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OVERVIEW OF INSTALLATIONS AND METHODOLOGIES FOR CONVEYOR IDLERS TESTING – DEVELOPED AT THE FACULTY OF MECHANICAL ENGINEERING AT THE UNIVERSITY OF BELGRADE

Žarko Mišković[1a], Radivoje Mitrović[1b], Danilo Pejčić[1c], Jovana Antić[1d]

[1] Faculty of Mechanical Engineering, University of Belgrade, Kraljice Marije 16, 11120 Belgrade, Serbia
[1a] zmiskovic@mas.bg.ac.rs, 0000-0002-8320-7191
[1b] rmitrovic@mas.bg.ac.rs, 0000-0003-0513-6540
[1c] dpejcic@mas.bg.ac.rs, 0009-0007-1661-2924
[1d] jrantic@mas.bg.ac.rs, 0009-0002-6452-0294

Abstract
Many studies have demonstrated that a significant share of energy losses in thermal power plants comes from transportation systems – especially belt conveyors and their critical components: conveyor (carrying) idlers. Conveyor idlers are mechanical assemblies responsible for transferring the combined load of the conveyor belt and the transported material to the support frame. Among their components, rolling bearings are the most critical, often representing the primary cause of failure. Rolling bearings are machine elements that transfer loads from rotating to stationary parts while maintaining the necessary precision and stiffness between components in relative motion. Considering the vast number of conveyor idlers and built-in bearings used in surface coal mines – often numbering in the hundreds of thousands – even modest advancements in understanding underexplored phenomena, optimizing existing idler and bearing designs, or developing reliable laboratory testing methodologies and installations can lead to substantial energy and cost savings at both local and global levels. This paper focuses on these challenges, providing a comprehensive overview of specialized laboratory installations developed at the University of Belgrade – Faculty of Mechanical Engineering (UB FME), aimed at testing and improving the performance and reliability of conveyor idlers.

***Keywords**: Conveyor Idlers, Experimental Testing, Testing Methodologies*

1. INTRODUCTION

The efficient transport of bulk materials requires equipment capable of spanning long distances while minimizing both energy consumption and material losses. Since their widespread adoption in the late 19th century, belt conveyors have become the primary solution for handling bulk materials – especially in coal mining operations. Their cost-efficiency, straightforward design, adaptability to various terrains, and strong resistance to environmental contaminants [1] make them vastly superior to other transport methods, which are now rarely used in large-scale energy systems. Despite these advantages, belt conveyors are still being developed, especially when it comes to their key components: conveyor (carrying) idlers [2]. A conveyor idler is a mechanical assembly consisting of a bearing unit (typically a pair of rolling-element bearings, though other configurations may also be used), sealing components, a shaft, and a cylindrical shell. The primary role of the idler is to transfer the combined load of the conveyed material and the belt's own weight onto the conveyor frame. During operation, the idlers are in direct contact with the conveyor belt, which drives their rotation through friction—similar to the principle of friction-based power transmission, where the driving element is a continuously moving flat surface, and the driven component is a friction wheel. To meet the diverse functional requirements and accommodate various types of bulk materials, multiple types of conveyor idlers have been developed, but the most commonly used type in the open pit coal mines of the Republic of Serbia has dimensions of Ø194 x 750 mm.

1.1 Conveyor idlers standardized technical requirements

Within the European Union, the primary standard governing the specifications of conveyor idlers is DIN 22112 – Parts 1, 2, and 3 [3]. This standard is the basis for national regulations in both EU member states and non-member countries, including the Republic of Serbia. According to this standard, conveyor idlers are required to meet the following key technical requirements:

- Idler Body (Shell) Material - The idler body must be made exclusively from welded steel tubes. The material should be S235JR or a comparable easily weldable high-strength steel according to DIN EN 10025. The nominal wall thickness must be 4 mm, with an actual minimum wall thickness of 3,7 mm. When refurbishing used idlers, a minimum wall thickness of 3,0 mm is permitted.
- Bearings - The idlers must be equipped with deep groove ball bearings, classification R0, with radial clearance grade C4. The angular misalignment between the inner and outer rings under maximum load must not exceed 10 arc minutes.
- Lubrication - Lubrication must be provided by lithium-based greases filling 2/3 to 3/4 of the free volume within the built-in bearing. The grease must be resistant to aging and capable of preventing corrosion.
- Service Life - With appropriate bearing selection, lubrication, and sealing, the idler must achieve a minimum service life of 20,000 hours at an operating speed of 650 rpm.
- Rotational Resistance - Rotational resistance is defined by the peripheral force acting on the idler shell (contact area with the conveyor belt). Maximum allowable values depend on the idler diameter.

2. UB FME CAPACITIES FOR CONVEYOR IDLERS TESTING

The conveyor idler testing equipment developed at the University of Belgrade – Faculty of Mechanical Engineering (UB FME) enables the examination of all conveyor idler technical requirements defined by the DIN 22112 standard and outlined in the previous chapter. Original experimental testing methodologies have been defined for the custom-developed test rigs, while standardized testing of rolling bearings' characteristics is conducted using certified equipment within the Laboratory for Testing of Machine Elements and Systems – LIMES.

2.1 Standardized rolling bearings testing methodologies

The standardized testing of rolling bearings installed in conveyor idlers is carried out in the LIMES Laboratory (within UB FME), using specialized equipment that is routinely maintained and calibrated to ensure accuracy. Established in 2002, since the year of 2008, LIMES has been accredited for the testing of bearings dimensions, radial clearance, vibration levels, and material hardness (accreditation number: 01-304), in accordance with the standards listed in Table 1. The laboratory team comprises five Ph.D. and two M.Sc. mechanical engineers, as well as one technician, all actively involved in the testing and research processes.

Table 1. Standardized rolling bearings testing methodologies – Laboratory LIMES 2025

Characteristic	Standard
Bearing inner diameter tolerances – d Bearing outer diameter tolerances – D Bearing radial clearance – C	SRPS ISO 1132-2:2017
Bearing vibration in the frequency ranges: 100–300 Hz, 301–1800 Hz, 1801–10000 Hz	SRPS ISO 15242-1,2,3:2018
Bearing ring hardness measured by Rockwell C method	SRPS EN ISO 6508-1:2024

2.2 Original conveyor idlers testing installations and methodologies

The experimental determination of the service life of conveyor idlers involves subjecting the idlers to various levels of maximum loads until failure occurs - i.e., until the allowable vibration or bearing temperature limit is exceeded - under unidirectional bending fatigue. The testing is conducted on a custom-built test frame developed at the UB FME, with its components and overall look shown in Figure 1. A specially developed testing methodology is employed for this purpose, which also enables measurement of rotational resistance at different rotational speeds. Also, an additional test frame was developed for evaluating the quality of the conveyor idlers sealing groups.

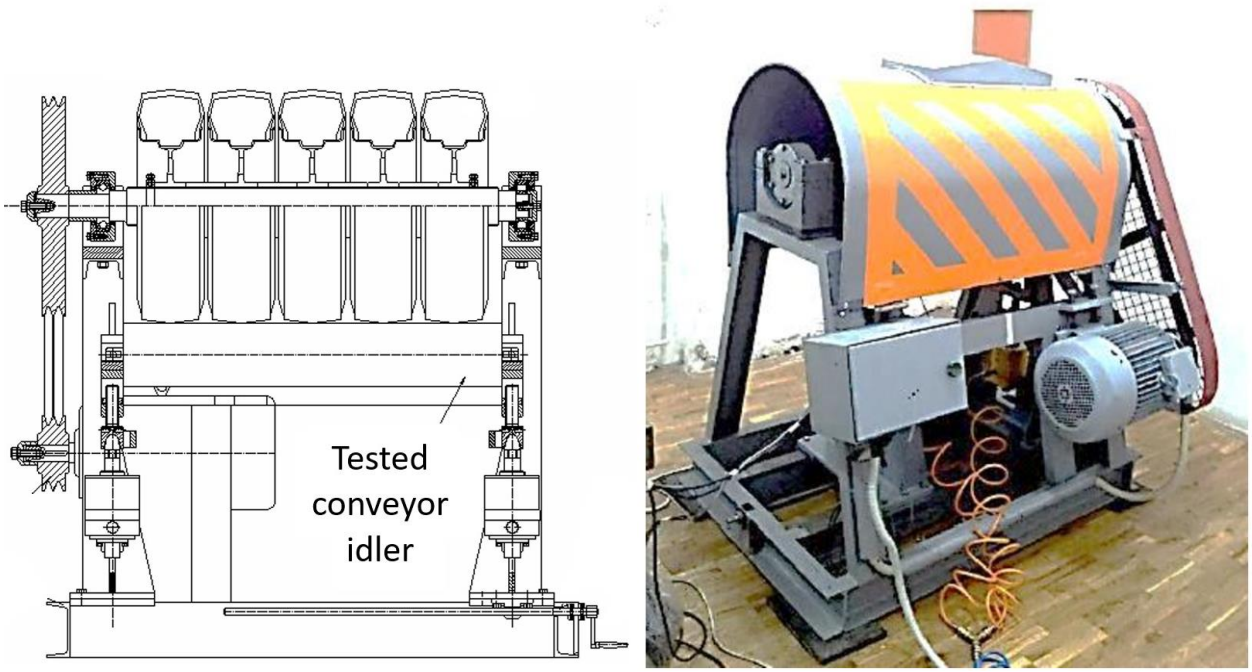

Figure 1. Original conveyor idler test frame developed at the University of Belgrade – Faculty of Mechanical Engineering

3. EXAMPLE PERFORMANCE TESTING RESULTS OF CONVEYOR IDLERS - WITH DISCUSSION

Figures 2 and 3 shows the performance testing results of conveyor idlers Ø194 x 750 mm produced by three well-known manufacturers from Serbia, during the 10hrs long testing.

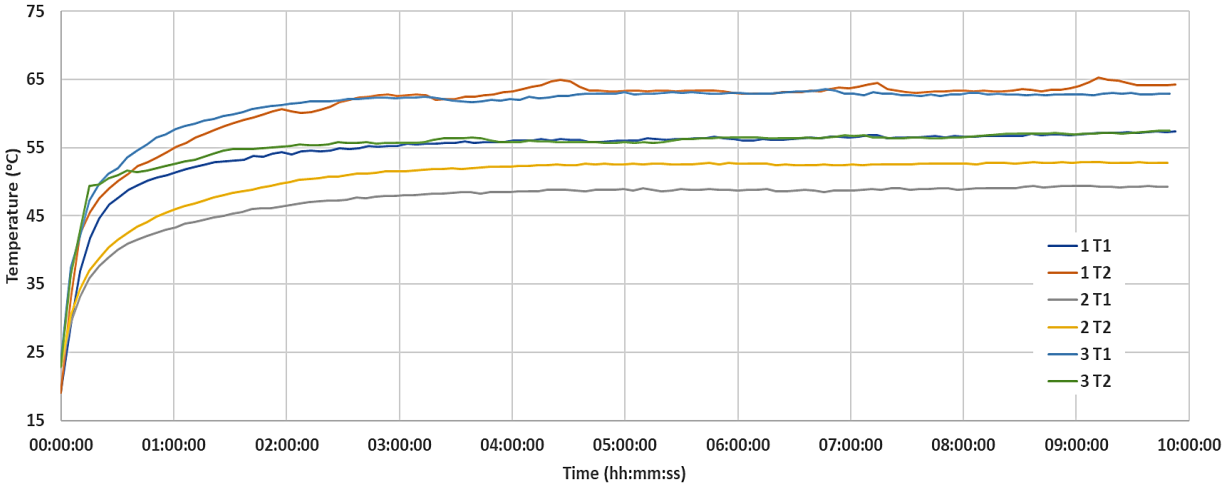

Figure 2. Measured bearing temperatures of Ø194 x 750 mm conveyor idlers – during 10hrs of testing

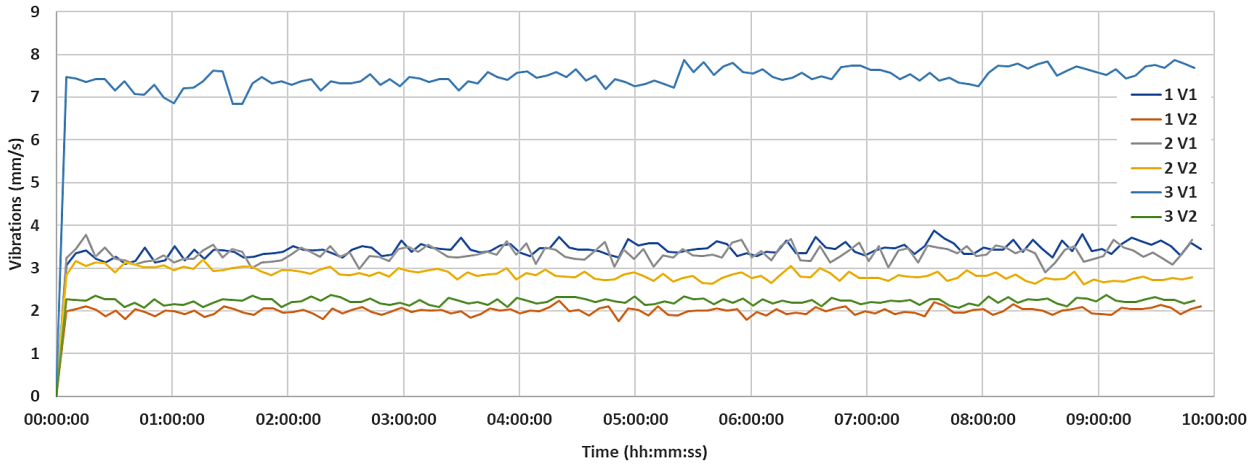

Figure 3. Measured bearing vibrations of Ø194 x 750 mm conveyor idlers – during 10hrs of testing

Based on the results presented in Figures 2 and 3, it can be concluded that the bearing temperatures of conveyor idlers from Manufacturers 1 and 3 are higher than those of the idler from Manufacturer 2. In terms of vibration levels, one bearing of the idler from Manufacturer 1 exhibits the lowest vibration among all measured values, while the vibration at the second bearing position is lower than that measured on the idler from Manufacturer 3. The vibration levels of the bearings in the idler from Manufacturer 2 fall between the values recorded for Manufacturers 1 and 3. This aligns with the temperature measurement findings, confirming that the conveyor idler from Manufacturer 2 exhibit the best characteristics.

4. CONCLUSIONS

Testing the performance of conveyor idlers is essential because these assemblies play a vital role in the performance, reliability, and energy efficiency of belt conveyor systems [4]. High-quality idlers reduce friction, prevent excessive wear on the conveyor belt, and contribute to smooth, uninterrupted operation. Through comprehensive testing, manufacturers can evaluate design integrity, verify material properties, and optimize key elements such as bearings and sealing systems. This process ensures compliance with international standards, improves operational safety, and significantly extends the service life of both idlers and conveyor belts. In large-scale applications – such as mining and energy production – regular testing helps reduce maintenance costs, minimize downtime, and achieve substantial energy and financial savings. The importance of laboratory testing of conveyor idlers performance – using original equipment and methodologies developed at the UB FME – has been recognized by the leading conveyor idlers manufacturers in the Republic of Serbia: Kolubara Metal, Ansal Steel, and PRIM Kostolac. As a result, these companies periodically send their conveyor idlers to the UB FME for testing, in order to verify the quality of their products and ensure the reliability of their manufacturing processes.

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