THE STAND FOR RESOURCE TESTS OF DRIVE LINES IN THE CLOSE CIRCUIT

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Summary. In work the material on development of a technical solution of a rational design of the stand for resource tests of drive lines for the purpose of increase of their accuracy and reliability by probes of influence of technological environments on durability of drive lines is presented.

Keywords: stand, resource tests, toothed gearing, conical reducer, drive line, durability, contact tension.

PROBLEM STATEMENT

Increase of power of power means, increase in working speeds and use of multipurpose difficult cars led to growth of requirements for reliability of transport and technological machine (TTM), in communication with what probes at design, technological and operational stages develop in the following directions [13]:

- improvement and modernization of designs for the purpose of increase of reliability and material capacity drop;
- development of new designs of drive gears for again created equipment with use of components of a modern technological level;
- improvement of technological processes and modernization of technical means of production and improvement of the maintenance operation and repair (MOR) methods.

However introduction of the developed perspective actions is slowed down by lack of high-quality experimental working off of decisions, that is obtaining information, for example, about a resource of the restored details, repaired assembly units and the upgraded units of equipment for short time. In this regard it is necessary to develop and improve means and methods of the bit-by-bit accelerated tests for an experimental assessment of a resource of the serial, skilled and repaired units, for example, drive lines [6].

ANALYSIS OF THE LAST PROBES AND PUBLICATIONS

In the field of probe of reliability of agricultural machinery works devoted to the solution of questions of diagnosing of a technical condition of transmission [3], modeling of process of ensuring reliability of difficult technological cars [5] and development of methods of forecasting of a residual resource of gears of agricultural cars [14] are known. However in the presented works the attention isn't paid to questions of the accelerated methods of probe of operability of cars and their units.

Development of methods for fatigue tests TTM studied by I.N. Velichkina, R.V. Kugel, L.M. Klyatisa, M.I. Lisova, J.N. Lomonosova and others, in which the issues of improving the methods of resource and posters of accelerated reliability testing, the application of the tests to the evaluation of quality indicators of production, accelerated-test-reliability of new and repaired bathrooms components of vehicles, tractors, etc. Moreover, poster tests on the basis of modeling loads acting in the real world, give an idea of the true picture of failure of parts [9].

The following principles are put in a basis of the theory of the accelerated bench tests: justification of modes of loading, combination of bench tests to the laboratory and field tests, the accelerated mechanical tests at the stand without and with speeding up of loadings, use of methods of calculation of optimum life cycles of cars by results of the accelerated bench tests, etc. [15].

Practical issues of development of perspective designs of stands for resource tests for the purpose of realization of achievements of the theory of the accelerated bench tests are resolved now not fully.

PROBLEM DEFINITION

Technical solutions on development of stands for tests of elements of drive lines which, contain the loading and closing toothed gearings, two propeller shafts, located in parallel among themselves and having on two tested hinges, and the electric motor bringing into rotation a power circuit, and also measuring equipment and the technological cameras [1, 2, 10] installed on shaft are known.

These stands possess the following essential shortcomings:

- short circuit of a power circuit by toothed gearings leads to energy consumption;
- metal consumption of the stand leads to energy consumption when modeling at the stand of fluctuations of a corner of a break of cardan joints, when modeling real conditions of their work;
- existence of axial considerable efforts in sline joints of shaft at change of a corner of a break in cardan joints which are absent in actual practice;
- low accuracy of results owing to impossibility of carrying out tests in conditions of the dusty (technological) environment.

The specified shortcomings testify to rather high energy consumption and the insufficient accuracy of bench tests.

Problem of the real work – development of a perspective design of the stand for carrying out resource tests for the purpose of an assessment of reliability of the serial, upgraded and repaired drive lines under operating conditions, taking into account drop of expenses of energy and increase of accuracy of tests.

STATEMENT OF THE MAIN MATERIAL

Bases of development of stands with the closed power circuit are put in works of employees NATI, NAMI, VISHOM and VNIIPP however developed by them stands possess small durability of technological toothed gearings, incomplete modeling of modes of loading and the technological conditions, raised by an expense of the electric power and a material capacity.

Proceeding from the revealed shortcomings of designs of existing stands [1, 2, 10] and on the basis of the principles of the theory of the accelerated bench tests in relation to TTM drive lines the skilled design of the stand with short circuit of a power circuit by one technological toothed gearing with reduction ratio equal to unit [11] was developed. Further modernization of the stand (fig. 1) is directed on its equipment by a technological chamber with possibility of creation of a steered electrostatic field [12].

Distinctive feature of mechanical part of the mentioned stand with a technological chamber is existence of an one-stage conical reducer with reduction ratio equal to unit in the form of technological drive which is located coaxially with the tested drive line, forming the closed power circuit (fig. 2).

The offered stand contains minimum possible number of gear gearings for short circuit of a power circuit that will allow to realize at tests of drive lines the major operational loading factors with the minimum expenses of energy. The increased radial sizes of tooth gears of a reducer in comparison with the radial sizes of joints of the tested drive line, at the same torque in a power circuit, allow to reduce considerably effort in a gears mesh, having provided its big durability in relation to the tested drive line.

Technological process of resource tests at the stand is carried out as follows. By means of a clutch 7 load the drive line 9 with the twisting moment which becomes isolated in a power circuit it is transferred through a conical reducer of wheels 5 and 6. The size of a corner of a break of hinges of the tested drive line 9 is defined by a corner of traverse of shafts of shaft 3 and 8. The electric motor 1 provides rotary movement through a clutch 2 and a shaft 3 located in a bearing part 4, the tested drive line 9.

Except basic elements the stand contains the technological camera 10 located between technological gear wheels 5 and 6 which by means of elastic insulators 11 is installed on the mentioned technological tooth gears 5 and 6 and covering a zone of an arrangement of the tested drive line 9. In a body of a main shaft 8 the axial port from which one party are established the fan 12, the accumulator 13, the adjustable gate 14, connected by the pipe duct 15, and from other party the valve 16 located in the camera 10 is executed. The conductor 17 connects the tested drive line 9 through a stand metal construction, an adjuster 18, the power supply 19 and probing devices 20 to the technological camera 10. The mentioned technological camera 10 can be executed from a conducting elastic material or with an internal conducting covering.

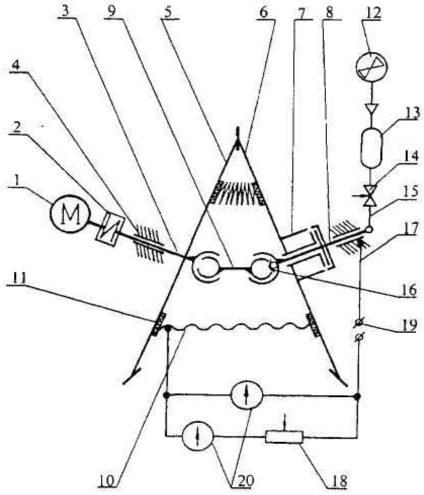

Fig. 1. The kinematic scheme of the stand for test of drive lines in the technological camera (RU 2205377)

Fig. 2. General view of details of a power circuit

Preparation of the technological environment carry out by means of a bookmark in the accumulator of 13 necessary components in demanded quantity and their hashing with air by means of the fan 12. Then by means of the adjustable gate 14, the pipe duct 15 through a main shaft 8 and the valve 16 enter part of contents of the accumulator 13 into the technological camera 10. Operations of preparation of the technological environment and its introduction in the mentioned camera 10 can be carried out both at the disconnected stand, and in the course of tests, varying structure and concentration of components of the technological environment. For active influence on particles of the technological environment being in the active technological camera 10, give tension on a metal construction of the stand and an elastic mantle of the mentioned technological camera 10. By means of an adjuster 18 and measuring instruments 20 establish and supervise the size and the direction of an electrostatic field in a zone of the technological camera 10.

Existence of the accumulator of the technological environment and its joint with space of a technological chamber by means of the constructive and technological elements executed in details of the stand, allows to vary structure and concentration of components of the technological environment in the course of tests with a research objective of influence of various components of the technological environment on operability of object of tests.

Application of elements and tools for an adjustable electrostatic field in a zone of a technological chamber gives opportunity to steer process of influence of particles of the technological environment on tested object by countersteering to inertia forces forces of the electrostatic field regulated both in size, and in the direction. Such action can provide, for example, pushing away of particles of the technological environment from walls of a technological chamber in countersteering to inertia forces, and the purposeful accelerated movement of particles of the technological environment from the periphery of a technological chamber to tested object can be considered as a factor toughening a mode of tests. Thus, use of the offered stand will allow to increase the accuracy of results and to expand possibilities of bench tests of drive lines and their elements.

The main problem of strength of the stand is design of technological drive for the purpose of determination of the demanded radial sizes of its bearing components from a condition of equality of torques in drives which (index T) and tested (index I) of drives follows from the constructive scheme of a power circuit with a coaxial arrangement technological. In this regard for this power circuit we have:

$$F_{tT} \cdot {d_{mT}}/{2} = F_{rI} \cdot \left(H_I - L_{wI}\right),$$

where: F_{rI} – radial force in bearing mount assemblies, N; H_{I} – distance between butts of thorns of a crosspiece, mm; L_{wI} – length of a needle roller, mm; F_{tT} – district force in the toothed gearing, N; d_{mT} – the average delitelny diameter of a tooth gear, mm.

Comparison of sizes of efforts in a power circuit for the accepted constructive parameters of the drive line allows to claim that district force in the toothed gearing makes 57% from the size of the radial force operating on a bearing mount assembly of the tested cardan joint.

The main reason for failure of bearings and toothed gearings is fatigue failure of a blanket of a material of thorns of a crosspiece and the teeths, resulting influence of sign-variable contact tension. In this regard the equation of interrelation of load parameters of technological and experienced drives on the basis of the equation of curve fatigue looks like [4]:

$$\sigma_{HT}^{m_T} \cdot L_{hT} = \sigma_{HI}^{m_I} \cdot L_{hI} = const,$$

where: σ_{HT}, σ_{HI} – contact tension in contact piece of details of technological and experienced drives, MPa; L_{HT}, L_{HI} – durability of details of the specified drives, h; m_T, m_I – exponents of curve fatigue of a materialov.

Contact tension in a cardan a bearing mount assembly at initial linear contact piece defined on the basis of a formula [4]

$$\sigma_H = \frac{2 \cdot \sqrt{\dfrac{5 \cdot 10^3 \cdot T \cdot K}{i \cdot Z \cdot \cos\alpha \cdot (H - L_w)}} \cdot \sqrt{\dfrac{2}{D_w \cdot \left(1 - \dfrac{D_w}{D_0}\right)}}}{\pi \cdot l^{0,5} \cdot 3{,}34 \cdot 10^{-3}},$$

where: T – a given torque, Nm; K – loading coefficient; i – number of ranks of bodies of swing; Z – number of needle rollers among the bearing; α – a contact piece corner, a hail; l – length of a contact platform equal to length of a roller, mm; D_w – diameter of a needle roller, mm; D_0 – the average diameter of the bearing, mm.

Contact tension on working surfaces of pryamozuby conical wheels we determine on the basis of calculation of equivalent cylindrical wheels [4]

$$\sigma_H = Z_E \cdot Z_H \cdot Z_\varepsilon \cdot \sqrt{\frac{3{,}85 \cdot 10^3 \cdot K_H \cdot T}{\gamma \cdot (1 - k_{be}) \cdot k_{be} \cdot d_{e1}^3 \cdot u}},$$

where: Z_E – the coefficient considering mechanical properties, МПа^{0,5}; Z_H – the coefficient considering a form of interfaced surfaces of teeths; Z_ε – the coefficient considering total length of contact lines; K_H – coefficient of increase in rated voltage; γ – coefficient of kickdown of bearing ability of conical drives; k_{be} – coefficient of width of a ring gear; d_{e1} – the external delitelny diameter of a gear wheel, mm; u – reduction ratio.

Comparison of calculated values of contact tension in elements of technological and experienced drives shows a underloading of the first by 7,6 time.

The resource of the drive line is defined by durability of bearing mount assemblies [7]

$$L_{ha} = \frac{2{,}2 \cdot 10^6}{n \cdot \beta \cdot \sqrt{\Delta_H}} \cdot \left[\frac{f_C \cdot Z^{3/4} \cdot D_w^{29/27} \cdot L_w^{7/9} \cdot (H - L_w)}{T \cdot K_d}\right]^{3{,}165},$$

where: f_c – coefficient of geometry of details of the bearing, accuracy of their production and a material; β – a corner of a break of the hinge, a hail; Δ_H – an initial radial play in bearing mount assemblies, micron; n – rotary speed of the drive line, min^{-1}; K_d – dynamism coefficient.

Comparison of settlement durability of technological and experienced drives in the range of loading of the drive line shows that the durability of technological drive exceeds durability tested almost in 4,5 million times that allows to increase number of the tested objects by one set of technological drive.

CONCLUSIONS

1. The modern system of experimental working off of perspective decisions on units of mechanical transmissions has to be based on the resource accelerated bench fail-safe tests.

2. The proposed technical solution is perspective from the point of view of realization of mechanics of a power circuit and expands the range of modeling of test conditions at increase of their accuracy and reliability.

3. Analysis of technical advantages and mathematical confirmation of operability of the stand testify to the high potential of its use in the conditions of resource fail-safe tests.

REFERENCES

1. A.S. №355527 SSSR, MKI G 01 M 13/04, G 01 N 3/56. Mashina dlja ispytanija kardannyh podshipnikov / Bokov E. S. (SSSR). - №1413550/25-28; zajavleno 06.03.70; opubl. 16.10.72; Bjul. №31.

2. A.S. №479980 SSSR, MKI G 01 M 13/02. Stend dlja ispytanija sharnirov kardannyh valov / Degtjarev M. G. i Djagis Z. S. (SSSR). - №1768793/27-11; zajavleno 05.04.72; opubl. 05.08.75; Bjul. №29.

3. Abdulgazis U., Abdulgazis A., Podrigalo M., Poljanskij A., Podrigalo N. 2012. Metod diagnostirovanija tehnicheskogo sostojanija dvigatelja i transmissii. Motrol. Motoryzacja i energetyka rolnictwa. – Lublin. Vol. 14. № 1, 37 - 41.

4. Birger I. A., Shorr B. F., 1993. Iosilevich G. B. Raschet na prochnost' detalej mashin: spravochnik. M. : Mashinostroenie, 640.

5. Dumenko K., Shevchenko E. 2012. Modelirovanie processa obespechenija nadezhnosti zernouborochnyh kombajnov. Motoryzacja i energetyka rolnictwa. Motrol. – Lublin. Vol. 14. № 2, 51-56.
6. Erohin M. N., Pastukhov A. G. 2008. Nadezhnost' kardannyh peredach transmissij sel'skohozjajstvennoj tehniki v jekspluatacii. : monografija. – Belgorod : Izd-vo BelGSHA, 160.
7. Flik Je. P. 1984. Mehanicheskie privody sel'skohozjajstvennyh mashin. – M. : Mashinostroenie, 272.
8. Gadolin, V. L., Drozdov N. A., Ivanov V. N. 1979. Mashiny i stendy dlja ispytanija detalej. ; pod red. D. N. Reshetova. – M. : Mashinotroenie, 343., il. (s. 324, ris. 8.5).
9. Kljatis L. M. 1984. Teorija uskorennyh stendovyh ispytanij. Mehanizacija i jelektrifikacija sel'skogo hozjajstva. № 4. 53-56.
10. Lysov M. I. 1945. Kardannye mehanizmy. - M. : Mashgiz, 110.
11. Pat. 2134412 Rossijskaja Federacija, MPK7 G 01 M 13/02. Stend dlja ispytanija kardannyh peredach / Sigaev A. M., Pastukhov A. G., Lopatin G. P.; zajavitel' i patentoobla-datel' Belgorodskaja gosudarstvennaja sel'sko-hozjajstvennaja akademija. - № 98101414/28; za-javl. 23.01.98; opubl. 10.08.99, Bjul. № 22. - 4.
12. Pat. 2205377 Rossijskaja Federacija, MPK7 G 01 M 13/02. Stend dlja ispytanija kardannyh peredach / Pastukhov A. G., Timashov E. P., Koshelev A. I.; zajavitel' i patentoob-ladatel' Belgorodskaja gosudarstvennaja sel'skohozjajstvennaja akademija. - № 2002112352/28; zajavl. 7.05.2002; opubl. 27.05.2003, Bjul. № 15. - 4.
13. Puchin E. A. 2013. Osnovy teorii nadezhnosti i diagnostiki tehnicheskih sistem : nauchno-prakticheskoe izdanie. - M. : FGBNU «Rosinformagroteh», 182.
14. Rogovskij I., Dubrovina O. 2012. Metodika prognozirovanija ostatochnogo resursa mehanizmov sel'skohozjajstvennyh mashin. Motoryzacja i energetyka rolnictwa. Motrol,– Lublin. Vol. 14. № 3, 200-205.
15. Velichkin I. N. 1999. Uskorennye ispytanija – zalog konkurentosposobnosti tehniki. Traktory i sel'skohozjajstvennye mashiny. № 3. 41-43.

СТЕНД ДЛЯ РЕСУРСНЫХ ИСПЫТАНИЙ КАРДАННЫХ ПЕРЕДАЧ В ЗАМКНУТОМ КОНТУРЕ

Аннотация. В работе представлен материал по разработке технического решения рациональной конструкции стенда для ресурсных испытаний карданных передач с целью повышения их точности и достоверности путем исследований влияния технологических сред на долговечность карданных передач.

Ключевые слова: стенд, ресурсные испытания, зубчатая передача, конический редуктор, карданная передача, долговечность, контактные напряжения.