A DEVICE DESIGNED TO MONITOR NEW BELT TYPES WITH APPLICATION OF DIAGNOSTIC SYSTEM

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The presented paper deals with the alternative of determination of state of new belt types of the belt gear in case of a designed device. The developing and structural-design stage, during which realization of a testing device was performed with Autodesk Inventor program, was followed by a production technology design. An electric motor serves as a device drive and belt gear with the other electric motor representing a system load factor. The frequency converters diagnosed 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. All the parameters can be assessed by a PC.

KEYWORDS

motor, diagnostics, stand, sensor, belt gear

1 INTRODUCTION

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 replacing the individual components. The device enables replacement of a small or of a big belt pulley as well as the replacement of the belts and change of input or output parameters, etc. For instance, the replacement of the belt pulleys is carried out to change 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.

The developing and structural-design stage during which a test stand design was realized is followed by production technology design. The production process proposal being recorded into technological documentation is realized within the frame of technological preparation of production [Bicejova 2013a, Bicejova 2013b]. This part of pre-production stages is referred to as the most arduous and time-consuming one during preparation phase of the production process. 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.

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 [Bicejova 2016a, Bicejova 2016b]. 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 of technological conditions under which the machinery operates [Mascenik 2012, Gaspar 2013].

2 COMPUTER AID IN MEASURING DEVICE DESIGN

3D modelling and simulation Autodesk Inventor software was used in developing and structural-design stage. The program allows creation and analysis of a complete product prior to its actual manufacturing. Inventor software also enables to benefit from digital prototyping by integrating 2D AutoCAD drawings and 3D data into a single digital model. This digital model creates a virtual representation of the final product and facilitates to improve design, visualisation and simulation of the product in practice with less reliance on costly physical prototypes. Moreover, it helps to improve time for product launching into the market and increases competitive advantage [Mascenik 2011], [Halko 2013].

Generate and share production-ready drawings easily for manufacturing teams and external suppliers. Autodesk Inventor software allows generation of technical and manufacturing documentation from a validated digital prototype to reduce of error rate and to deliver designs in a shorter period of time. Maximise reuse of 2D AutoCAD drawing assets and create drawings faster in Inventor. Sufficient is to call out drawing views, including front, side, ISO, detail, section and auxiliary views, and Autodesk Inventor projects the corresponding geometry. Generate automated and associative parts lists and bills of materials developed specifically for mechanical engineering. Automatic updates mean that changes appear in the entire design and thus everyone involved is kept on schedule with exact number of parts, identification and ordering. Inventor allows creation of true DWG-based drawings of 2D and 3D designs from any CAD source [Mascenik 2014, Halko 2013].

Inventor software offers a wide range of tools to simplify the transition from 2D to 3D design and helps users to become productive instantly. Breakthroughs in design and part modelling provide design tools that are considerably easier to learn and use. Intuitive sketching and direct manipulation modelling offer uninterrupted work procedure for fast exploring and assessment of concepts. Specialised functions accelerate the design of plastic components and sheet metal. Furthermore, easy-to-use tools facilitate procedure in assembly creation to assure that all parts and components fit together correctly [Mascenik 2012, Novakova 2008].

Design Automation

Autodesk Inventor features the rules-based design and automation tools of standard tasks which facilitate the work and allow the user to concentrate on design intent rather than modelling geometry manually. Inventor captures the functional requirements of a design to drive the automatic creation of intelligent components and accelerate the individual design stages. The technology of Inventor iLogic dramatically simplifies rules-based design to help any Inventor user– even one with little or no programming experience. It helps define complex configurations of products, increase development productivity, and optimize designs [Mascenik 2012, Krenicky 2011].

High-End Visualisations

Create stunning renderings, animations and presentations quickly and easily to improve communication with partners and customers. Autodesk Inventor software offers high-end visualisation, illustration and animation tools directly in the standard workspace, providing you with a realistic representation of a design at all times. Dynamic shading, precise lighting control and the library of high-resolution textures make it easy to create photorealistic scenes of final products within the frame of actual environments [Mascenik 2012, Halko 2013].

3 MEASURING DEVICE DESIGN

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 (Fig. 1). 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, a screw rod and thrust bracket. The quantities inevitable for calculation and for the slip are monitored and assessed by a computer through sensors of actual revolutions of both the driven and driving electric motors. The values of intensity of tensioning force are assessed by a PC. Figure 1 shows the scheme of the designed device and in Figure 2 the actual designed measuring device of the belt gear slip is shown.

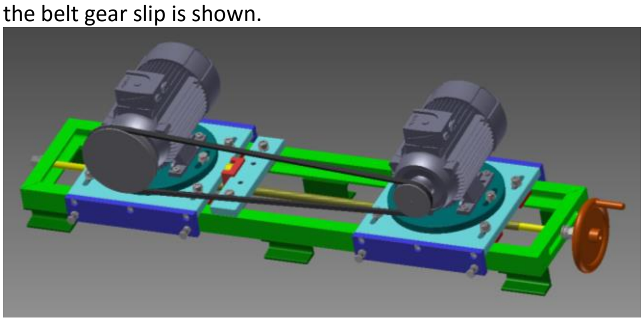

Figure 1. Newly designed stand for belt gear testing

Monitoring and adjustment of the belt tightening is directly connected via force tensometric sensor of EMSYST EMS50. Membrane sensor features bridge interconnection in case of small dimensions and measurement is carried out in direction of pressure. The range of force measurement is from 0.1 up to 100 kN. The sensor can serve for industrial as well as laboratory purposes. The position of the sensor is shown in Fig. 2.

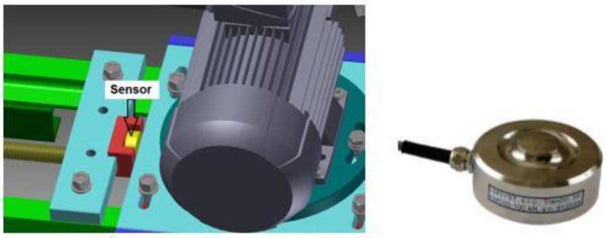

Figure 2. Monitoring of belt tightening with tensometric sensor of thrust

The design of the belt gear tightening includes a screw rod in the lower part of the device (Fig. 3). Turning of a crank shall assure 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 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.

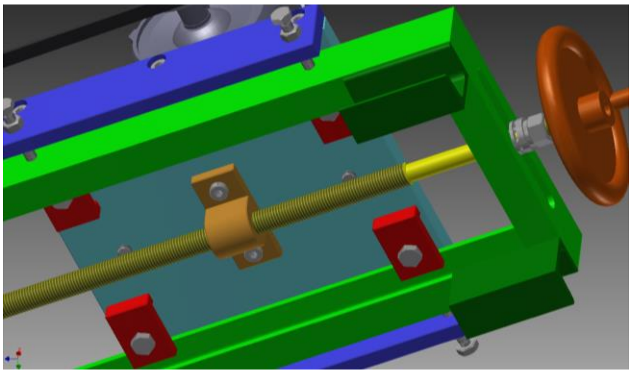

Figure 3. Belt tightening with a screw rod

Fig. 4 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.

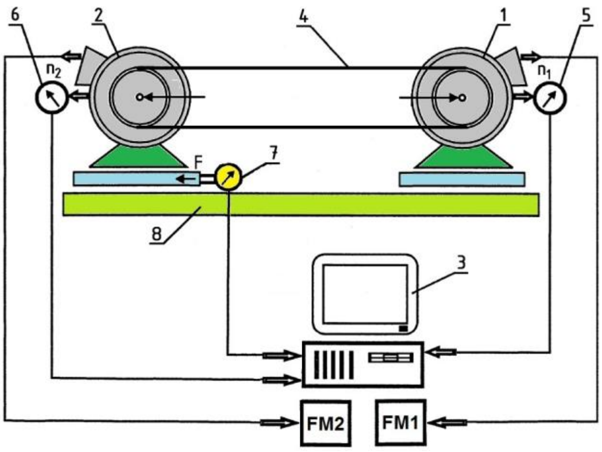

Figure 4. Scheme of device designed to test the belt

4 MEASURING DEVICE DESIGN

Multipurpose device designed to test new types of belt gears features a control part consisting of frequency converters directly connected with the electric motors, of two input circuit breakers FM 3p 10A/C in a modular box, of two control boxes (start, stop, potentiometer), of a single central STOP button and of a connecting cable with transducer USB/RS485 to set up FM1 and FM2 and to assure connection with the PC.

Frequency converter is a device that converts electric current of one frequency to electric current of another frequency. A frequent reason for frequency converter installation is a need of continuous regulation, e.g. of revolutions of asynchronous electric motor.

Electric motors are controlled by frequency converters Altivar 71 of ATV71HU15N4, ALTIVAR 3x400V/1.5kW type designed by Schneider Electric with the possibility of a full momentum open-loop control (Fig. 5). It is the converter with properties and simple adjustment that predetermine the use in more complicated applications with performance of up to 500kW. The following characteristics of this frequency converter rank among the main ones: - regulation of speed or momentum with vector control even in case of rather low revolutions, - possibility to control high revolution motors up to 1000Hz (over 37kW of up to 500Hz), - possibility of control at zero revolutions and open-loop control of synchronous motors, - controlled braking and momentum control on the basis of weight, - possibility of diverse braking methods with option of energy recuperation to the DC power network. Frequency converter Altivar 71 lacks a display, yet contains an auxiliary device - the operation7-segment LCD display fixed to the front panel of converter. Figure 5 shows the applied frequency converter and control panel with LCD display.

Figure 5. Frequency converter Altivar 71 with control panel

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) [Puskar 2012, Puskar 2013]. Its output is a configuration file that can be archived, printed or exported to Excel. The created configuration can be read by Multi-Loader which, apart from other, allows copying of parameters without use of personal computer. Figure 6 demonstrates working environment of SoMove program.

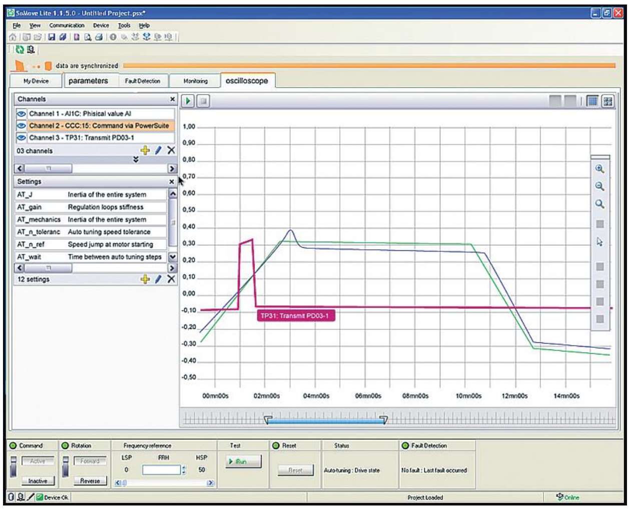

Figure 6. Work area of monitoring and adjusting software of SoMove

Fig. 7 shows already realistic design of device intended for measuring of, for instance, belt gear slip or for testing of new belt types. In measurement of the belt gear slip the input parameters are represented by card revolutions of the electric motor and theoretical gear ratio. Input parameters include also the values of tensioning force and of torque which are read off the measuring device directly on the device.

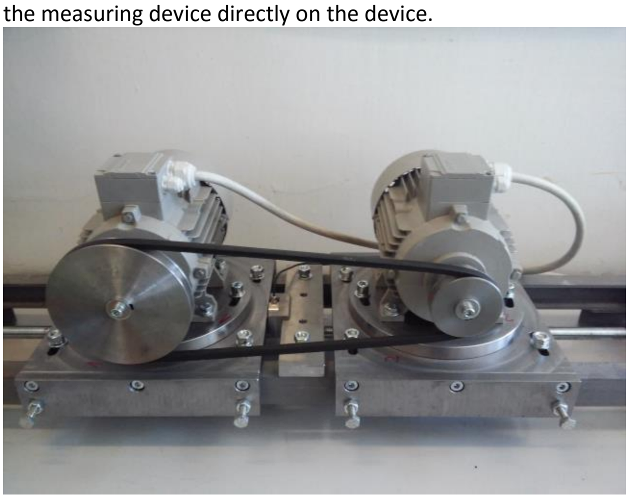

Figure 7. Newly designed testing device

5 CONCLUSION

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 [Murcinkova 2013].

Contemporary gears with the V-belts represent powerful drive; however, the optimal output shall not be achieved without, for instance, correct tightening and layout. High output is given by a multi-year research and development carried out by the engineers and by the technicians heading towards the refinement of materials and processes. Although the belt gear represents rather obsolete component of output transfer, the current belt gear is exceptionally powerful means of the output transfer between the driving machine and other device.

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