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Lathe machining in the era of Industry 4.0: Remanufactured lathe with integrated measurement system for CNC generation of the rolling surfaces for railway wheels

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Abstract. Many projects and researches in the field of remanufacturing of specialized lathes are presented in the specialized literature. In the process of design for remanufacturing, a great number of solutions contain different aspects and data important to consider. The paper presents important stages of theoretical and applied research regarding the modernization of a conventional lathe with two working units by adaptation of four driving chains for CNC advance/positioning movements and improvements of translation couplings, adaptation of CNC equipment for driving and measuring simultaneous both wheels mounted on axle. The reducing of geometrical errors of the running profile is very important in reshaping the worn wheelsets. The lathe remanufacturing process involves the restoration of functional requirements and measurement of the geometric precision. The CNC capabilities of the remanufactured lathe require a database of parametric representation of profiles and rolling surfaces using CAD techniques according to international standards.

Keywords: Railway wheel profile, CNC lathe remanufacturing, Rolling surface reshaping, Wheelset.

1 Introduction

Future industry relies on new design concepts and methods, data acquisition, processing, visualization, automation and manufacturing technologies [1]. Industry 4.0, a term coined by the German Government, is to undertake the challenges in integrating technologies like Cyber-Physical Systems, the Internet of Things, and the Internet of Services to advance improvements in industry as shown in figure 1. One of the main identified challenges is lack of adequate skill-sets and human resources to expedite the march towards industrial 4.0.

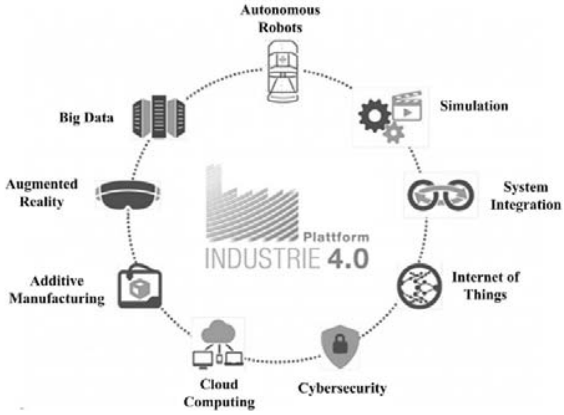

Fig. 1. Primary technologies of the new industrial paradigm – Industry 4.0

The lathes for processing the wheels and wheelsets of the railway vehicles are diversified and modernized in accordance with the requirements of railway transport standards and norms in the field. During the operation of the railway vehicle, the contact surfaces between the wheels and rail become worn [2]. This wear lead to changes in wheel and rail profile, contact surface and, consequently, to instability in the movement of vehicles. Therefore, the maintenance and repair of the rolling stock are important for traffic safety and passenger comfort [3, 4].

The wheelsets are the most loaded components of railway vehicles. They are subject of a continuous process of wearing according to difficult running conditions: non-uniform loads, alteration of rail and wheel profile, temperature variations, curved paths, sudden changes of speed, breakings, etc. In the moment that the wheels reach a critical level of wear, they must be reshaped or replaced, when the material to be removed by cutting exceeds a certain limit. Using wheels with appropriate profile reduce the risk of derailment and minimizes the dynamic interaction between the vehicle and the track, reducing noise, vibration and wear [5]. The researches in the domain of rail transport focus on increasing the reliability of the rolling stock and traffic safety, operating costs reduction, improvements of the manufacturing technologies, control, maintenance management, reduction of noise and wear in operation [6].

The main requirement of this approach is the profile processing and maintaining the contact surfaces of wheels and rails within geometric and functional parameters. Profiling and re-profiling of wheels are performed by technological processes on specialized lathes. Due to the high cost for acquisition of such a modern new machine tool, the manufacturers often have an option for the remanufacturing [7] of an existing machine tool. Thus, there is a need for development and implementation of an automated equipment for simulation, manufacturing and measuring of wheels running profile, both static and dynamic by adding driving, command and measurement systems. The remanufacturing costs are soon recovered by increasing the productivity and profiling/ re-profiling accuracy. Also, the life of the lathe is highly increased.

2 Initial setup: structure of the technological system

The analyzed technological system is composed of: a Polish machine tool UBC 150 RAFAMET lathe [8], modern measurement equipment, certain turning tools [9, 10] for this type of machine tool, CNC equipment, clamping devices, etc. A representation of the remanufactured lathe as it will be in the end of the project is done in figure 2 using a scheme of rotational and translational couplings that ensure the generation and auxiliary trajectories. The lathe processes the rolling surfaces of the wheelset in a single clamping, having two working units. Each one of these units has in its structure two radial sledges, a longitudinal sledge and a transversal sledge [11].

The two working units WU1 and WU2 have identical structures and driving systems. Their role, from the point of view of generating the running surfaces of the wheelset (WS), consist of movement B11, B12 and C1 for unit WU1, respectively, B21, B22 and C2 for unit WU2. Involving of wheelset in a cutting movement A (n_c) at both ends of the axle is ensured by two electric motors ME1, respectively ME2. The main spindles MS1 and MS2 using the clamping and fixing devices CD1, respectively CD2, provides driving rotational movement of the axle. The positioning movement is performed and controlled by CNC equipment on +Z and -Z directions, to determine the reference position depending on which they will be performed the movements for simultaneous processing of running profiles.

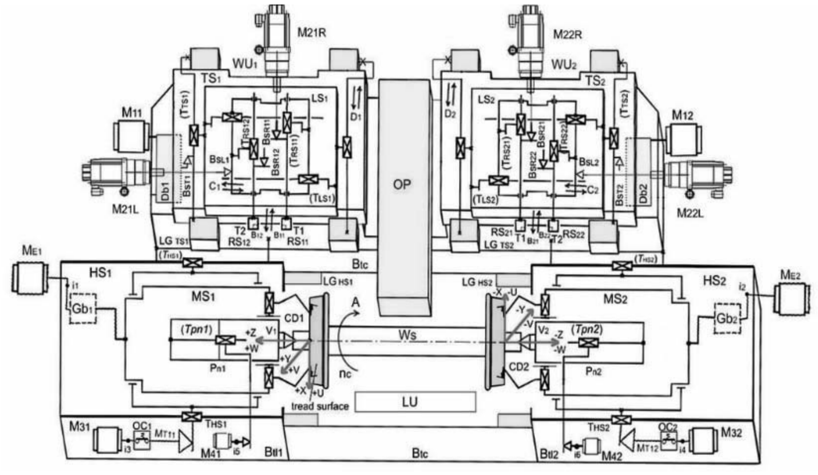

Fig. 2. Structure of the UB 150 RAFAMET lathe: A – main cutting motion, B1, B2 – advance radial motions and positioning, Bg – bearing, Bs – ball screws (L-longitudinal, T-transversal, R-radial), Btc – central bed, Btl – lateral beds, C1, C2 – advance longitudinal motions and positioning, CD – clamping devices, D1, D2 - transversal positioning, Db - distribution box, Gb