**Nexus : Journal of Innovative Studies of Engineering Science ( JISES )**
Volume: 01 Issue: 03 | 2022 ISSN: 2751-7578
**http://innosci.org/**

# To Determine the Bending Stiffness of Stand Cardan Shafts, Splined Joints of Construction and Road Vehicles

**Alimjon Akhmadjanovich Riskulov**
*Doctor of Technical Sciences, Professor, "Materials science and mechanical engineering" department, Tashkent State Transport University, Tashkent, Republic Of Uzbekistan*

**Murodjon Iskandarovich Rakhmatov**
*Senior teacher of the "Automotive and automotive industry" department, Tashkent State Transport University, Tashkent, Republic Of Uzbekistan*

**Jamshed Sadulloevich Avliyokulov, PhD**
*Head of the "Automotive and automobile industry" department, Tashkent State Transport University, Tashkent, Republic Of Uzbekistan*

**Annotation:** This publication presents a stand for experimental studies of the bending stiffness of spline joints of cardan shafts. The obtained experimental dependences on the dependence of the radial force of the splined connection with different levels of wear of the cardan shaft are presented.

**Key words:** construction and road machines, vibration diagnostics, operational defects, stand for experimental research, spline connection, cardan drive, shaft deviation.

Currently, the number of construction and road machines in the country that use more powerful power plants, universal working bodies, multi-stage mechanical and hydromechanical gearboxes and other aggregates, components and gears interconnected mechanisms has increased [1,2].

Abrasive wear is one of the main reasons for the failure of cardan mechanisms of construction and road vehicles operating in adverse environmental conditions due to abrasive microparticles and an increase in dynamic loads on the transmission, unstable loads, as well as frequent starts and stops. Abrasive wear destroys the micro geometry of the profiles of the working surfaces of the splines, which leads to an increase in the lateral space and a decrease in the flexural stiffness, which in turn leads to an increase in dynamic loads and vibrations. Vibration not only has a negative effect on the operator, but also carries information about the defects that cause it. Determining the relationship between vibration parameters of machine structures, parameters of operational defects of cardan transmissions and their changes during operation allows for quick diagnosis and prediction of the technical condition of the elements of transmissions of construction and road vehicles. Thus, the development of on-site vibration methods for diagnosing operational defects and predicting the operation of cardan transmissions reduces the complexity of maintenance and repair, as well as increases the reliability and safety of construction and road vehicles [1,2,3].

Determining the wear of the spline connection of each of the propeller shafts was done by measuring the width of each spline in three sections along its working length. The measurement error results of spline connection wear of each of the shafts are shown in Table 1.

**Table 1. Values of measurement errors of wear of spline joints**

| № | **Wear value** I, mm | **Absolute error** Δb, mm | **Root mean square** error $\sigma_b$ | **Relative error** $\varepsilon$, % |
|---|---|---|---|---|
| 1 | 0,3 | $2{,}948 \cdot 10^{-3}$ | $1{,}504 \cdot 10^{-3}$ | 0,51 |
| 2 | 0,5 | $3{,}767 \cdot 10^{-3}$ | $1{,}922 \cdot 10^{-3}$ | 0,526 |
| 3 | 0,65 | $5{,}835 \cdot 10^{-3}$ | $2{,}977 \cdot 10^{-3}$ | 0,547 |

The bending stiffness of the splined joint was determined by the magnitude of the shaft deflection under the action of a radial force applied in the middle of the common part of this joint.

To determine the bending stiffness of the splined connection of the cardan shaft, a stand was used, which was based on a laboratory installation with a loading device (screw press) *1*, which provides axial movement to the universal table *2*, and on which support prisms *3* are installed. Dynamometric ring *6* with a dial indicator *5*, mounted in the mechanism of the installation movement *7*. An I-beam *9* with a pointer indicator *8*, which is attached directly to the studied driveline. The scheme and general view of the stand are shown in Figure 1.

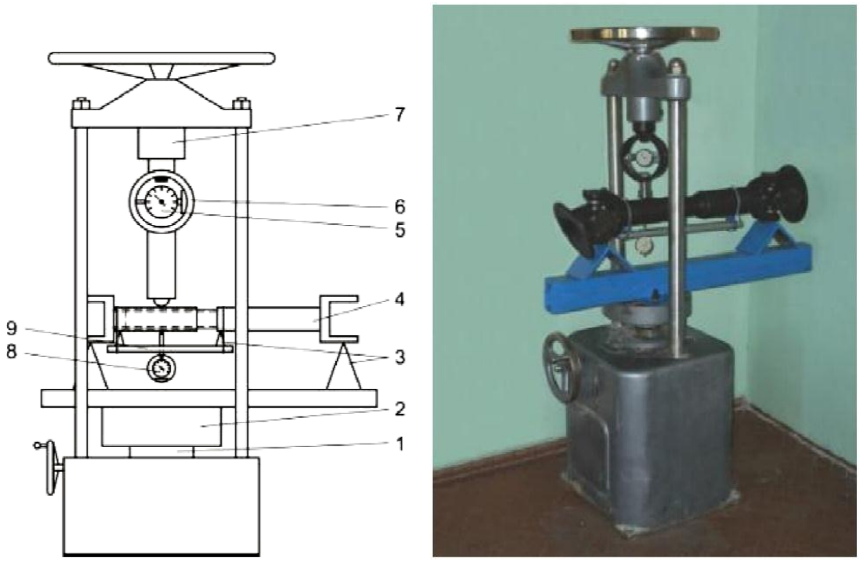


**Figure 1. Stand for determining the bending stiffness of the splined connection of the cardan shaft: *a - scheme; b - general view***

The results of the measurement error of the shaft deflection e under the action of the radial force F of each of the shafts are shown in Table 2.

**Table 2. Shaft deflection measurement errors**

| № | **Wear value** *I, mm* | **Root mean square error** $\sigma_b$ | **Absolute error** $\Delta e$, mm | **Relative error** $\varepsilon$, % |
|---|---|---|---|---|
| 1 | 0,30 | $1{,}05 \cdot 10^{-3}$ | $2{,}58 \cdot 10^{-3}$ | 5,83 |
| 2 | | $4{,}26 \cdot 10^{-3}$ | $2{,}18 \cdot 10^{-3}$ | 4,72 |
| 1 | 0,50 | $1{,}67 \cdot 10^{-3}$ | $4{,}08 \cdot 10^{-3}$ | 6,00 |
| 2 | | $8{,}33 \cdot 10^{-3}$ | $2{,}04 \cdot 10^{-3}$ | 4,90 |
| 1 | 0,65 | $8{,}60 \cdot 10^{-3}$ | $2{,}00 \cdot 10^{-2}$ | 4,90 |
| 2 | | $8{,}82 \cdot 10^{-3}$ | $2{,}16 \cdot 10^{-2}$ | 5,00 |

From the analysis of experimental data, we can conclude that the obtained experimental dependences should be approximated by two straight lines, the equation of which has the form

$$e = b_0 + b_1 \cdot \Phi$$

The coefficients $b_1$ and $b_0$ of the regression equation were calculated using the least squares method. The obtained values of the coefficients are shown in Table 3

Nexus : Journal of Innovative Studies of Engineering Science ( JISES )
Volume: 01 Issue: 03 | 2022 ISSN: 2751-7578
http://innosci.org/

**Table 3. Results of regression analysis**

| № | Wear value *I, mm* | Lot boundaries, *H* | Regression equation coefficients | |
|---|---|---|---|---|
| | | | $b_1$ | $b_0$ |
| I | 0,30 | 0<br>71,2 | $1{,}00*10^{-3}$ | 0 |
| II | | 71,2<br>352 | $7{,}72*10^{-5}$ | $6{,}60*10^{-2}$ |
| I | 0,50 | 0<br>71,2 | $1{,}57*10^{-3}$ | 0 |
| II | | 71,2<br>352 | $4{,}61*10^{-5}$ | $10{,}7*10^{-2}$ |
| I | 0,65 | 0<br>81,2 | $5{,}51*10^{-3}$ | 0 |
| II | | 81,2<br>362 | $1{,}03*10^{-4}$ | $43{,}9*10^{-2}$ |

The results of the dependence of the deflection of the cardan shaft e on the radial force F at different degrees of wear of the splined joint with applied regression lines are shown in Figures 2 ... 4.

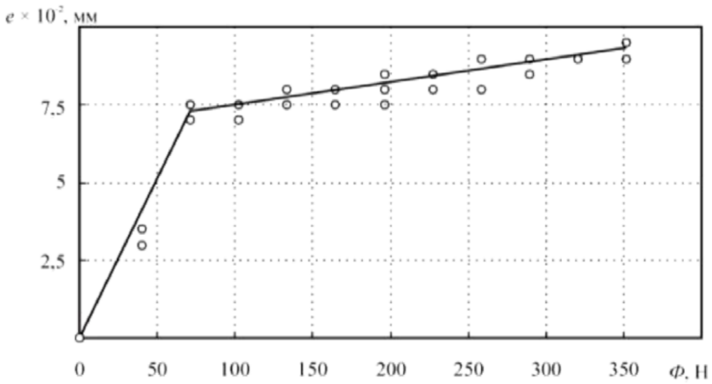


**Figure 2. Dependence of the deflection of the cardan shaft e on the radial force *Φ* with wear of the splined connection *I = 0.30 mm***

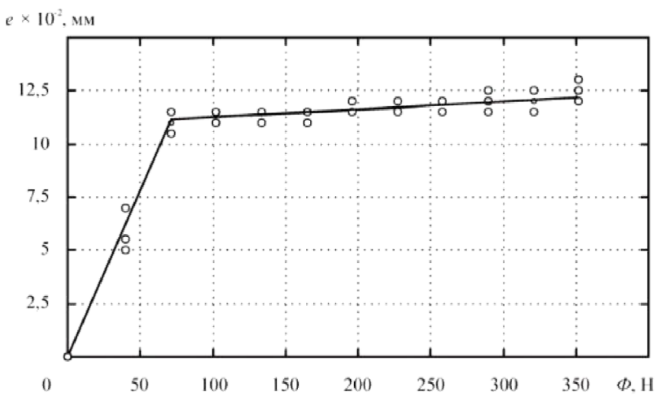


**Figure 3. Dependence of the deflection of the cardan shaft e on the radial force *Φ* with wear of the spline connection *I = 0.50 mm***

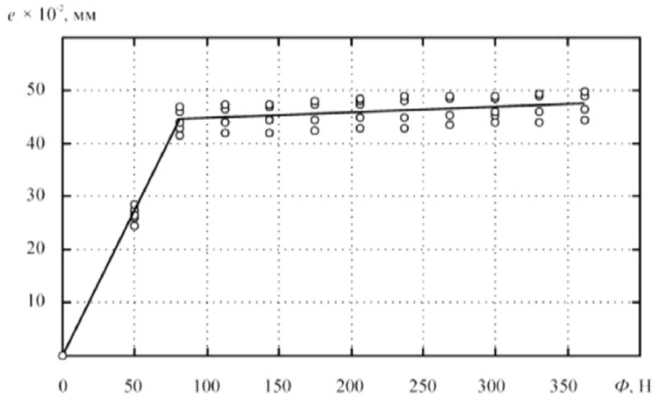


**Figure 4. Dependence of the deflection of the cardan shaft e on the radial force *Φ* with wear of the spline connection *I = 0.65 mm***

For the convenience of analyzing the results of the deflection of the cardan shaft e from the radial force Φ, we will build a combined graph shown in Figure 5.

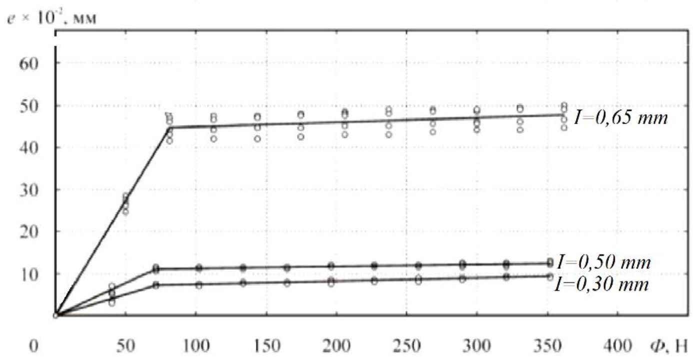


**Figure 5. The combined graph of the dependences of the deflection of the cardan shaft *e* on the radial force *Φ* at different degrees of wear of the spline connection**

The obtained experimental dependences of the change in the deflection of the spline connection on the value of the applied radial force have two pronounced linear sections. In the first section, when the radial force changes from zero to a certain value, the rigidity of the spline joint is significantly lower than in the second section, where the radial force has higher values. This nature of the dependence is explained by the fact that when a radial load is applied in the joint, gaps are first sampled, as well as contact deformation of microroughnesses and the lubricating layer, which have low rigidity. With a further increase in the load, after the selection of the gaps, only bending deformations of the directly splined shaft and bushing occur, which have a significantly higher rigidity.

Thus, the deflection of the shaft e of the driveline under the action of the radial load *Φ* will be determined mainly by the first section of the obtained dependence for the bending stiffness of the spline connection. The first section is characterized by the parameter $b_1$, which is equal to the tangent of the slope of the approximating straight line to the x-axis. Therefore, first of all, the dependence of the change in the value of the parameter $b_1$ on the amount of wear of the spline connection *I* is of interest. The graph of this dependence is shown in Figure 6

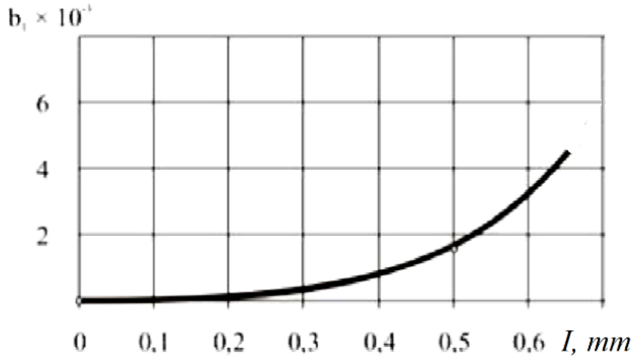


**Figure 6. Dependence of the parameter $b_1$ on the amount of wear *I***

From the presented graphic dependence, it can be seen that with increasing wear, the intensity of reducing the flexural rigidity of the splined joint increases.

**References**

1. Zhulay V.A. Possibility of vibration diagnostics of operational defects of CRM cardan transmissions / V.A. Zhulay, V.I. Enin, A.N. Shchiyenko // Construction and road machines. – 2009. – № 2. P. 46-47.
2. Zhulay V.A. Predicting the performance of cardan gears using vibrodiagnostic methods / V.A. Zhulay, V.F. Babkin, V.I. Enin, A.N. Shchiyenko // Construction and road machines. – 2010. – № 1. P. 50-53.
3. Zhulay V.A. Lifts for diagnostics, maintenance and repair of construction and road machines / V.A. Zhulay, N.P. Kuprin, V.L. Tyunin, A.N. Shchiyenko, S.A. Khrushchev // High technologies in the building complex. 2019. – No. 2. S. 97-106.