TECHNOLOGICAL SYSTEM FOR PROFILING/ RE-PROFILING RAILWAY WHEEL SETS

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Abstract: This paper presents some considerations on the development of a technological system for profiling/ re-profiling and measurement the profile of the railway wheel sets in order to improve maintenance and security of railway transport. Lathes for reshaping the wheels and wheel sets of the railway vehicles are diversified and modernized in accordance with the requirements of railway transport. The paper presents some considerations on modernization of a conventional lathe with two working units by adaptation of CNC equipment for driving and measuring simultaneous both wheels on an axle. On radial sledge of each working units, on which are mounted the profiling tools, in the immediate proximity of them, are placed the measurement systems in order to determine the axial position of lateral internal faces of the wheels, the diameters of the wheels and the main geometrical parameters of the rolling profiles. The measurements are done before re-profiling to determine the wear of the profile and choice the diameter and the profile of the wheels after reshaping and after processing, to determine the conformance with specifications.

Keywords: railway wheel sets, wheel lathing, railway wheel profile, wheel wear

1. Introduction

Improving the safety and security of transport and reducing the negative effect on the environment has been a major objective in the last decades, due to the rapidly increasing needs of freight and passenger transport and due to the reversible relation between human and nature, as well as health and traffic.

Especially, the high-speed train requires careful consideration of the problems related to the contact between wheel and track. Worldwide there is an intense concern for the development of high-speed railway transport as an advantageous alternative to the road and even air transport, in terms of traffic safety, transport capacity, energy consumption and environmental protection [1].

The performance of rolling stock maintenance will have a great influence on transport safety and passengers comfort. A key element in the maintenance of the rolling stock is the re-profiling of the wheel sets.

The reasons for re-profiling wheels are [2]:
- Corrective maintenance: keeping the safety limits according to standards; removing the wheel defects and wear;
- Conditional maintenance: optimization the re-profiling interval determined by research; removing wheel defects at the beginning; minimization of components stress; noise reduction; improve the wheel life time.

Three major aspects require special attention in wheel re-profiling process:
- choosing the appropriate profile
- framing prescribed tolerances
- compliance with surface quality.

The importance of improving the wheel sets re-profiling technology results not only from the need to reduce maintenance costs, but also from the need to enable modern high speed trains to use their potential under conditions of reliability and safety of transport.

Unfortunately in most railway workshops from our country and from many other countries, for turning the profiles of the train wheels are used machine tools manufactured as far back as the ’60-’70 years. Their performance no longer meets current requirements of precision and productivity [8]. Purchase and installation of new modern machines is too expensive for these workshops. By using modern electronics and software technology these machines can be modernized and automated with lower costs. CNC technology provides opportunity for retrofitting and automation the existing lathes used by railway maintenance workshops for re-profiling wheel sets. Implementation of CNC offer a number of new possibilities including improving wheel running profile measurement, maintaining a database with measured profiles and with normalized profiles, wheel profile optimization, intelligent machining cycles and simplified operator interface.

The technological measurement and manufacturing system presented in this paper, includes: wheel profile and diameter measurement before and after machining; a CNC system with 4 translation axis integrated in structure of a horizontal lathe type UB 150 - RAFAMET-Poland, with two working units, for driving and control of reshaping and measurement processes; intelligent machining cycles for wheel turning and measurement.
2. Original machine-tools structure

In our days it is very important for companies to understand the present state of the manufacturing systems and to take appropriate measures for maintaining firm’s competitiveness.

Modern manufacturing systems require machine-tools and control systems that are open architecture and flexible to be easy reconfigurable and adjusted as required by the production process.

Rebuilding, modernisation or maintenance of the old classical machines, especially the large and expensive ones, is an option considered by more and more manufacturers. These actions include the repair or replacement of some worn mechanical components such as leading screws, linear guides, bearings, pneumatic, hydraulic and electrical systems. But most important benefits are made by introducing the numerical control in the machine tool structure and upgrading the driving systems to a high-speed, digital interface.

This paper presents some of the preliminary stages of our applied research on modernization of the conventional lathe with two working units.

UBC 150 RAFAMET abovefloor horizontal lathe [6] is a machine tool, with two working units, for processing the running surfaces of both train wheels on an axle, in a single clamping (figure 1).

Each unit has in its structure two radial sledges (RS11, RS12, respectively RS21, RS22), a longitudinal sledge (LS1 and LS2) and a transversal sledge (TS1 and TS2) that support the other sledges and are doing the positioning movement when the wheel sets diameters range is changed.

The movements for wheels running profile manufacturing and tools positioning are driven as follows: in advance movement with an electric motor with variable speed and in positioning movement with a constant speed motor.

Function of reversal movement is achieved by an inverting mechanism with gear and electromagnetic coupling [6]. The wheel set is driven in rotation simultaneously at both ends by two rotating clamping devices. The cutting tools are mounted on radial sledges. For shaping the running surfaces of wheels, for each radial sledge is used a electro-mechanical copying system (EMC, figure 1 b. and c.), port program being open contour metal templates (T, figure 1 c.) [6].

The main disadvantage of this operating system is that for each profile is necessary a template and tool initial position adjustment.

This is made manually, requiring a long time that is reflected in a reduced productivity.

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Fig. 1 Lathe structure

a. Frontal view; b., c. electro-mechanic profile copying system; d. schematic diagram of wheel reshaping lathe

WU1, WU2 - working units; B – the bed of the lathe; BTHS1, BTHS2 - beds of headstocks; HS1, HS2 – headstocks; Pn1, Pn2 – tailstocks; CL1, CL2 – clamping systems; LS1, LS2 – longitudinal sledges; LGL1, LGL2 – linear guides of longitudinal sledges; TS1, TS2 – transversal sledges; LGT1, LGT2 – linear guides of transversal sledges; RS11, RS12, RS21, RS22 – radial sledges; LGR1, LGR2 – linear guides of radial sledges; EMC - electro-mechanic copying system
3. The structure of the lathe after modernization

Modernisation of this lathe consist in adaptation of four kinematic chains for CNC advance/positioning and improvements of translation couplings, adaptation of CNC equipment for manufacturing and measuring simultaneous both wheels mounted on axle, reducing of geometric errors of running profile processing [4]. The modernization process also involves replacement or reconditioning of some mechanical components (guides, leading screws, bearings) [4] and development a wheel profile measurement system for determining the wear before reshaping and initial position of reshaping tools and verify the conformity of wheels after processing. Introducing the CNC control for moving on processing directions (X and Z axes - Figure 1 d.) has the following advantages:

- increasing the flexibility of operations, machine settings being fast changed for a new wheel sets type manufacturing;
- removing the need for a large number of templates, expensive and difficult to make;
- operating program is built in the software, not in hardware like in conventional machines; numerical programs can be modified easily to switch from one profile to another;
- higher accuracy by eliminating the adjustment errors made by the operator;
- higher productivity due process automation, including wheel running profile measurement before and after reshaping.

The proposed structure of the lathe after modernization is presented in figure 2.

![Fig. 2 Structure of the automation lathe](image)

**Fig. 2 Structure of the automation lathe**

MP1, MP2 – spindle driving motors; SE - spindle encoder; WU1, WU2 - working units; T1, T2 - reshaping tools; MS1, MS2 - measurement heads; ML1, ML2 – motors for longitudinal sledges movement; MR1, MR2 – motors for radial sledges movement; RS11, RS12, RS21, RS22 – radial sledges; LS1, LS2 – longitudinal sledges; LSLS1, LSLS2 – linear incremental scales for longitudinal sledges position measurement; LSRSL1, LSRSL2 – linear incremental scales for radial sledges (RS11, RS21) position measurement; Gb – gearboxes; Bg – bearings; BSLS1, BSLS2 – ball screws for longitudinal sledges; BSRSL1, BSRSL2 – ball screws for radial sledges; PS - power supply; PLC+MC – CNC system; DC1, DC2 - Drive control systems; PC – Operator panel communication (operating, programming, visualisation)

4. Measurement and manufacturing process

For railway transportation safety, wheels profile and diameter have to be inspected regularly. For these inspection operations there were developed a series of measurement and control gauges and equipments. But wheels geometry measurement is also part of the reshaping operation. Measurement must be done before and after turning.

Past practice in wheel measurement before and after turning involved manual measurements. These measurements may introduce human errors [3] because of the incorrect placement of measuring instrument, wrong reading of measuring instrument, imprecise measuring instrument.

Many gauges were developed for measurement of wheel parameters. They allow only discrete values measurement, not of entire tread profile (figure 3).
Unfortunately, these gauges are still widely used in rolling stock maintenance workshops, even when reshaping is done on CNC machines.

In recent years, there were developed various automated wheel measurement systems. They have the following advantages [3]: safety – remove operator; economical - efficient method of data collection; accuracy - measuring capability exceeds human capability and measurements are consistent with drives quality; wide range of capabilities. With such systems, wheels profile measurement is generally performed by acquiring polar or cartesian coordinates of a number of points on wheels profile, in a section, with contact or non contact measuring elements. These coordinates are transmitted in digital format to a computer for processing, interpretation, display and storage.

Coordinate systems of the scanning elements for the two wheels are coplanar, but displaced to each other and sometimes rotated.

The relative positions of these coordinate systems affect the accuracy of measurements. If the measurement is done outside the manufacturing machine-tool, it is possible to determine the characteristics of the measured profiles, but it is not possible to determine wheel set position in the coordinate system of the machine-tool.

For wheels profiling more efficient it is preferably for the measurement systems to be mounted on the machine tool and to have the same coordinate system with tools. By positioning of two measuring heads on the radial sledges in the near proximity of the tools, the axial position of the lateral faces, the diameter of the wheels and the wear of both wheels on an axle profiles are determined in the reference system of the reshaping tool.

Both measurement heads and tools are displaced by the same driving systems, directly governed by the numerical control unit of the machine tools. In this way machining is more efficient and accurate. Wide range of programming possibilities guarantee easy adapting of the turning process to dimensions and profile of the wheels. The axial position of the lateral faces of the wheel, the running diameter and the geometrical parameters of the profiles of both wheels on an axle are determined before reshaping, to choose appropriate profile to be reshaped and determine the starting point for turning process, and after reshaping to determine the conformity of reshaped wheels to specifications.

The diagram for reshaping and measurement process is presented in figure 4.

The measurement system allows measuring of the geometrical parameters simultaneously for both wheels mounted on an axle.
Fig. 5. Measured parameters

Measured parameters are according to figure 5:
- Wheels rolling diameter (D) (700 – 1500 mm);
- Profile specific parameters and their measurement range: flange height (Sh) (22 to 37 mm); flange width (Sd) (20 to 35 mm); flange gradient (qr) (6 to 11 mm); total profile width (Lr) (130 to 145 mm); profile wear on rolling diameter (A);
- Back to back distance L (1356 to 1364 mm);
- Wheel full profile;
- Out of roundness (ovality) and undulations wear of running profile, and axial run-out of lateral faces.

Fig. 6. Wheel parameters measurement system

Fig. 7 Measurement process
Measurement of internal frontal faces and axial run out
Measurement of flange height
Measurement of flange angle and thickness
Measurement of running diameter and out of roundness
Measurement of wheels width
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5. Conclusion

Development of CNC technology made it possible to optimize the turning process of railway wheels in manufacturing, repair and maintenance workshops for rolling stock rolling. From operator point of view the work is easier because many of the options are automatically selected. Using appropriate CNC modules enable the machine - tools to cut the selected profile according to a set of coordinates. Spindle speed and cutting parameters are easily programmable and adjustments are made by simple tool correction.

Integrating into the structure of machine-tools modules for both wheels simultaneous measurement, before and after turning, manufacturing processing becomes more precise and efficient.

In this paper we present some considerations regarding modernization of a lathe for wheel sets profiling/re-profiling. The original lathe is equipped with an electro-mechanic profile copying system consisting of a metal template and a follower that opens and closes valves that control the tooling profile. The mechanical nature of this system makes wear inevitable, for each profile need another template. Adjustments on the template mechanism require skill and a considerable amount of time.

The new solution has significant benefits. Part measurement is faster, more accurate and gives a complete profile instead of discrete points. The machining is better optimized with significant costs savings.

Acknowledgement

This technological system is developed under Partnerships in Priority Areas Programme - PNII supported by MEN-UEFISCDI, in the project PN II-PT-PCCA-2013-4-1681 – “Mechatronic system for measuring the wheel profile of the rail transport vehicles, in order to optimize the reshaping on CNC machine tools and increase the traffic safety”.

The work of Ghionea Ionuţ has been supported by the Sectorial Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/S/138963

6. References


