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The Diagnostic System of Low Speed Bearings

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Abstract. The subject of paper is the design of control system of slow running bearings including strength analysis and load capacity measurement with the intention to apply the results to the manufacturing operation by the chain conveyor in the paint shop.

Introduction

The diagnostics of low speed bearings is very desirable in a wide range of industrial sectors. Mainly in the transport technologies is necessary to identify the damaged bearing before a production failure and large economic losses become. Chain conveyors are used in the bodywork painting process and chain wheels are mounted on shaft, which is currently mounted on two roller bearings. Shaft speed is relative slow, ones of rpm. There is no doubt that the reliability of this construction has a main influence to the volume of production, especially since the paint shop is the bottleneck of whole production process of cars. The diagnostics of high speed bearings is based on vibration measurement that is reliably used for many years. For the diagnostics of low speed bearings there is no appropriate physical method, which has been able to identify the bearing damage. The topic of the article is focused on solving problem of diagnostics of low speed bearings with intention to apply obtained results to the manufacturing process in the paint shop.

Used Methods

The design of control system of slow running roller bearings is based on analyzation of the current state. The basis is to determine a load in all manufacturing conditions and to determine the force of the chain in the most exposed position. With knowledge of manufacturing operation force of the chain, it is possible to calculate the load of shaft and roller bearings. The results may be used for FEM analysis, calculation stresses and deformations of each part of the current state as a basis of design solution.

The design solution of a system of diagnostics of slow running roller bearings can be based on the principle of rolling resistance or vibration measurement. However effectivity of the vibration detection depends on a sufficient level of measured acceleration, which cannot be achieved in slow rotational movements. It means for the current state to dismount chain and then measure the rolling resistance or increase the rpm by external power and measure the vibration.

Pursuant to demand for the reliability of chain conveyors and the shafts and chain wheels mounting, was designed a system consists of two pairs of roller bearings - shaft and frame. These are connected to each other by the so called reference part that is the freely rotable part.

This solution allows identification of bearings damage with two methods. The first method is depending on change of rolling resistance during forced rotation of reference part. The other method uses vibration measurement by increasing the rpm with properly connected external power. This innovative solution is protected by patent.

Kinematic link between shaft and reference part allows distribution dynamic load between shaft and frame bearings, which is convenient for manufacturing operational matters. Based on this kinematic link shaft and reference part are in forced rotation. Due to kinematic link of shaft, reference part and frame, the design solution leads to integration of planetary mechanism with spur or bevel cogwheels. This solution is protected by patent as well.

After strength analysis of the designed solution, the prototype was made with the intention to experimentally measurement of deformation by nominal and maximum value of load. The fatigue test is already prepared.

Description of Current State

Current state of shaft mounting of chain wheel of conveyor is made of two spherical roller bearings mounted to the frame by bearing units. Chain wheel is connected to free end of shaft and is separated by front plate of frame, which is connected to the frame of paint shop production line.

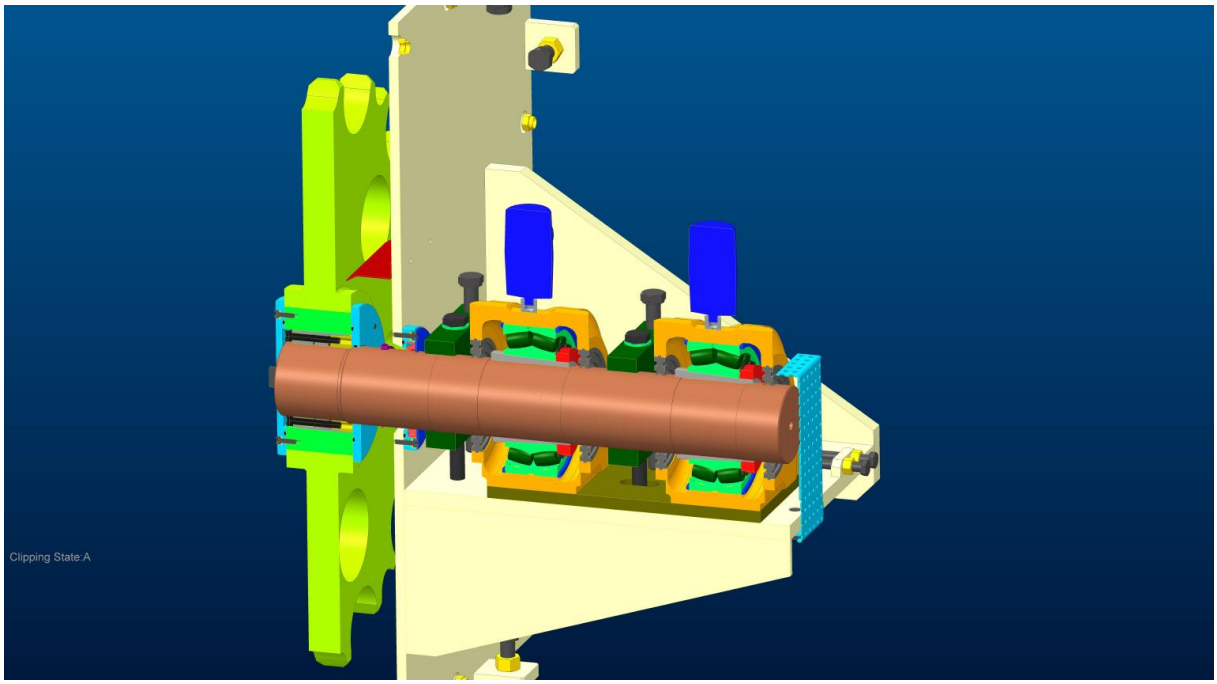

Fig.1 Current state of shaft mounting of chain wheel

The advantage of current shaft mounting of chain wheel of conveyor is its relative simplicity. Significant disadvantage is complicated dismounting and changing of bearings. Because of that, the vibrodiagnostics of bearings was implemented with using latest technologies. Sensors of low frequency vibration are used for identification of damaged bearing. The difficulties consist of insufficient intensity of vibration of slow running bearing. Its value merges with vibrational background of paint shop production line. The reliability of identification of damaged bearing is insufficient.

Design Solution of Diagnostic System

Reliable design of control system of slow running bearings can be based on identification of change the rolling resistance of bearing or its vibrations during the sufficient rpm. Both these methods are difficult to be realized during the manufacturing operation. The change of rolling resistance can be identified only with increased power load, which is usually too late. The sufficient rpm value of bearing can happen only if the standard, low speed operation is off.

The design solution of design of control system of slow running bearings, which is the topic of this paper, comes from the idea, that if one ring of the roller bearing is forced low speed, the second ring of the roller bearing is freely rotable. This diagnostic solution allows identification of change of rolling resistance of shaft bearing or sufficient rpm increase on its freely rotable ring that allows identification of damage of bearings using known methods of vibrodiagnostics. The freely rotable ring of the shaft bearing is rotably mounted to frame using frame bearing. The reference part is mounted between shaft and frame bearing (Fig. 2).

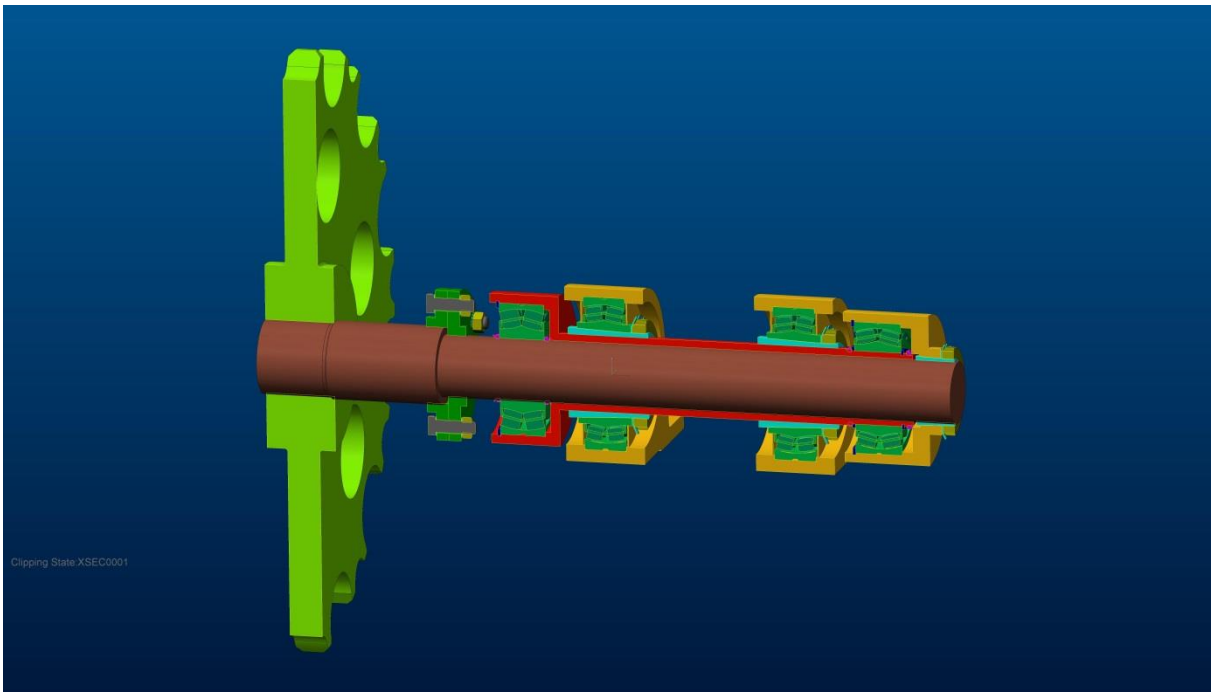

Fig.2 Drafted solution of shaft mounting of chain wheel

The change of bearings is quite a difficult operation, and because of that, the shaft is divided between chain wheel and bearing. This design allows to repair or change of bearing outside of the paint shop production.

This solution provides a number of design variants, one of which was chosen as optimal and then analyzed.

Strength Analysis

Strength analysis is an important field of every design solution. With this shaft mounting solution, the strength analysis is mainly focused on stress and deformation calculations. In all cases, the Ansys software for FEM analysis was used.

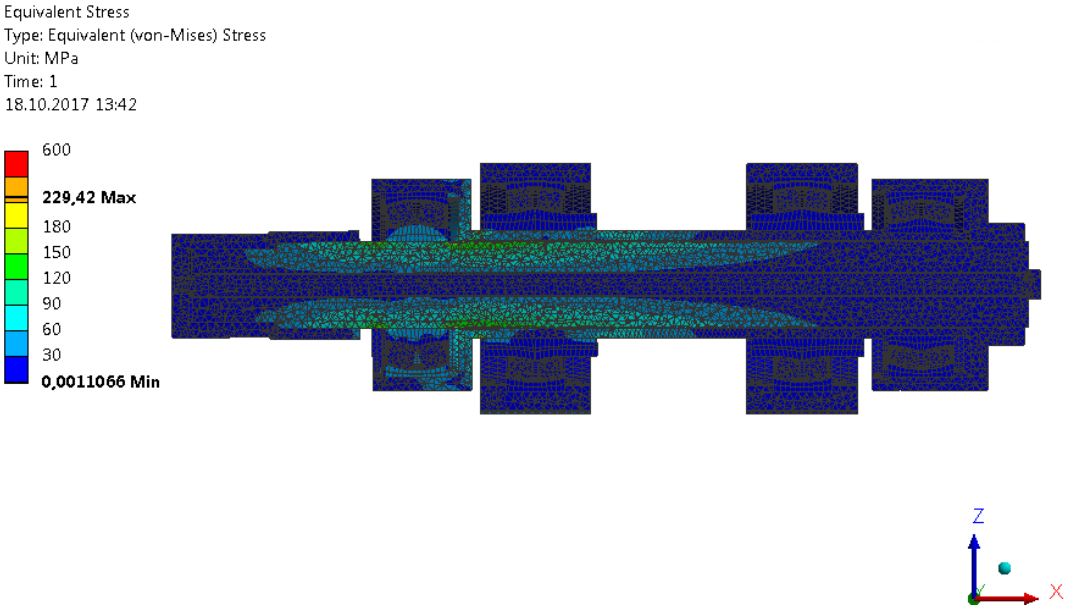

Fig.3 Equivalent stress (von Misses) of designed solution

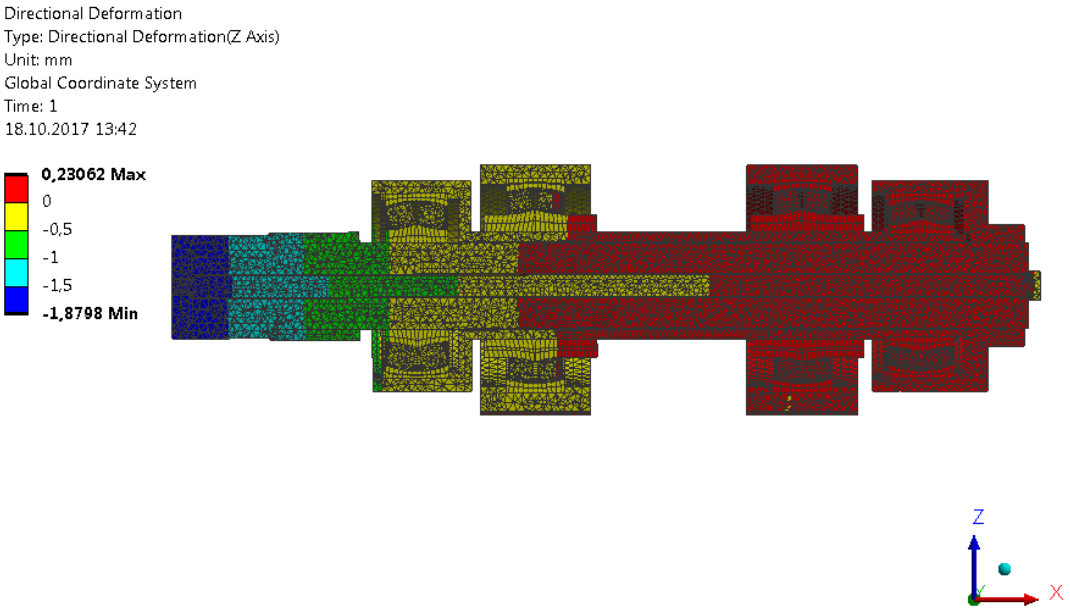

Fig.4 Deformation in z-axis direction of designed solution

Damage Identification System

The identification of damaged shaft or frame bearing can be made based on the change of rolling resistance. For this purpose, the kinematic and moment link of shaft, reference part and frame that consists of planetary gear with simple planets and bevel cogwheels, was designed. Shaft cogwheel with main axis of rotation is tightly connected to shaft. Frame cogwheel with main axis of rotation is connected to frame by adjustable frictional moment. The link between these cogwheels is made by satellites that are mounted to the pins of reference part.

The motion of reference part is determined by kinematic and moment link of planetary gear. If the rolling resistance of shaft bearing increases out of load capacity limit, the frictional moment between frame cogwheel and frame is exceeded. The frame cogwheel then starts to rotate in the same shaft direction.

If the rolling resistance of frame bearing increases out of load capacity limit, the frictional moment between frame cogwheel and frame is exceeded. The frame cogwheel then starts to rotate in the counter shaft direction.

Both rotations of frame cogwheel against the frame can be easily identified by connected sensor (Fig. 5).

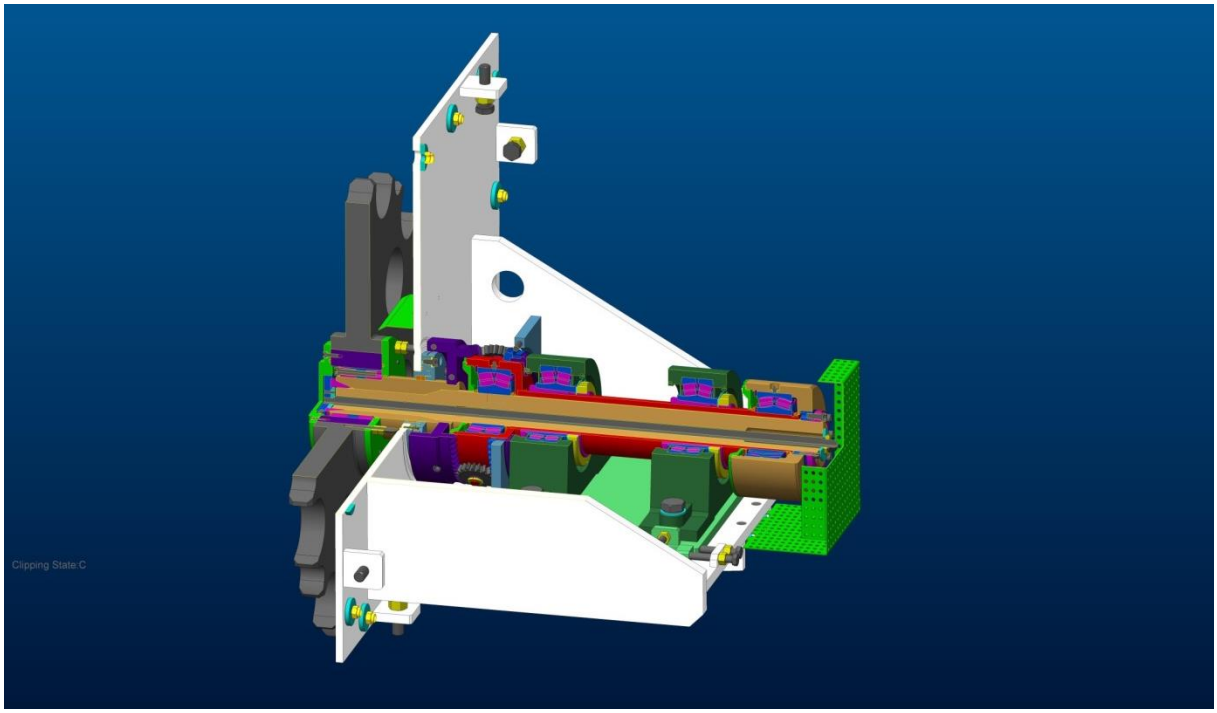

Fig.5 Designed solution of shaft mounting of chain wheel

Conclusion

The paper is focused on actual issue of diagnostic of low speed roller bearings. The designed solution uses reference part between shaft and frame bearing. Change of rolling resistance, which leads to bearing damage, can be identified using reference part. This can be realized during the manufacturing operation. The designed diagnostic system consists of planetary gear with bevel gears. Considering this is an original solution, two applications for patent were filed. One of them has been granted.

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