bobbin's unbalance, the suplimentary power consumption ΔP for different oil viscosities, starting with a basical functioning with a viscosity ν = 7 cSt.

The suplementary power consumption ΔP significant increases for viscosities upper the value of 22 cSt. For exemple, when a textile spindle with an unbalanced value $\Delta = 2.5 \cdot 10^{-4}$ Nm is running – figure 12 using an oil viscosity of 30 cSt but not of 7 cSt, the suplimentary power consumption ΔP is:

-1.0 Watt/spindle at 16000 rpm;

-0.36 Watt/spindle at 10000 rpm.

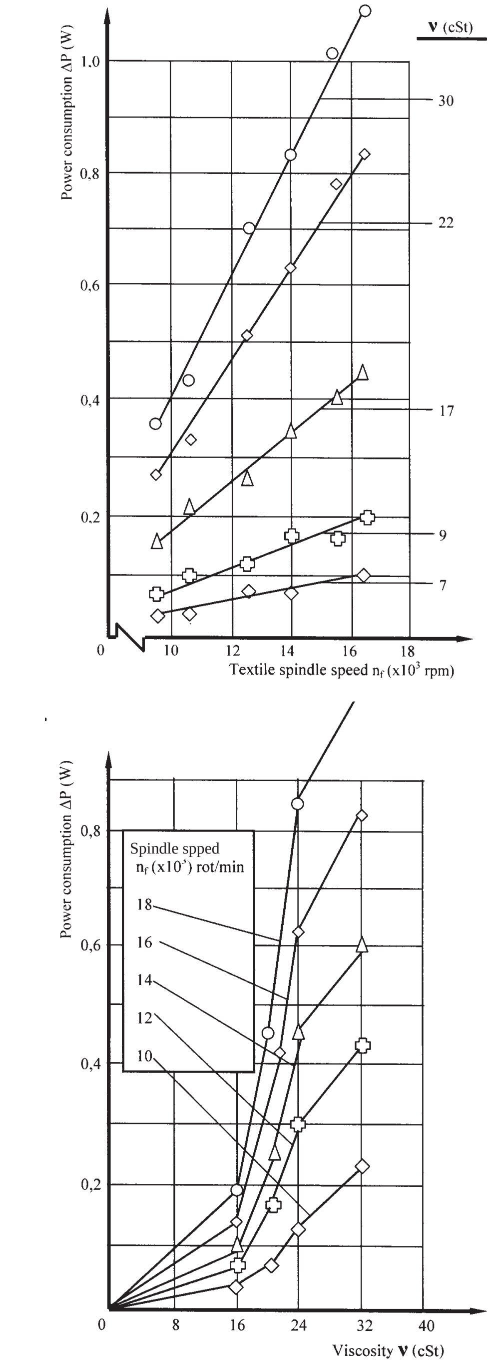


Fig. 12. HZ textile spindle with bobbin unbalanced by 2.5 . 10^{-4} Nm

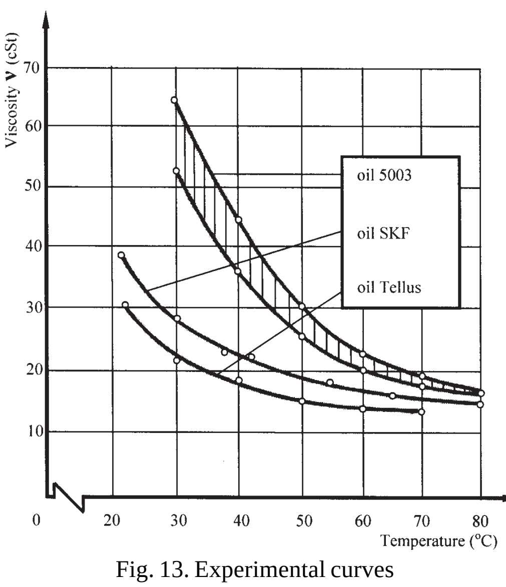


Fig. 13. Experimental curves

The power consumption is significantly higher when the textile spindles operate with high and very high speeds.

In figure 13 are presented the experimental curves for three oil types main used for textile spindles with their viscosity between 20....30cSt. From these curves it is possible to be observed that for temperature zone 40....50^{0}C (as an usual temperature met in operating proceses for textile spindles), only Tellus and SKF oils offer adequate values for viscosity.

Conclusions

The exeprimental researches point out that the increasing of textile spindles vibration amplitudes values eoth in accordance with a viscosity value decreasing, but, in the same time an increasing of power consumption when oils with higher values for viscosity are used; these are phenomen with a significant negative influence on the dynamics stability during the operating processes.

The experimental results presented as influence diagrams would be considered a contribution to built an important database on which support will be possible to be taken the best decisions concerning the adequate selection of the oil viscosity dedicated to textile spindles.

As a final conclusion, it is recommendable to be used oils with values of viscosity between ν = 7....15 cSt at 50^{o}C temperature with adequate additives. The necessity of additives is imposed by the low values for viscosities which are able to generate unexpected tribological phenomenon inside the textile spindle support especially for the lower bearing.

References

1. IANUS G., GRIGORAS St., HANGANU L. C., BORZAN M., Mat. Plast., **44**, nr. 1, 2007, p.47

2. HANGANU L., Analiză critică a soluţiilor constructive pentru fusele textile, Revista Română de textile-pielărie, nr.4, 2001, p 27

3. HANGANU L., A New Mathematical Model Applied to the Theoretical Study for Textile Spindles, Buletinul Institutului Politehnic din Iaşi, Tom XLVII (LI), Fasc. 3-4, Secţia Construcţii de Maşini, 2001, p. 21

4. HANGANU L. C., STIRBU C., IANUS G., Software for Textile Spindles Dynamics Study, Buletinul Institutului Politehnic din Iaşi, Tomul L (LIV), Fasc. Vb, Secţia Construcţii de Maşini, 2004, p. 413

5. IANUS G., HANGANU L. C., STEFANOVICI M., The Considering of The Loading Task for The Estimation of The Bearings Greases Durability from The Textile Spindles, Buletinul Institutului Politehnic din Iaşi, Tomul L (LIV), Fasc. 6A, Secţia Construcţii de Maşini, 2004, p.191

6. HANGANU L., C. VILCU C., Contributions to The Theoretical Study of Textile Spindles Dynamics, Meridian Engineering, nr.3, Chişinău, 2002, p. 82

7. HANGANU L. C., STIRBU C., Special Program for Textile Spindles Dynamics, IX. International Conference on the Theory of Machines and Mechanisms in association with the II. CEACM Conference on Computational Mechanics, Proceedings, August 31 – September 2, Liberec, Czech Republic, 2004, p.339

8. IANUS G., HANGANU L. C., Apreciations on Lubricant Degradation of Card Cylinders Bearings with Vibrodiagnosis Help, Conferinţa Internaţională "Tehnologii moderne, calitate, restructurare", TMCR-2005, Chişinău, mai 2005, **5a**, p. 571

9. IANUS G., HANGANU L. C., Estimation Methods Concerning Lubrication Quality of Card Cylinders Bearings, Conferinţa Internaţională "Tehnologii moderne, calitate, restructurare", TMCR-2005, Chişinău, mai 2005, **5a**, p. 579

10. HANGANU L., IANUS G., Experimental Research on Textile Spindles Damping Systems in Order to Decrease Their Power Consumption, The 15th International Colloquium Tribology, Technische Akademie Esslingen, January 17 – 19, 2006

11. HANGANU L., Instalaţie pentru măsurarea consumului de putere la fusele textile - Brevet de invenţie, România nr.87020.
12. HANGANU L., Suport tijă pentru fuse textile cu tub rigid de legătură între lagăre şi rezemare elastică faţă de cupă, Brevet România nr.99305
13. HANGANU L. C.,VILCU MARIA, HARGHEL LIVIA, Maşini de filat cu inele -elemente teoretice şi experimentale, Editura Tehnopress, Iaşi, 2004
14. VÎLCU MARIA, HANGANU L. C., VÎLCU C., Tehnologia firelor textile, Editura Tehnopress, Iaşi, 2005
15. HANGANU L. C., Maşini pentru filatură - ediţia a II-a, Editura Junimea, 2007
16. HANGANU L. C., et. al., Sisteme de control activ a subansamblelor specifice masinilor textile si implementarea acestora la masinile pentru filatura, Grant CNCSIS, Cod 518, Tema 32, Contract nr. 33371/ 29.06.2004, act adiţional 34664/2005
17. IANUS G., OLARU D., HANGANU L. C., et. al., Fiabilitatea sistemelor de control activ la maşinile textile considerând fenomenele de macro, micro şi nanotribologie, Grant CNCSIS, cod 490, tema 31, Contract nr. 27637/2005
18. HANGANU L. C., et. al., Sisteme mecatronice mobile inteligente cu impact ecologic pentru echipamente textile - SYMTEX, proiect CEEX 4694 modulul I/2006, contract nr. 205/20.07.2006 cu AMCSIT-Politehnica Bucureşti
19.VISILEANU EMILIA, GHITULEASA CARMEN, HANGANU L. C, et. al., INCDTP – active partner of the RDI national network. Part IV, Ind. Text. nr. 1, 2008, p.3
20. HANGANU L. C., PANTELIMONESCU FL., PEPTANARIU M., BALAŞCA M, SAVENCU C., VISILEANU EMILIA, RĂDULESCU R., Mechatronic mobile system for monitoring textile equipment using GSM network. Part I, Ind. Text., nr. 4, 2008, p. 147

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