MONITORING OF PARAMETERS DIRECTLY INFLUENCING PERFORMANCE TRANSFER BY BELT GEAR

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The aim of the presented paper is to point out the possibilities of determination of new types of belts of the belt gear in case of a newly developed device. The developing and structural-design stage was followed by production and installation of the device. An electric motor serves as a device drive and belt gear input. The other electric motor represents a system load factor. The frequency converters diagnosed and monitored by the software intended for the purpose drive both motors. Through a simple adjustment of the designed device, diverse types and dimensions of the belts and belt pulleys can be changed. Monitoring and diagnostics of the tracked parameters was performed by the sensors fixed in the positions prescribed in advance.

KEYWORDS

stand, belt gear, motor, diagnostics, sensor

1 INTRODUCTION

Scientific, technical and technological advancement in the sphere of production and use of the belts gave rise to a number of kinds and types of belts. Contrary to other gear types the driving belts are characterized by a few advantages such as low weight, lower price or an alternative to be used as a slip clutch. In case of device damage frequent is destruction of belts and usually more expensive device remains intact. Constantly increasing demands regarding the V-belts require continuous quality improvement of the offered belts.

Within the frame of the issue the belt gear testing with a newly designed stand was proposed. The testing stand was designed and a 3D model was created by means of the Autodesk Inventor program and consequently it was manufactured [Gaspar 2013]. The entire device consists of three parts – the measuring, the control, and the monitoring ones. The newly designed stand serves for the research in the sphere of testing of the existing as well as of the new types of belts and of belt pulleys.

2 CURRENT STATE-OF-THE-ART OF BELT GEARS

The belt gears are indirect mechanical gears used for transfer of lower, medium, extraordinary and high performance mostly among shafts with parallel axes in all branches of industry.

Belt Pulleys

The belt pulleys are made from diverse materials, for example small belt pulleys can be made from plastic (polyamide, etc.), aluminium, structural steel, grey cast iron. For high revolutions the belt pulleys might be from steels intended for casts. From the point of view of diameters and weight the belt pulleys could be made from stamped plates and the big ones may be welded from plates of the weldable structural steels.

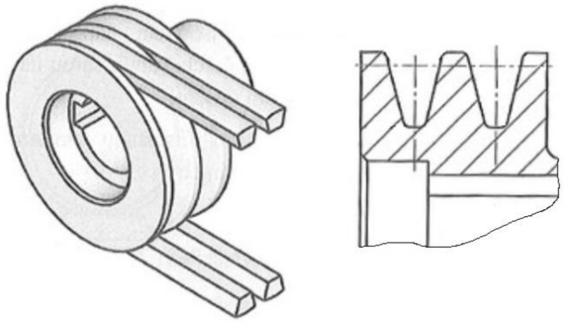

Figure 1. Example of standardly used belt pulley

Stress and Pre-stress Formation

Pre-stress can be achieved through diverse methods. If the driving device can be shifted, the change of axial distance as well as pre-stress formation are shown in Figure 2, during the standstill of the devices the pre-stress is formed by means of horizontally oriented screws which results in axial distance change and consequently by retightening of the screws the driving device is fixed. The different case can be the use of weight or of a driven device turned around the pin and stabilization by means of a bolt (Fig.3) or by means of a flexible element damping the variability of operation dynamicity [Puskar 2012].

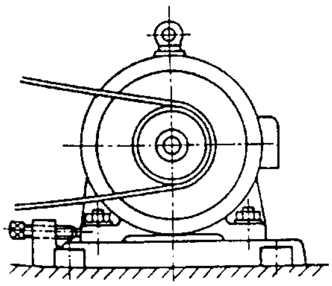

Figure 2. Tightening achieved by shifting

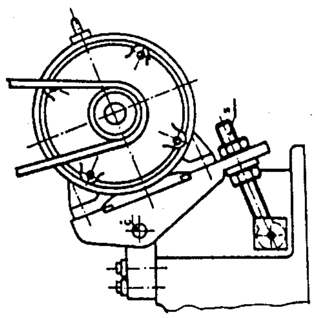

Figure 3. Tightening achieved by reclining

In tightening the tightening pulleys are placed in the proximity of the unloaded strand. In case of flat belts the angle of wrap (of contact) (Fig.4) is considered to be extended. The extension of the angle of contact between the belt and the belt pulley must not be the most appropriate for the V-belts as the outer part of the V-belt is characterized by alternation of tensile and compressive stress. The inner part is typical for alternation of tensile and compressive force (Fig.5). Placing the pulley onto the inner part of the V-belt in the proximity of unloaded strand and closer to bigger pulley the angle of wrap is minimized partially, yet alternation of tensile and compressive stress is absent in the belt fibres (Fig. 6).

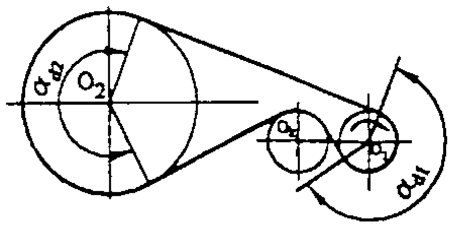

Figure 4. Tightening through angle extension

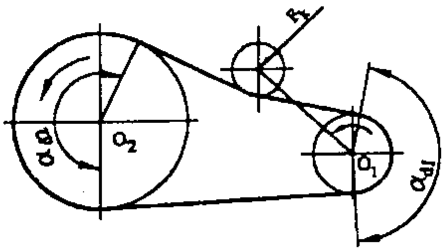

Figure 5. Tightening through alternation of tensile and compressive stress in the belt fibres

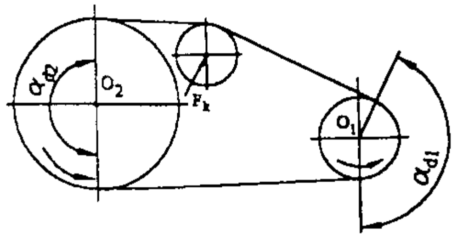

Figure 6. Tightening without alternation of compressive stress in the belt fibres

3 MEASURING DEVICE OF THE BELT GEAR SLIP

The device consists of the basic frame containing a drive electric motor and a brake. The belt pulleys mounted on the electric motor shaft and the brakes are connected by the V-belt and thus together they form the belt gear. The electric motor fixed on the frame is adjustable with the option of the V-belt tightening. The brake effect, the extent of which can be controlled proportionally, induces inevitable torque in the electric motor along with respective forces of the belt in its converging and diverging strands. The difference causes the belt pulley slip inevitable to be measured. Tightening of the belt and the respective shift of the electric motor are performed through a proving ring by a tightening screw and by a thrust bracket.

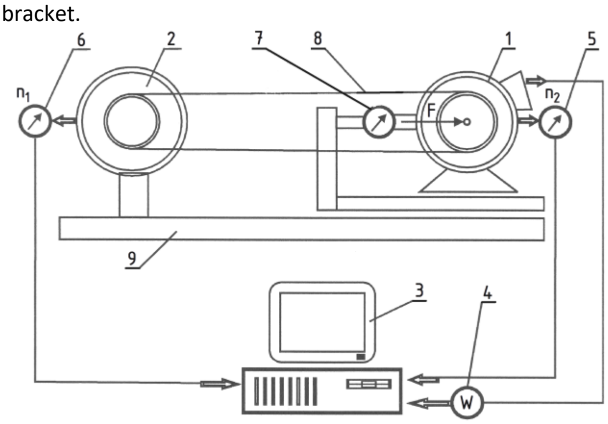

Figure 7. Scheme of measuring device of the belt gear slip, 1 – Electric motor, 2 – Brake, 3 – Computer, 4 – Sensor of output, 5 – Sensor of revolutions n_1, 6 – Sensor of revolutions n_2, 7 – Proving ring with deviation meter, 8 – Belt, 9 – Frame

The quantities inevitable for calculation and for the slip are monitored and assessed by a computer through sensors of the electric motor revolutions and of the brake. The values of electric motor input power and of intensity of tensioning force of the proving ring are read directly off the measuring devices [Krenicky 2010]. The following Figure 7 shows the scheme of the designed device and in Figure 8 the actual designed measuring device of the belt gear slip is shown [Bicejova 2016a].

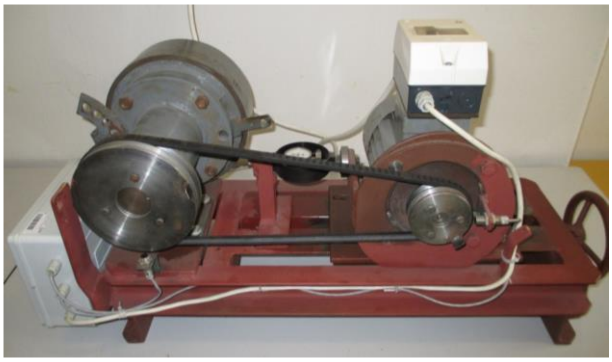

Figure 8. Measuring device of the belt gear slip

To allow actual measurement as mentioned afore the device must contain the sensors out of which a signal is sent to the computer and consequently the monitored state of the belt gear is assessed. The following Figure 9 shows the sensors of a small (driving) and of a big (driven) belt pulley.

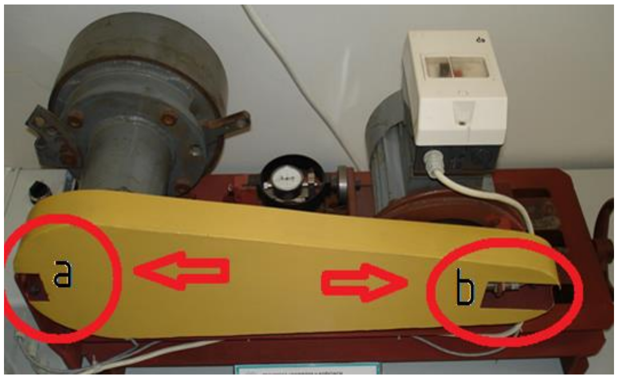

Figure 9. Measuring device of the belt gear slip Fixed sensors for measurement of revolutions a) driven belt pulley b) driving belt pulley

The device in question intended for measurement of the belt gear slip is designed as a universal device in case of which a simple adjustment allows adding or changing of the individual components. The device enables replacement of the small or of the big belt pulley as well as the replacement of the belts and of input or output parameters, etc. For instance, the change of the belt pulleys is carried out for the purpose of change of the gear ratio between input and output, which also represents the intention within the frame of the research innovation in the sphere of the belt gear testing [Bicejova 2013a].

4 NEWLY DESIGNED DEVICE FOR BELT GEAR TESTING

The developing and structural-design stage during which a test stand design was realized is followed by a production technology design. The production process proposal being recorded into a technological documentation is realized within the frame of technological preparation of production. This part of pre-production stages is referred to as the most arduous and the most time-consuming one in the course of preparation phase of the production process [Smeringaiova 2016].

Primary task of technological preparation of production is especially:

- processing of structural and technological analyses,
- selection of adequate semi-finished products,
- determination of number and order of production, check, and assembling operations,
- selection of adequate machines, tools, appliances, instruments, measuring devices,
- calculation of basic technical and economic data on consumption of time, material, energy,
- processing of programs for NC machines, robots, and control device [Bicejova 2016b].

The production process as a set of independent activities in which input material is transformed to finished structural parts of a measuring device is realized on the basis of technological procedures. Technological procedures are intended for production of individual components and for final equipment assembly. Technological procedure determines inevitable production equipment, tools, appliances, measuring devices, and technological conditions to assure accordance with the respective technological procedure, economic production of components meeting qualitative and quantitative requirements prescribed by technical documentation. It is a standard of the applied machinery and auxiliary equipment employed in production as well as a standard related to technological conditions under which the machinery operates.

The newly designed device consists of the basic frame containing a drive electric motor and a driven electric motor, which is included into the assembly as a brake element. The belt pulleys mounted on the electric motor shaft and on the driven electric motor are connected by the V-belt and thus together they form the belt gear. The asynchronous electric motors Siemens (1LA7090-2AA10ZA11 1.5KW 2900/min 400V Y 50Hz IMB3 PTC thermistor) fixed on the frame are adjustable with the option of the V-belt tightening. The driven electric motor controlled by a frequency converter is set up as the brake the extent of which can be controlled proportionally and in the electric motor its brake effect induces respective forces of the belt in converging and diverging strands. Yet, the difference causes the belt pulley slip that can be measured. Tightening of the belt and the respective shift of the electric motor are performed with a tensometric sensor of thrust, with a screw rod and with a thrust bracket. The quantities inevitable for calculation and for the slip are monitored and assessed by a computer through sensors of actual revolutions of the driven and of the driving electric motors. The values of intensity of tensioning force are assessed by a PC. Following Figure 10 shows the scheme of the actual designed measuring device of the belt gear slip [Bicejova 2013b, Mascenik 2016].

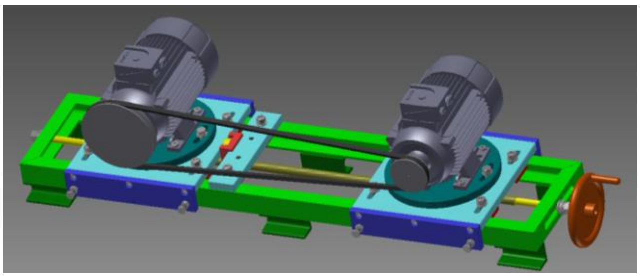

Figure 10. Newly designed stand for belt gear testing

Monitoring and adjustment of the belt tightening is directly connected via force tensometric sensor of EMSYST EMS50. A membrane sensor features bridge interconnection in case of small dimensions and measurement is carried out in direction of pressure. Force measurement ranges from 0.1 up to 100 kN. The sensor can serve for industrial as well as for laboratory purposes. The position of the sensor is shown in Fig. 11.

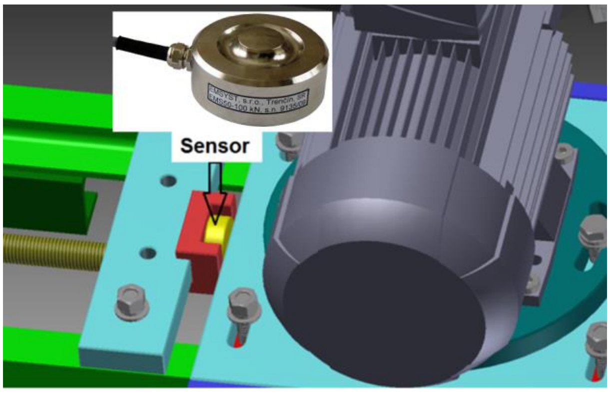

Figure 11. Monitoring of belt tightening with tensometric sensor of thrust

The design of the belt gear tightening includes a screw rod in the lower part of the device. Turning of a crank assures a shift of the respective electric motors and tightening of the belt. With a simple replacement of belt pulleys or belts the device can test also the new belt types. To test the belts under extreme conditions a correct layout of the belt pulleys can be misaligned through a simple adjustments and modifications, yet setting of specific angle and axial misalignment is required.

Following Figure 12 shows a scheme of the device designed for measuring of belt gear slip or for testing of new belt types. The device assembly consists of the following: 1 – driving electric motor, 2 – driven electric motor as the assembly brake, 3 – monitoring and assessing computer, 4 – belt, 5 – sensor of the actual revolutions of input belt pulley, 6 – sensor of the actual revolutions of output belt pulley, 7 – tensometric sensor of thrust, 8 – supporting frame, FM1 – frequency converter to control the driving electric motor, FM2 – frequency converter to control the driven electric motor [Mascenik 2016a-c].

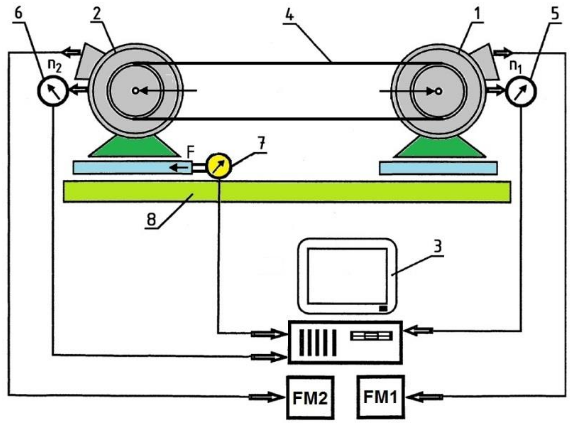

Figure 12. Scheme of device designed to test the belt gears

Frequency converters can be controlled and monitored when the entire assembly is connected to the PC through monitoring and adjusting SoMove software. SoMove software is used for configuration and adjustment of parameters of Altivar frequency converters, of Lexiujm synchronous drives, TeSys motor starters. SoMove program features a unique option of off-line mode which allows access to any parameter of the adjusted device (prior to connection to a superior system). Its output is a configuration file that can be archived, printed or exported to Excel [Murcinkova 2013]. The created configuration can be read by Multi-Loader which, apart from other, allows copying of parameters without use of personal computer. Following Figure 13 demonstrates the working environment of SoMove program [Bicejova 2016c].

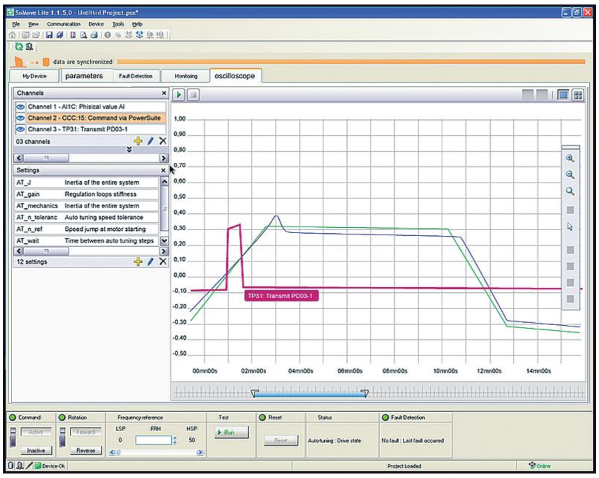

Figure 13. Working area of monitoring and adjusting software SoMove

5 CONCLUSIONS

The main intention of the testing of the belt gears of the newly developed device is determination of recommendations regarding the decrease of fault rate of the belt gears as in the practice during the belt gear operation the faults occur in the form of rapid belt wear, decrease of revolutions of the driven belt pulley, overheating of the belt under influence of external effects, cross-sectional ruptures in the bottom part of the belt, longitudinal ruptures, and wear of the upper part of the belt.

One of the aims of the measuring device design is to determine limiting conditions or to define a destruction point through extreme loadings of the belt. The stand design stemmed from the essential technological and structural knowledge gained from technical literature, available materials and practical advice offered by the experienced professionals [Mascenik 2014]. The selection of the most suitable alternative was preceded by a proposal of several alternatives and their detailed analysis by means of virtual model. Through application of the installed sensors the device allows measuring of the actual revolutions of belt pulleys which are compared with the ones set up for frequency converters. Monitoring of the inevitable parameters to determine for example the belt gear slip is carried out by means of the sensors installed at pre-defined places the data from which are processed by the PC. When the device is placed on a damping or rubber pad the vibrations of conversion can be measured. The results and knowledge of research measurements could contribute to the sphere of development of new types of belt gears.

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