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REDUCTION OF NOISE AND VIBRATIONS OF VARIOUS TRANSPORT EQUIPMENT WITH A SUITABLY CHOSEN SHAFT COUPLING

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Abstract: The drive is an essential part of the transport equipment. It consists of parts that affect the noise and vibrations of the bottom device. The article describes the main parts of transport equipment. It mainly describes the parts of the mechanical test equipment for measuring vibration and noise. This article examines whether using different types of flexible couplings in a mechanical system can reduce noise values and vibrations. Because, by reducing vibrations and noise, we can ensure better working conditions not only for the operator of the given equipment but also extend the life of transport systems and thereby reduce the costs of operation and maintenance of various equipment.
Keywords: flexible coupling, vibration, noise, mechanical system, electric motor

1. INTRODUCTION

The shaft coupling is one of the important parts of the machinery drive. These drives are found in most transport machines and equipment. At the Department of Design and Machine Parts, KKDaL SjF TU in Košice, attention has been devoted for a long time to research and development of flexible shaft couplings and control of dangerous torsional oscillations in mechanical systems, precisely by applying these couplings. According to several authors [1, 2, 3, 7].

The most appropriate way to control the dangerous torsional oscillation of mechanical systems is the application of a suitable flexible shaft coupling. By controlling this dangerous torsional vibration, we can eliminate or significantly reduce negative effects on the environment (vibrations, noise) [11, 14, 15]. This process also protects individual parts of machinery from mechanical damage. This dangerous torsional oscillation occurs in various transport, lifting and handling equipment and it is necessary to eliminate it or possibly reduce it to the permissible value. The most at risk are equipment working with cyclic operations such as grab cranes, skips, and transport trolleys on ropes or rails. However, dangerous torsional oscillations also occur in devices with continuous and periodically operating devices such as belt conveyors, chain and vibrating conveyors, bucket elevators, etc. A flexible shaft coupling can be used in all these devices.

Measuring the noise and vibrations of mechanical systems is very important, it is an essential part of the analysis of vibrodiagnostics [4, 5, 6, 9]. The monitoring of noise and vibrations in mechanical devices is important from the point of view of the dynamic action of forces. The oscillation of mechanical systems can cause feedback in other parts and components, and this can be a strong source of mechanical vibration and noise [17]. By using different types of flexible couplings in the mechanical system, we can reduce the noise values and thus the vibrations. In terms of torsional vibrations, the system can operate in the sub–resonance region, in the resonance region, or in the supra–resonance region.

The article will show how by changing the shaft coupling we can change the properties of the drive and thus reduce adverse effects such as noise and vibrations. With a suitably chosen flexible coupling in a mechanical device, we can move the working area of the transport device outside the resonance area and thus protect the given device from possible damage. In the article, we will show in detail on the graph how changing the clutch changed the vibrations and noise of the entire mechanical device.

2. TRANSPORT EQUIPMENT

Every transport device must have a drive. This drive drives the output device mostly through a gearbox [8, 12, 16], which reduces the revolutions and increases the torque and transfers the given power to the output. This output can be a belt wheel or a drum. The goal of any transport device is to move or move people or goods from one place to another. Examples of such transport devices can be seen from Figure1 to Figure 4. Today, conveyor systems are an integral part of all automated workplaces. Such systems include not only the conveyors themselves, but also electronic or pneumatic elements and software that ensure the correct operation of the entire workplace [13].

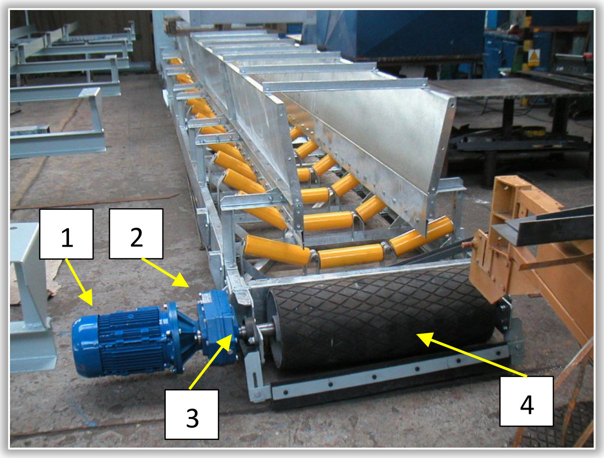

Figure 1. Belt conveyor drive

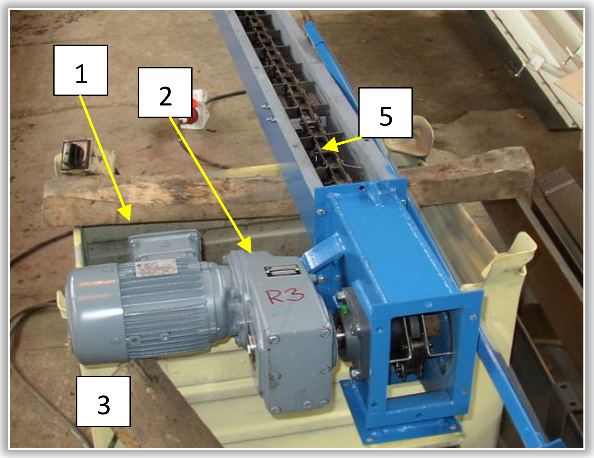

Figure 2. Chain conveyor drive

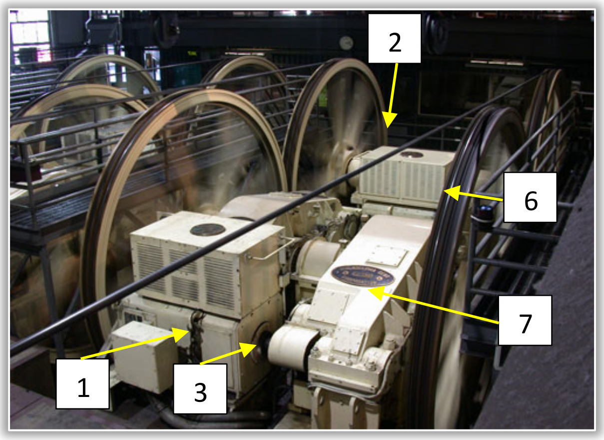

Figure 3. Cable car drive

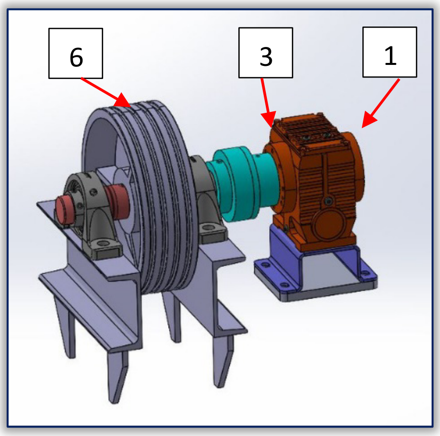

Figure 4. Scheme of the elevator drive station

Each such drive consists of the basic parts shown from Figure 1 to Figure 4. The basic part is the electric motor (1) which transmits the torque with revolutions via the gearbox (2) to the drive device. If necessary, the electric motor can be connected to a gearbox as in Figure 4. In such a case, we are talking about an electric gearbox.

The goal of every gearbox is to reduce high revolutions increase the torque and transfer this torque through the shaft coupling (3) in the case of a belt conveyor Figure 1 on the drive drum (4) which drives the conveyor belt or in the case of a chain conveyor Figure 2 to the sprocket that drives the conveyor chain (5). If we are talking about transport facilities such as cable cars Figure 3 or Elevators Figure 4 so our goal is to transfer the torque to the drive wheel (6) which drives the rope of the given device.

It is also possible to use various additional gears and in Figure 3, where a belt transmission (7) is used, whether due to a change in the gear ratio or a large axial distance. In transport technology, there are various coupling options or combinations, while it should be emphasized that the right shaft coupling (3) is an essential part of such a system, which has a significant impact on the noise and vibrations of the entire transport equipment.

3. DESCRIPTION OF THE TEST MECHANICAL SYSTEM AND MEASURING DEVICES

We performed our measurements on a mechanical system designed by our department. The mechanical system that we used for our measurements is located in the laboratory of our department (Figure 6).

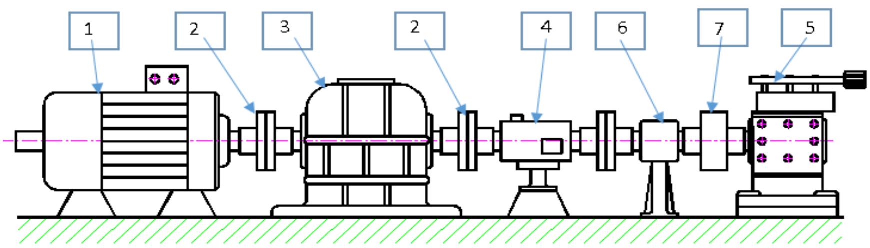

Figure 5. Model of the investigated mechanical system

The main parts of this mechanical system are shown in the diagram (Figure 5): electric motor 1, fixed disc clutch 2, gearboxes 3, torque sensor 4, compressor 5, bearing body 6 and flexible shaft couplings 7 under investigation. [1, 2, 17].

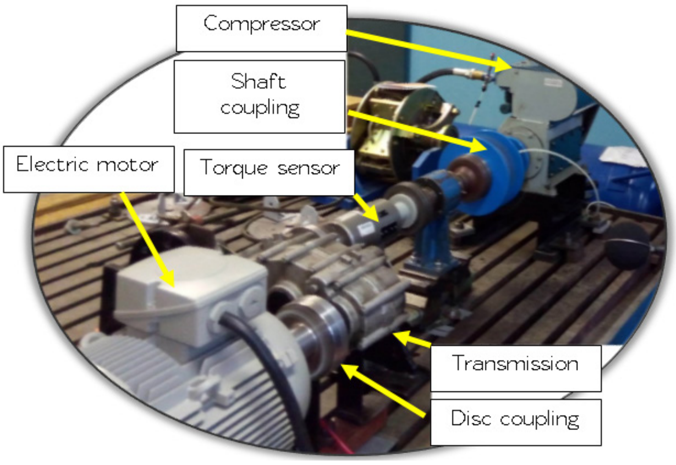

Figure 6. Assembled examination of the mechanical system

To measure the noise of the mechanical system, we used a sound analyzer Type 2250. This device is the 4th generation from Brüel & Kjær. The philosophy is based on extensive research, the result of which is that this device ensures simple and safe use. Type 2250 has won several awards for its functions, excellent ergonomics and attractive design. The Type 2250 can be expanded with several software modules, including frequency analysis, logging (profiling) and recording of the measured signal.

The combination of software modules and innovative hardware makes the device a specialized solution for performing measurement tasks with high accuracy. It can be used in areas of the environment, but also in the work environment.

We measured the vibrations of the system with the Analyzer Adash 4101 device. The performance of the analyzer is determined by the firmware stored in the device's memory. The firmware is designed on a modular basis, which allows the user to specify the desired properties of the selected measurement. In the instruments of the 4100 series, there are two main types of measured data – static and dynamic. Static data is represented by a single value (real or complex). An example is the result of a broadband measurement of vibration values (for example, ISO 2372) or a measurement of revolutions per minute. Dynamic data is made up of measured values. An example is the result of a signal spectrum or time measurement. This enables real–time measurements of amplitude and phase per revolution frequency. By measuring, we can find and reveal the place where the vibrations are greatest.

4. DESCRIPTION OF THE INVESTIGATED SHAFT COUPLINGS

In Figure8, Figure10 and Figure12, we see the shaft couplings used during the measurement. We successively performed measurements on the flexible Periflex coupling (Figure 8), the Hardy shaft coupling (Figure 10) and finally we also used the Gurimax gear shaft coupling (Figure 12). Shaft couplings connect to the compressor and gearbox. The stability of the connection is ensured by a bearing housing fixed to the base plate.

Periflex shaft couplings (Figure7) are flexible rubber hoops that connect two shafts and flexibly transmit torque from one to the other. They ensure the smooth operation of the machinery and eliminate the effects of uneven and jerky operation of the drive. The coupling is placed on the flanges ending the shafts and firmly fixed with pressure plates.

The Hardy–typed coupling (Figure9) is able to compensate for big angular deviations, thanks to its rubber element. It has an excellent dampening effect on the load peaks. The Juboflex coupling consists of two metal hubs and a flexible rubber element. It is available with a solid hub or taper bored version, depending on the size.


Figure 7. Periflex flexible shaft coupling

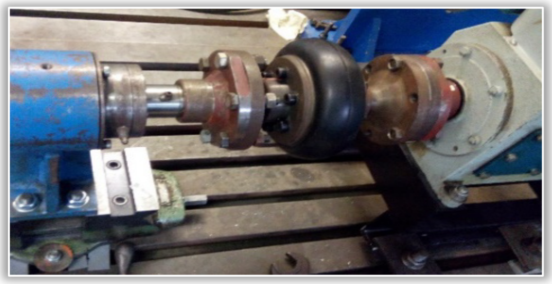
Figure 8. Mounted flexible Periflex shaft coupling in the test mechanical system

Figure 9. Hardy shaft coupling

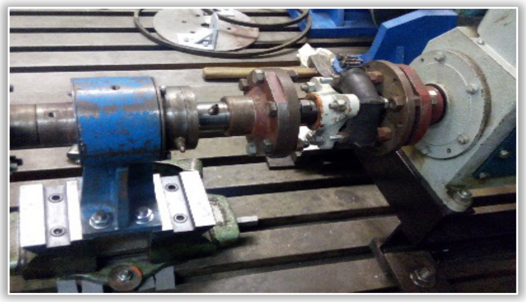

Figure 10. Mounted Hardy flexible shaft coupling in the test mechanical system

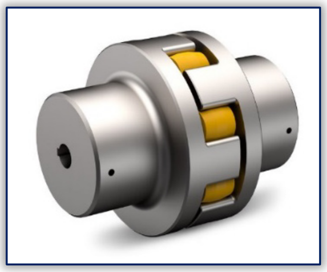

Figure 11. Toothed shaft coupling – Gurimax

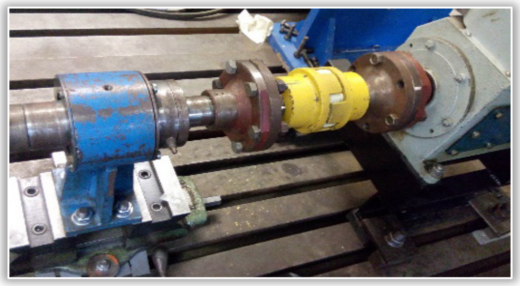

Figure 12. Mounted Gurimax flexible shaft coupling in the test mechanical system

The Gurimax coupling (Figure 11) provides a simple and efficient way to connect two shafts, it is also possible to connect a flange to the shaft. It is bland and will meet all requirements for overall length. The clutch insert enables easy assembly and disassembly of the entire clutch and cam ring. This clutch provides damping of torsional vibrations, noise reduction and electrical insulation. Compensation of angular, radial and axial assembly inaccuracy. The design of the clutch with two–part storage of the flexible element ensures easy assembly and disassembly without the need to relocate the drive. This clutch can transmit a large range of transmitted torques (from 750 Nm to 39000 Nm).

5. RESULTS OF EXPERIMENTAL MEASUREMENT

We carried out a series of measurements on the investigated mechanical system. We gradually changed the parameters in the mechanical system. The Periflex shaft coupling was the first to be used. The rotation speed varied from 200 rpm^{-1} to 1000 rpm^{-1}. Using the measuring device, we recorded in detail the vibration values listed in Table 1 and the noise values in Table 2. After performing a series of measurements, we replaced the Periflex coupling with a flexible Hardy coupling and repeated the measurements.

The Gurimax shaft coupling was the last coupling that was installed in the examined mechanical system. After performing these measurements, we recorded and compared the results.

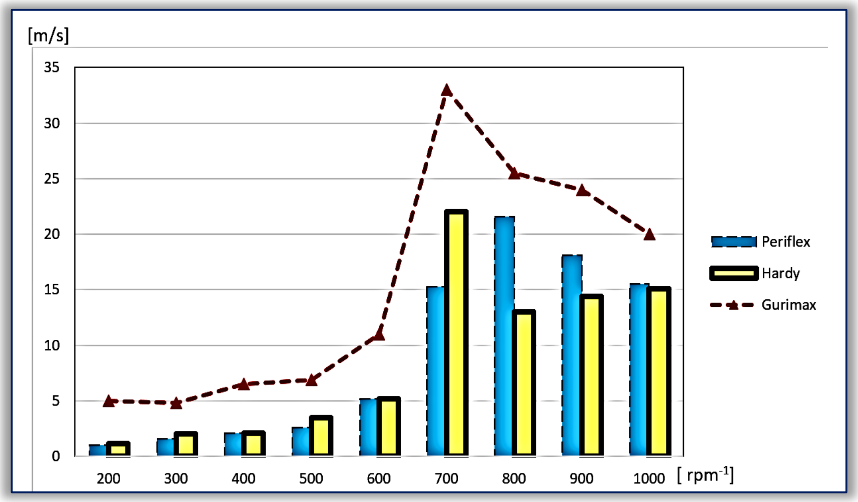

Figure 13. Vibration magnitude of the mechanical system when using Periflex, Hardy and Gurimax shaft couplings

Table 1. Vibration values of the mechanical system when using 3 shaft couplings

Vibrations [m/s]									
speed [rpm^{-1}]	200	300	400	500	600	700	800	900	1000
Periflex	1	1,6	2,1	2,6	5,2	15,3	21,6	18,1	15,5
Hardy	1,15	2	2,1	3,5	5,2	22	13	14,4	15,1
Gurimax	5	4,8	6,5	6,9	11	33	25,5	24	20

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In Figure 13 we can see that the lowest vibration values were achieved by the mechanical system with the use of the flexible shaft coupling Periflex. The vibrations reached the lowest value of 1 m/s at the lowest examined speed of 200 rpm^{-1} and the value gradually increased up to the maximum vibration value of 21.6 m/s at the speed of 800 rpm^{-1}. By further increasing the speed, the vibration value decreased to a value of 15.5 m/s, which it reached at a maximum speed of 1000 rpm^{-1}.

Similar values were achieved by the mechanical system when using the Hardy clutch. The vibrations reached the lowest value of 1.15 m/s at the lowest examined speed of 200 rpm^{-1} and the value gradually increased up to the maximum vibration value of 22 m/s at a speed of 700 rpm^{-1}. By further increasing the speed, the vibration value decreased to a value of 15.1 m/s, which it reached at a speed of 1000 rpm^{-1}. Higher vibration values were achieved by the mechanical system when using the Gurimax tooth clutch. The vibrations reached a value of 5 m/s at the lowest examined speed of 200 rpm^{-1} and the value gradually increased up to the maximum vibration value of 33 m/s at a speed of 700 rpm^{-1}. By further increasing the speed, the vibration value decreased to a value of 20 m/s, which it reached at a speed of 1000 rpm^{-1}.

Table 2. Noise values of the mechanical system when using 3 different shaft couplings

	noise [dB]								
speed [rpm^{-1}]	200	300	400	500	600	700	800	900	1000
Periflex	84,2	86,6	89,3	90,2	98,9	107	108,5	109,5	108,4
Hardy	85,6	91,2	89,3	92	97,2	115	107,9	104,2	106,9
Gurimax	98,7	97,1	100,1	102,7	106,9	127,4	113	127,7	112,2

In Figure 14 we can again see the noise values. It can be seen on the graph that the lowest noise values were achieved by the mechanical system with the use of the flexible Periflex shaft coupling.

The maximum noise value is 109.5 dB. This highest value was reached at 700 rpm^{-1}. Similar values were achieved by the mechanical system when using the Hardy clutch. The noise of the system with the use of this clutch reached a maximum value of 115 dB at a speed of 700 rpm^{-1}. The Hardy clutch and the Periflex clutch reached sub–par noise levels, which were mainly manifested at higher speeds of the mechanical system.

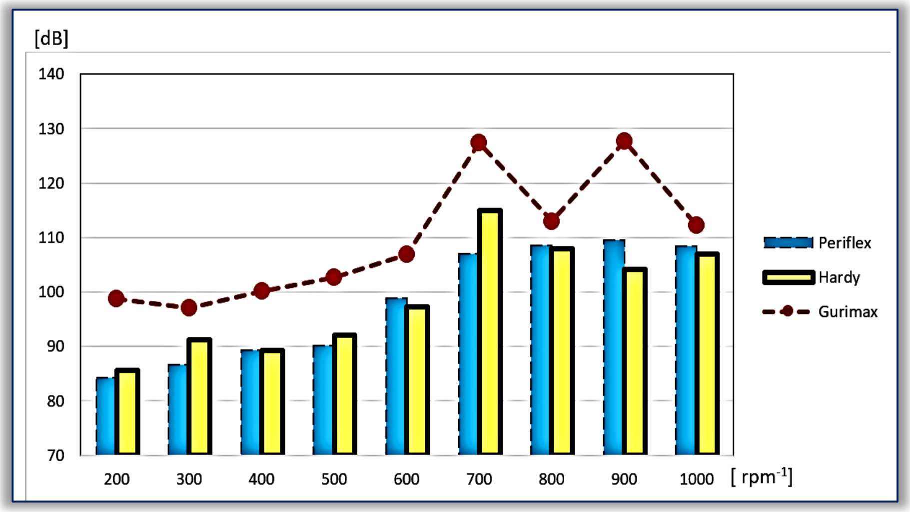

Figure 14. Mechanical system noise when using Periflex, Hardy and Gurimax shaft couplings

The mechanical system achieved the highest vibration values when using the Gurimax tooth clutch. Noise reached a value of up to 127.7 dB in the range of revolutions from 700 to 900 rpm^{-1}. It was visible on the graph and we even noticed this increase in noise even without devices.

6. CONCLUSIONS

This article investigates the noise and vibration of a mechanical system. The article carefully observes the effect of three shaft couplings on the noise and vibration of a mechanical system, which is similar to that of various transport equipment. Mechanical systems are used in such transport equipment and these have a great influence on the properties of the entire transport equipment. The described measurements are also performed on such a system.

One component in this mechanical system was gradually changed – the flexible shaft coupling, and we investigated how this coupling changes the noise and vibration values. We can conclude that the smallest vibration and noise values were exhibited by the mechanical system with the installed flexible

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Periflex coupling. This clutch was the most flexible and was able to reduce the noise and vibration values the best. Very similar vibration and noise values were achieved by the mechanical system also using the Hardy clutch, which had similar properties. The mechanical system achieved the highest noise and vibration values when using the Gurimax tooth clutch. The mechanical system reached the highest values of vibration and noise at 700 rpm^{-1}, when resonance occurred. When using the flexible shaft coupling Periflex, it was at a speed of 800 rpm^{-1}.

This means that by changing the properties of the mechanical system, i.e. by changing the properties of the clutch, we can change or shift the resonance area of various transport equipment and thereby improve working conditions. By reducing vibrations and noise, we can ensure better working conditions not only for the operator of the given equipment, but also extend the life of transport systems.

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