Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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*Annals of DAAAM International*

# RESEARCH ON THE IMPROVEMENT OF RAILWAY TRUCK AXLES MACHINING

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***Abstract:*** *This paper presents several ways to increase machine cutting performances in order to establish the most suitable ways for machining railway carriage axles. We analyse in what follows the Ultrasonically Assisted Machining, Low Frequency Vibrations Assisted Machining, Plasma Assisted Machining, Micro-Plasma Assisted Machining, High Pressure Jet Assisted Machining, Cryogenic Assisted Machining. Simultaneously, we have been performing experimental research regarding axle machining on numerical control lathes.*
***Key words:*** *Mounted axle; assisted cutting, experimental research*

## 1. INTRODUCTION

Railway axle machining is a specific technical domain with significant effects on railway traffic safety (Talambă & Stoica, 2005). Due to continuous increase of passenger safety demands, researchers working in this domain are continuously in quest for new solutions of machining technology improvement and increase of product quality, which requires new research focusing on high efficiency production processes.

This work identifies and describes the main ways of increasing the performance of machining by cutting and identifies also those that are mostly adequate for railway machining. Also the author presents the most important aspects of several experimental research works on axle machining on numerical control lathes. Further research will be carried out, to improve the mathematical and experimental modelling of the process in view of optimizing the railway axle machining by cutting, either assisted or not-assisted by different power sources.

## 2. AXLE MACHINING ISSUES

The mounted axle is a revolving body, the axis of which must coincide with the longitudinal geometric axis of the axle. Before mounting, the axle and wheels must be checked for adequacy with the requirements of technical documentation, such as: surface roughness, correct hardness, lubricant quality, tightness, pairing of wheels and identity marking of axle and wheels. Roughness parameter Ra of finite surfaces and ready to be assembled must comply with the producer drawing of mono-block wheel. Railway axles are machined by cutting on numerical control lathes. The axle machining technology shows a series of different features as compared to the machining technology of smaller dimension shafts (Pruteanu, 2005).

After forging, the axles are subject to annealing and baking treatment. Next, there are performed the material quality control, centring on a drilling machine and horizontal bore and cutting. Axle boring is performed on numerical control large lathes with large distance between peaks, relatively high power lathes (Talambă & Stoica, 2005). Axles are marked with the order and batch number.

The most important specified requirements include the achievement of cone bore axis co-axiality with the axle rotation axis, as well as perpendicularity of end surface of shaft as against its rotation axis. The mono-block wheels are machined on numerical control turning lathes.

This currently applied technology today can be made more efficient in two ways: by applying in different phases the assisted cutting of several power forms or by extending the research for the increase of performances and improvement of not-assisted machine cutting on numerical control lathes.

## 3. ANALYSIS OF SEVERAL MACHINE CUTTING PROCESSES ASSISTED BY DIFFERENT POWER SOURCES

For the machining optimization of railway axles there were performed extensive research to determine several ways of raising the performance of machine cutting processes by supply of exterior power, such as: Ultrasonically Assisted Machining – USAM (Ionescu, 1999); Low Frequency Vibrations Assisted Machining – LFVAM (Ionescu, 1999); Plasma Assisted Machining – PAM (Popa, 1997); Micro-Plasma Assisted Machining – MPAM (Paun, 1998); High Pressure Jet Assisted Machining – HPJAM (Vişan et all., 1999); Cryogenic Assisted Machining – CAM (Ionescu, 1999).

Improvement solutions of railway trucks axles machining mainly rely on achievements of the authors.

| Procedure | Specific parameters |
|---|---|
| USAM | Frequency f = 20 kHz; amplitude a = 5 …25 µm; Finishing regimes for cutting, drilling, boring, etc.; vibrations applied after principal cutting force direction |
| LFVAM | Vibrations can be classified according to their generation: mechanical, electrical-hydraulic and electromagnetic; the turning rate must be correlated with the frequency (odd number of oscillations per rotation); Frequencies in the domain of hundred Hz; Amplitudes in the domain of several micrometer scores |
| PAM | Power 20 kW; idle run voltage $U_o$ = 60 V DC; arc intensity about 320 A; plasma gas flow rate 10 to 12 l/min.; Diameter of plasma generator nozzle 4.5 to 5.5 mm.; Distance nozzle to part 8 to 10 mm.; Minimum cooling water 8 l/min.; Cooling water pressure 3.5 to 5.5 bar |
| MPAM | Diameter of plasma generator nozzle 0.1 to 0.2 mm.; arc intensity: 1 to 7 A for thickness of 0.3 mm; voltage 45 V; plasma gas: argon; plasma gas pressure: 0.09 to 0.22 MPa; protection gas: Argon + 7%$H_2$; 4l/min. |
| HPJAM | • Pressure p = 80 to 400 bar, most frequently about 100 bar; flow rate 8 to 10 l/min; liquid velocity in the cutting area of over 100 m/sec; |
| CAM | Liquid nitrogen cooling down to – 196 $^oC$; applicable in principal to turning and drilling |

Tab. 1. Specific parameters of machine cutting assisted by different power forms

The summary tables 1 and 2 show the results of this study, while focusing for each of the above mentioned methods, on relevant aspects, such as: principal specific parameters, accuracy of dimensions, accuracy of macro-geometry and micro-geometry, precision of the relative position, advantages, as well as disadvantages and limitations.

| Procedure | Technological characteristics/accuracy |
|---|---|
| USAM | • D*imensions accuracy*: very good, IT2 to IT6;<br>• F*orm accuracy*: circularity and cylindricity, classes IV to V<br>• *Roughness*: Turning - Ra = 0.6 to 3.2 µm; Drilling - Ra = 0.8 to 3.2 µm; Boring - Ra = 0.4 to 1.6 µm;<br>• *Other technical characteristics*: lower cutting forces; increase of fatigue resistance, increase of corrosion resistance, finishing and super-finishing, cutting depth is limited by the power of ultra-acoustic chain; difficulties in tuning on resonance frequency |
| LFVAM | • D*imensions accuracy*: relatively good, IT5 to IT7<br>• F*orm accuracy*: circularity and cylindricity, classes V to VI<br>• *Roughness*: Ra = 1.6 to 6.3 µm;<br>• *Relative position***:** significant reduction of deviation from straight line in drilling;<br>• *Other technical characteristics*: reduction of burr by 95 %; efficient for drilling only |
| PAM | • D*imensions accuracy*: low for all types of machining;<br>• F*orm accuracy*: low for all procedures;<br>• *Roughness*: high<br>• *Other technical characteristics*: used in machining of hardly machinable materials, high output; allows for intensification of cutting regime; significant reduction of cutting forces (45 to 50%,); structural changes and induction of thermal stress in material; only used for rough cutting regimes |
| MPAM | • D*imensions accuracy*: relatively good<br>• F*orm accuracy*: relatively good (better than PAM)<br>• *Roughness*: Relatively good (better than PAM)<br>• *Other technical characteristics*: efficient machining of medium and small parts of hard material, with the possibility to intensify the cutting regimes; reduction of cutting forces; semi-finishing regimes |
| HPJAM | • *Dimensions accuracy*: very good, IT5 to IT7;<br>• *Form accuracy*: circularity and cylindricity classes IV to V;<br>• *Roughness*: Turning - Ra = 0.6 to 3.2 µm; Drilling - Ra = 0.2 to 1.6 µm;<br>• *Relative position***:** Significant reduction of deviation from straight line in deep drilling;<br>• *Other technical characteristics*: Significant reduction of cutting forces; avoid dysfunction of chips removal; increase of tools service life; intensified cutting regime; reduction of working time by 50 to 75% as compared to normal machining |
| CAM | • *Dimensions accuracy*: Relatively good;<br>• *Roughness*: Turning - Ra = 0.5 to 6 µm; Drilling - Ra = 1.6 to 6.3 µm;<br>• *Other technical characteristics*: doubling of tools service life; increase of surface fatigue resistance. |

Tab. 2. Technological characteristics of machine cutting assisted by different power forms

As well known, the specialist publications provide only a few data relating to relative position accuracy, which leads us to the idea that in case of applying one of these processes in machining railway axles, where the relative position precision plays and important part, additional research is required. Based on the analysis of data shown in tables 1 and 2, it has been assumed that in the case of railway axle machining, special attention must be paid to machine cutting assisted by high pressure jet of cooling liquid.

This process implies minimum funding, as the high pressure pump is easy to provide, while tools are available with from various suppliers, such as interior channel drills for injection of liquid in drilling area, or can easily be achieved by adjustment of standard tools, for the cutting bits. The precision characteristics and advantages of this process are very good and are considered to be adequate for machining of mounted railway axles.

In parallel to this theoretical research, the authors have been engaged in experimental research regarding the cutting of axles on Doosan numerical control lathes, to determine the process function “Surface roughness”. The authors prepared a factorial experimental programme with three independent variables: feed $s$, speed $v$ and cutting depth $t$, with three levels of variation. The authors performed 12 experiments of which 4 identical. After preliminary data processing it has been noticed a deviation from cylindricity of 3 µm, while the smallest roughness value $Ra$ = 0.69 µm was registered for $s$ = 0.125; $v$ = 230 m/min and $t$ = 0.5 mm.

## 4. CONCLUSIONS

A solution for the increase of machine cutting performances on railway axles implies also processes with additional exterior power. This article focuses on the study of machine cutting assisted by ultrasonic vibrations, cutting assisted by low frequency vibrations, plasma assisted cutting, micro-plasma assisted cutting, high pressure liquid jet cutting and cryogenic cutting. The results that were obtained by applying these processes are presented comparatively with machining on numerical control lathes based on experimental research prepared by the authors.

The limitations of this research work consist in its applicability only for train truck axle machining.

Research will be enlarged by mathematical and experimental modelling of the process based on the data obtained and determining process functions in view of optimizing railway axle machining.

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