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INFLUENCE OF THE TECHNOLOGICAL PARAMETERS OF THE ASSEMBLING TO THE QUALITY CONNECTIONS WITH THE INTERFERENCE SHAFT-WHEEL IS TOOTHED WITH THE COMBINED THERMAL METHOD

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In the article the results of the studies are given on the establishment of the influence of the technological parameters of the assembling with the interference connections shaft-wheel is toothed without the keys with the use the combined thermal method during the combination of heating the wheel of the toothed and the low-temperature cooling of shaft.
Keywords: *connection with the interference, thermal composition, rear axle shaft is toothed.*

In different transfers wide application found the cylindrical connections shaft-wheel toothed, connected with the use of key landings and which work with the diverse forms of operating loads. However, key connections in design and technological sense are imperfect, and also they lead to an increase in the metal content of composite articles. In a number of cases they use during assembling of shafts with the wheels toothed couplings with the interference and the keys. In this case for guaranteeing the operational strength the interference can be basic or auxiliary construction-engineering element. In one case major portion of the load is received by landing, and key roofing to additionally guarantees strength of connection, in the second case the interference fit is used for the partial unloading of key and centering of components. The key and interference fit together do not work in also the time with the reversible load. For guaranteeing their joint operation key must be established on the thrusts in both grooves, and this creates the specific technological difficulties and leads to the additional economic expenditures [1].

By the most universal and expedient connection of shaft with the wheel toothed *in the absence the keys* connection with the interference, whose assembling is accomplished by different thermal methods [1, 2]. These connections transfer the significant both constants by the value and the direction torques and cyclically changed on the value and the sign. In these cases the guarantee of the increased operational strength of interference fits is very important. Different standard forms of microrelief and topology of its putting on the shafts for this purpose are used. However, in a number of cases these methods do not nevertheless satisfy the requirements of operational reliability. Therefore it is very important to develop new in the forms of microrelief and its topology, which would consider form and nature of operating loads, the technological parameters of the realization of the technology of assembling with the temporarily formed thermal clearance [3, 4].

Formulation of the problem

The establishment of the values of the technological assembly-line parameters with the combined thermal method of assembling the in the absence the keys landings of the connections shaft- wheel is toothed, which will ensure an improvement in the quality of the composite full-scale articles, which work on the twisting. In this case was provided for the application in the zone of contact of the connections of the persistent regular microrelief, applied to the shafts in parallel to the axis of connection, also, with different parameters of the area of putting (topology) [5, 6].

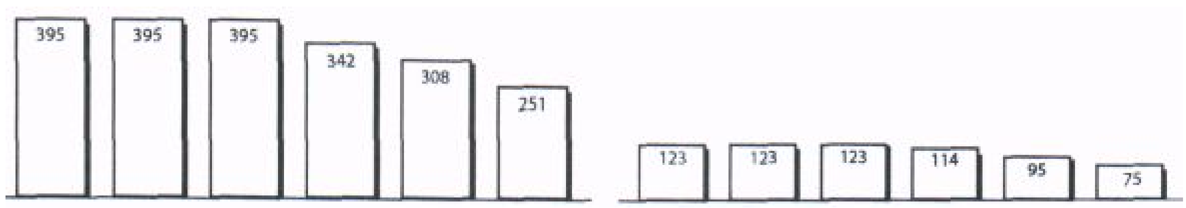
Objects and the methods of the investigation

As the subjects of a study serve the in the absence the keys connections shaft-wheel is toothed, connected with the interference by thermal methods. For the solution of the problems presented were used the fundamental theoretical positions of the technology of machine building, theory of plasticity, elasticity and thermal conductivity, methods of the optimization, probability theory, mathematical statistics and the method of the final elements, regression analysis, computer programming.

Results and discussion

Comparative studies according to the evaluation of the influence of the technological assembly-line parameters the stress-strained state and strength of in the absence the keys cylindrical connections with the interference are examined per the carrying assembly unit shaft-wheel the toothed cylindrical. The diameter of landing is accepted equal to 52 mm, the length of landing 50 mm, the outside diameter of the gear of 180 mm. Roughness of the contact surface of the components of R_a=0,8-1,25 mkm. Calculated assembly-line interference was preliminarily calculated and accepted equal to 0,080-0,110 mm. Material of the wheels of toothed steel of 40X, shaft steel of 40XH2. In this case the influence on the quality indicators of the connections of the height of persistent regular microrelief and area of its putting on the shaft was examined. Taking into account that shaft- wheel toothed in the process of operation they undergo twisting, it was accepted to bring microrelief to the shaft in parallel to the axis of connection. For the formation of connections with the interference the necessary values of the temperature of thermal influence for the mating parts, which make it possible to accomplish assembling with the thermal temporarily formed assembly-line clearance, were calculated.

In terms of the obtained computed values of temperature were executed the experimental-design studies the tension-strained state of the connection of the wheel of toothed with the shaft with the use of a method of final elements. The partition of the wheel of toothed and shaft into the finite-element models was carried out for this, approximating the full-scale articles. Then they were carried out the technological preparation of the components, their assembling by the thermal methods and strength test during the twisting (to the turning). The results of experimental studies of the averaged stresses are represented in Fig. 1, 2 and the strength in Fig. 3.



1 2 3 4 5 6 **1 2 3 4 5 6**

a ***b***

Fig. 1. **Distribution of equivalent stresses in the wheel toothed $\sigma_{ек}$ (*a*) and the shaft $\sigma_{ев}$ (*b*) during their assembling by thermal methods with the interference:**

1 – with heating of the wheel boss to +178…+183°C;

2 – by cooling nave down to -192…-195°C;

3 – with heating of the wheel boss to 185…125°C and by cooling nave down to -56…0°C without the regular microrelief;

4 – with heating of the wheel boss to 100…40°C and by cooling nave down to -163…-103°C without the regular microrelief;

5 – with heating of the wheel boss to 80…20°C and by cooling nave down to -186…-126°C without the regular microrelief;

6 – with heating of the wheel boss to 100…40°C, by cooling nave down to -163…-103°C and with the use of regular persistent microrelief with the height $R_в$=0,1N_{min}, 0,3N_{min} and 0,5N_{min} accordingly.

1 2 3 **1 2 3**

a ***b***

Fig. 2. **Distribution of equivalent stresses in the wheel toothed $\sigma_{ек}$ (*a*) and the shaft $\sigma_{ев}$ (*b*) after their assembling in a combined thermal manner with the interference with heating of the wheel boss to 100…40°C, by cooling the nave to -163…-103°C and with different length $L_в$ (the area) putting the regular microrelief:**

1 – putting regular microrelief on the length of the landing $L_в$ = 10 мм;

2 – putting regular microrelief on the length of the landing $L_в$ = 25 мм;

3 – putting regular microrelief on the length of the landing $L_в$ = 50 мм;

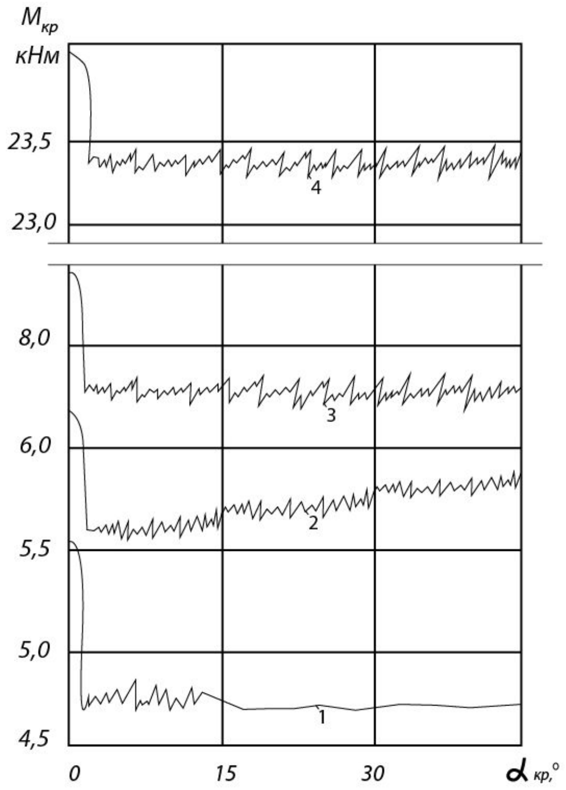


Fig. 3. **Curved crankings of bushing relative to shaft in the coordinates torque $M_{кр}$ and the angle of the turning $\alpha_{кр}$ during the assembling:**
1 – with the heating by heating the wheel of the toothed;
2 – with heating of the corona of the toothed;
3 – with heating of the corona of toothed and with the reticulated standard microrelief;
4 – with heating of the corona of toothed and with the regular persistent microrelief.

As a result the full-scale tests of the carrying units of reducers under the influence of torque it is established, that koeffitsitnt of friction (cohesion), determined according to the tests of laboratory models are completely reliable data and can be used for calculating the bearing capacity of landings on the thrusts, which work in the conditions of the action of torque.

Conclusions

The results of the executed experimental studies made it possible to establish that to the quality of connections with the interference of shaft with the wheel toothed during their assembling by the combined thermal method of the assembling essential influence render the interrelation of the temperature of heating and of cooling the mating parts before the assembling, the parameters of regular microrelief and the topology of its fulfillment on the contact surface of shaft. In this case:

1. The combined thermal method of assembling makes it possible to interconnected reduce simultaneously the temperature of heating one component and low-temperature

cooling of another, due to this to decrease the stress-strained state of the components before the assembling and in a number of specific cases to decrease the power consumption, to create specific conditions for introducing the microrelief, thereby to obtain the maximum density of the contact zone and the strength of landings.

2. Are established with the combined thermal method of assembling rational temperatures of heating and cooling the components during assembling of connections with the interference. It is confirmed, during assembling of connections with the assigned assembly-line interference after the levelling off of their temperature the stress-strained state during the interconnected combination of reduction in temperatures of heating and cooling it remains constant.

3. The application of the recommended regimes of uneven heating and cooling with the temperature distribution in the wheel toothed and the shaft respectively in interval of 100…40^{o}C and -163…-103^{o}C with an increase in altitude of persistent regular microrelief in the range from 0,008 to 0,04 mm, the stress-strained state of connections is reduced. In this case equivalent stresses decrease by 26,61% in the wheel toothed and by 34,21% in the shaft.

4. The application of the recommended regimes of the uneven heating of the wheel of toothed in the range of temperatures 100…40^{o}C and coolings of shaft down to temperatures -163…-103^{o}C and increase in the area of putting the regular microrelief lengthwise of landing from 10 to 50 mm ensure a decrease the stress-strained state in the wheel toothed to 49,36% and the shaft to 39,02%.

5. The use of uneven heating of nave and sheave of toothed and cooling of the landing part of the shaft respectively in the range of temperatures 100…40^{o}C and -163…-103^{o}C, 80…20^{o}C and 186…-126^{o}C make it possible to descend on 37 - 46% of expenditure of energy.

6. Calculated contact pressure and radial stresses are reduced with an increase in the depth of the penetration of regular microrelief and area of its putting on the shaft. It is confirmed that the maximum permissible height of microrelief during assembling of the components of those prepared from steels must not exceed 0,5 from the value of minimum assembly-line interference.

7. An increase in the area of putting persistent regular microrelief on the shaft during the assembling by the combined thermal method of the assembling ensures redistribution and reduction in the stresses in the contact zone.

8. The full-scale tests of reducers confirmed the results of theoretical-analytical and experimental-design studies, that makes it possible to recommend the combined thermal

method of assembling, persistent regular microrelief and topology of its putting on the shaft for guaranteeing the increased strength characteristics of connections the shaft- wheel their toothed with simultaneous decrease the stress-strained state expenditures.

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И.Л. Оборский

Влияние технологических параметров сборки на качество соединений с натягом вал-колесо зубчатое при комбинированном термическом способе

В статье приведены результаты исследований по установлению влияния технологических параметров сборки с натягом безшпоночных соединений вал-колесо зубчатое с использованием комбинированного термического способа при сочетании нагрева колеса зубчатого и низкотемпературного охлаждения вала.

Ключевые слова: *соединение с натягом, термическая сборка, вал-колесо зубчатое*

І.Л. Оборський

Вплив технологічних параметрів складання на якість з'єднань з натягом вал-колесо зубчасте при комбінованому термічному способі

У статті наведені результати досліджень по встановленню впливу технологічних параметрів складання з натягом безшпонкових з'єднань вал-колесо зубчасте з використанням комбінованого термічного способу при поєднанні нагрівання колеса зубчастого та низькотемпературного охолодження вала.

Ключові слова: *з'єднання з натягом, термічне складання, вал-колесо зубчасте*