ISSN: 2181-3337 SCIENCE AND INNOVATION
INTERNATIONAL SCIENTIFIC JOURNAL
2022 № 3

"PROBLEMS OF CONNECTING SHAFTS OF LOW RIGIDITY. ENSURING THEIR OPERABILITY AND ACCURACY OF CONNECTIONS"

Akramova Komila Shuxrat qizi
Student, Namangan Institute of Engineering and Technology, Uzbekistan;
https://doi.org/10.5281/zenodo.6660104

Abstract. *At the present time, ensuring the operability of low-rigidity shafts is not an easy, but an urgent task. In this article, the problems of connecting shafts of low rigidity are analyzed, an analysis is made of ensuring their performance and accuracy of connections.*

Keywords: *shaft, VMF, roughness, fretting corrosion, stiffness.*

«ПРОБЛЕМЫ СОЕДИНЕНИЯ ВАЛОВ МАЛОЙ ЖЕСТКОСТИ. ОБЕСПЕЧЕНИЕ ИХ РАБОТОСПОСОБНОСТИ И ТОЧНОСТИ СОЕДИНЕНИЙ»

Аннотация. *В нынешнее время обеспечение работоспособности валов малой жесткости представляет собой не легкую, но актуальную задачу. В данной статье проанализированы проблемы соединительных валов малой жесткости, сделан анализ обеспечения их работоспособности и точности соединений.*

Ключевые слова: *вал, ВМЖ, неровнота, фреттинг-коррозия, жёсткость*

INTRODUCTION

With the development of technology, both in our Uzbekistan and around the world, in the technical and operational fields, the issue of extending the service life and quality of parts, while minimizing time and money, is becoming increasingly important.

A fundamentally new direction in the modern organization of work to improve the accuracy and performance of low-rigidity shafts is the introduction of a complex of technological and design developments instead of separate isolated measures. The need for an integrated approach when considering issues related to accuracy was pointed out in the works of Yu.M. Solomentsev and V.G. Mitrofanov, I.N. Markova, A.V. Pusha, I.I. Artemov.

Progressive ways to improve the accuracy and performance of VMF are: the introduction of new technologies that provide an increase in the characteristics of fatigue resistance, a decrease in the amount of warping and runout, protection of the threaded joint of the shafts from damage by fretting corrosion. Research in this direction is the basis for the development of practical ways to ensure the required accuracy and performance of low-rigidity shafts..

Relevance of the research topic: The replacement of failed shafts of low rigidity is associated with the dismantling of the line of shafts, as well as mating components and parts, with a complete or partial loss of equipment performance. Therefore, ensuring the operability of low-rigidity shafts is a very urgent task, especially in the conditions of mass production of technological equipment.

MATERIALS AND METHODS

The main causes of failures of shafts of low rigidity are: fatigue failure; unscrewing of the line into links; radial runout is above the allowable; thread crumpling.

The rigidity of a shaft is judged by the ratio of its length ***(f)*** to its diameter ***(d)***

$$k = l/d \quad \text{or} \quad k = l/2R$$

Shafts qualified as rigid include shafts for which k = 3...5; for shafts of medium rigidity, k = 5 ... 10, shafts with k = 10 ... 12 or more are classified as low rigidity.

Table 1.1 shows data on the rigidity of the links of the VMF line of textile machines, from which it can be seen that all shafts (for spinning equipment they are usually called links according to GOST 12188) are of low rigidity. The coefficient k, which estimates the stiffness, varies from 11 to 41.

Shafts of low rigidity are stepped shafts with a length of 456 to 1260 mm with a centering surface and a thread for connecting them in a line.

Machine type	Shaft diameter, mm	Stiffness factor	Permissible deflection, mm	Link length, mm	Material
Ring-spinning					
П-І14МШ	19	24	0,09	456	Steel 45 GOST 1050-88 Hardening by high frequency heating
	32	14,1	0,09	456	
П-76-ИГ	28	16,2	0,09	456	
	40	11,4	0,09	456	
П-66-5М3 П-76-5М4 П-83-5М4	26	20	0,1	528	
	19	24	0,09	456	
Roving					
Р-260-5 Р-192-5	32	31…..37	0,2…..0,24	992…..1184	
Tape					
Л-50-2М Л2-50-220У	30	17...23	0,1...0,14	506-696	
Spinning and twisting					
ПК-100М ПК-100И1	30	40...42	0,24...0,25	1200-1260	

Table 1.1

The line of shafts of low rigidity consists of a number of links (drawing cylinders, winding, flattening shafts), has a length of 1.5 to 16 m, is a multi-support multi-link shaft. Replacing a failed One of the links is associated with a stop of draw frames or with the shutdown of one side of the spinning machines; with complete or partial loss of working capacity, with the dismantling of the line of shafts and mating units and parts. Therefore, the downtime of machines for replacing two or more shafts is at least 8 hours.

At present, domestic plants (Penza, Kostroma, Orlovsky) produce shafts of low rigidity from steel 45a GOST 1050, hardened by heating the HFC surface. Steel 45 is less sensitive to alternating loads, well processed by a cutting tool, subjected to various types of heat treatment and surface plastic deformation - SPD (roller rolling, knurling and threading). According to GOST 12188, the links of corrugated cylinders must be made of steel, the mechanical properties of which are not lower than those of steel 15 in the normalized state. The hardness after heat treatment of the outer surfaces should not be lower than HRC, 56, bearing and guide journals - not lower than HRC, 46. The thickness of the hardened layer should be uniform in cross section and be 5-6% of the shaft diameter.

GOST 12188 establishes the following norms for the runout of shafts of low rigidity for spinning equipment: the radial runout of corrugated pedestals, the bearing neck and guide surfaces (holes and the centering surface of the trunnion) relative to each other should not exceed: protrusions - 0.03 mm. According to GOST 22209, the radial runout should not be more than 0.03 mm of the first line of the VMF drawing device and 0.05 mm of the remaining lines of spinning and twisting machines.

During operation, VMFs perceive a radial load, experience the effects of bending and torsional moments, friction forces in the supports and on the working surfaces at the places where the product passes (tapes, rovings, yarn). The force analysis of the operation of the VMF performed by other authors showed that the bending moments acting in the radial sections of the shafts can exceed the calculated values by 3 or more times due to the fact that the bearing journals do not actually lie on one straight line. The maximum bending moment will act in the cross section of the VMF support pins in the case when two adjacent supports are shifted down.

The dimensional analysis of the VMF, performed by the author, shows that due to errors in manufacturing, installation and uneven wear of the supports, the geometric axis of the assembled line of exhaust cylinders of ring spinning machines, winding shafts of spinning and twisting machines, etc., may have a deviation from straightness up to 0.8 mm. Important requirements for the work of the VMF are to ensure the minimum value of the runout of the working surfaces in the places where the produced product passes and their durability, which should not be less than moral or technical and economic. Beating of the VMF excitation of the oscillatory movement of the product passage line, as well as a periodic change in the circumferential speed of the shafts of low rigidity.

As a result of the eccentric occurrence of rolls of low rigidity, product unevenness occurs. The irregularity of the yarn is striking on quality fabrics. The most dangerous in relation to the periodic unevenness obtained on the occasion of the beat of the VMF. In addition to periodic unevenness, the beating of shafts of low rigidity can lead to the edge of yarn breakage on spinning and weaving equipment.

According to studies performed by the authors of other works, the probability of a weakening of the yarn, leading to its breakage, increases sharply with an increase in the beating of the draft cylinders. If the probability of breaking with a beat value equal to 0.1 mm is taken as unity, then with a beat value, equal to 0.2 mm, the probability of breakage increases by 37 times, and with a beating equal to 0.3 mm - by 638 times.

To identify the actual value of the runout of the VMF, the author [1] carried out observations of the operation of several spinning machines with different periods of operation. The number of bedside tables, the runout of which exceeded the runout tolerance of 0.05 mm established in accordance with GOST 12188, was, according to observations for machines with a service life of one year - 23.5%, four years - 33.5% and eleven years - 51%.

Research objectives

1. Analysis of failures of technological equipment, including studies of the causes of failures and damage to the VMF.

2. Selection of the criterion and assessment of the accuracy of the shaping operations of the technological process of manufacturing VMF.

3. Increasing the value and performance of VMF based on the choice of hardening, shaping technologies and technologies for protecting a threaded joint from damage by fretting corrosion.

4. Development of methods and laboratory facilities for fatigue testing of high-temperature fluids and evaluation of the tribotechnical characteristics of metal-cladding anti-fading lubricant compositions that implement the selective transfer effect (IT).

5. Development of a simulation method for determining the fatigue resistance characteristics, which allows testing the VMF in an accelerated mode.

6. Carrying out tests for resistance to fatigue of standard samples, VMF and tests of metals cladding anti-fading lubricant compositions.

RESULTS

The choice of optimal technological modes of aging of the shafts.

Based on the available (a priori) information and preliminary experiments on the fatigue resistance of smooth specimens to stabilize the geometric shape of the VMF links by reducing warpage during the PPD process during the running-in operations of intermediate necks and knurling with rollers, cold straightening, surface hardening using high-frequency current for heating surfaces, we recommended thermal aging, which should be carried out after operations indicated by the sign • [2]. For the experiment, the most massive VMF, exhaust cylinders, motor shafts, which have undergone mechanical, thermal effects, RPM, a large number of stress concentrators, are used in the process of shaping.

In the experiments, the method of central compositional orthogonal planning of the second order PFE 2^2 was used. This methodallows, with a small number of experiments and samples, to obtain a sufficiently high accuracy and separate estimates of the influence of each factor. Two indicators were chosen as optimization parameters: Y_1 - warpage value, mm; $Y_2 = N * 10^5$ - cyclic durability (thousand cycles) at a voltage of 450 MPa and a loading frequency of 1500 cycles per minute.

Threaded connections are coated with a lubricant with anti-fretting properties before assembly. In the absence of lubricant or its insufficiency, there is a possibility of fretting corrosion, the appearance of scuffs during the make-up of the shafts. When lubricating the connection shafts with metal-plating oils, industrial oils, etc. When assembly, they are extruded, and the contact surfaces operate in a mode close to dry dry friction, which contributes to the occurrence of seizure and fretting corrosion. For lubrication of threaded joints and partial elimination of fretting processes, special greases are used, made on the basis of Mo82, graphite, copper, aluminum, lead, zinc powders and their compounds (sulfides, oxides, etc.).

For large and special threads, the use of lubricants is promising with fillers up to 10% metal cladding and thread lubricants.

The magnitude of the tightening force Pm of a threaded connection is related to the initial tightening torque MA, the thread pitch P, the average thread diameter, the effective radius Pe of the end surface of the shafts, friction coefficients fr and fι of the threaded connection and the ends of the parts to be screwed by the ratio:

$$M_A=F_M(0{,}16P+0{,}58d_2f_r+\frac{D_э}{2}\cdot f_r)$$

It can be seen from the expression above that at a constant value of MA, the tightening Pm gain is of great importance at significant coefficients fr and fι. It has been experimentally established that 90% of the tightening forces in a threaded connection appear during training, while 50% of the losses occur due to the twisting of the reverse shafts and 40% of the consequences of the application in the thread.

DISCUSSION

The use of an anti-fretting lubricant composition makes it possible to reduce coefficients of friction and eliminate fretting corrosion. The coefficients of friction, depending on the technology of forming the shafts and the composition of the anti-fretting compositions, have a fairly large range $A_f=f_{max}-f_{min}$ fluctuations in values are very significant. Depending on the conditions of application of the shafts, lubricating anti-fretting compositions are selected according to the coefficient of friction. When choosing a lubricant, it is necessary to reduce both the maximum values of the friction coefficients and to reduce their dispersion (f_{max} - f_{min}), while in order to increase the performance of threaded shaft connections, in any case, preference is given to lubricants with an anti-fretting effect. The presence of a lubricant reduces local stress concentrations, protects against seizure, achieves better surface running-in, improves working conditions for an assembler. The use of special lubricants greatly simplifies assembly and disassembly operations and ensures the creation of a minimum clamping force, which helps to reduce the likelihood of thread crushing. It has been established that for disassembling threaded connections it is not enough to apply a force equal to the force when screwing them. In general, the moment M required to unscrew the threaded connection is determined by the formula:

$$M_= M_п+M_r+M_т$$

where: M_n - useful moment in the thread; Mg is the moment of friction forces in the thread; M is the moment of friction forces between the end surfaces of the shafts. If the sum of the moments of the friction forces in the thread and the end surfaces of the shafts is close to zero, then the threaded connection is unscrewed.

To prevent self-loosening of threaded shaft connections, it may be recommended to increase the clamping force and use special safety devices. The most effective and simplest method is the use of lubricants with anti-fretting properties, which realize the effect of IP, prevent fretting corrosion and self-unwinding due to the locking effect of servovite copper films.

The relationship between the clamping force and the tightening torque can be accurately determined by calculation, which makes it possible to use connections with a smaller thread diameter.

As a result of the developed technological and design measures, the endurance limit was increased from 32 to 52 MPa for low-rigidity shafts 1260 mm long and from 25 to 47 MPa - 450...700 mm long. A method is proposed for protecting the threaded connection of shafts from damage by fretting corrosion based on the developed metal-cladding lubricating anti-fretting composition that implements the IP effect, which does not require large capital expenditures for practical implementation.

CONCLUSION

Upgraded technology of shaping and hardening of VMF surfaces, which makes it possible to reduce the amount of warpage and runout and increase the fatigue resistance characteristics.

The causes of failures and damages of the VMF of technological equipment of mass use at textile enterprises have been established, which include: fatigue failure due to imperfection of the manufacturing technology and design of shafts of low rigidity, non-unscrewing of the shaft line into links due to damage to the elements of the threaded connection by fretting corrosion, runout above the allowable due to warping of the VMF, thread collapse due to unregulated tightening force. A scheme has been developed for analyzing the causes of destruction and damage to the VMF, in accordance with which the following were carried out: fractographic studies of fractures; analysis of the accuracy of shaping by operations of the technological process; analysis of the chemical composition and mechanical properties of the starting material; operating and loading conditions; stress-strain state, etc. On the basis of a scientifically based choice of hardening technologies and shaping technologies, experimental fatigue studies of standard samples of steel 45 were carried out, according to the results of which the best option was selected that provides the fatigue limit stress σ1=54 kg/mm^2, 200°C - 2 hours).

References

1. Belov Yu.V. Study of the process of cold straightening of corrugated cylinders of spinning machines.
2. Denisova N.E., Shorin V.A. Increasing the fatigue resistance of shafts of low rigidity by constructive and technological methods // Sat. mater. Sh Всерос. scientific-practical. conf. “Modern technologies in mechanical engineering - 2000”, Part P. - Penza, 2000.
3. Computer-aided design and production in mechanical engineering Solomentsev Yu.M., Mitrofanov V.G., Prokhorov A.F. and others / Shod general ed. Yu.M. Solomentseva, V.G. Mitrofanova.- M.: Mashinostroenie, 1986, 256 p.
4. Markov I.N., Artemov I.I. The manifestation of the kinematic error of gears under the influence of loads and rotation speeds. Bulletin of Mechanical Engineering No. 3, 1986, pp. 21-23.
5. Mirzaumidov A.Sh. Akramova K.Sh. (2022). "Comparative aspects of long and short shafts, in order to justify the feasibility of their replacement." Academic Research in Educational Sciences, 3(6), 230-232.
6. Push A.V., Yurkevich V.V., Eroshenko I.P. Predicting the shape of a part during

turning. Problems of accuracy control of automated production systems, №l -2, Penza, 1996, pp.9-11.
7. Artemov I.I. System for comprehensive accuracy assurance of automated production of gears//STIN No. 6, 1998.
8. Muratkin G.V. Increasing the accuracy of non-rigid parts such as shafts by controlling their stress state during processing by GIPD methods. - Cand. dis. - Moscow, 2000, 195 s.