Publishing House
AKAPIT

COMPUTER METHODS IN MATERIALS SCIENCE
Informatyka w Technologii Materiałów

Vol. 9, 2009, No. 2

COMPUTER MEASUREMENT SYSTEMS IN RESEARCH OF NON-CONVENTIONAL METAL FORMING PROCESSES

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Abstract

Severe Plastic Deformation processes are one of the new method of metal forming processes. At present some research in this range is be carrying at Process Modelling and Medical Engineering Department of Silesian University of Technology. This research concerns two non-conventional metal forming methods: compression with oscillatory torsion and rolling with cyclic, transverse rolls movement. Characteristic feature of both of these processes is significant participation of share stresses in the whole process of metal deformation, caused by additional tools movement. Thus the processes were called MEFASS processes (Metal Forming Aided by Shear Stresses).

In this paper the rolling mill for MEFASS rolling is introduced. Special attention is expended to the problem of process parameters measurements. The structure and functions of rolling mill measurement system are presented.

Research results gained with this measurement system are also introduced. Correlation between oscillation of MEFASS rolling parameters and position of working rolls during the process was observed and explained. Calculation of deformation work with taking advantage of recorded process data is also presented in this paper. This problem is considered for the first time in the research all over the world.

Key words: rolling, change of the strain path, Severe Plastic Deformation, measurement systems

1. INTRODUCTION

The effect of “strain accumulation” is used in forming processes called SPD (Severe Plastic Deformation) in literature. These processes are considered as one of the possibilities to obtain materials with new microstructure and utilitarian properties. Thanks to research, which are conducted from many years, these methods are still developed [1] as well as first industrial application are revealed [2,3].

Department of Process Modelling and Medical Engineering of Silesian University of Technology conducts a research in order to recognize phenomena, which are the result of strain path change and also development of manufacturing technology based on these processes. Because of strain leading method this processes are called MEFASS processes, which means Metal Forming Aided by Shear Stresses [4].

However research of new metal forming processes require new approach of process parameters measurement topic. Forming process with change of the strain path are characterized by high number of parameters, which have influence on final process effects, as well as high variation of these parameters during the process. Thus it is necessity to implement modern detecting elements, signal amplifier and computer software for measurement system operation.

 ISSN 1641-8581

2. CHARACTERISTIC OF MEFASS ROLLING PROCESS

In mechanical working severe, accumulated plastic strain can be achieved by different methods. In MEFASS rolling process the change of the strain path is caused by additional, cyclic movement of working rolls. In the aim of research conduct the rolling mill with possibility of additional tools movement was built.

The rolling stand enable to move working rolls, with 60 mm diameter, in transverse direction to direction of rolling. Frequency of this cyclic movement can be regulated from 0 to 3 Hz. Maximum value of rolls displacement is ± 2mm, which allows to reach maximum relative rolls displacement of 8 mm. Kinematic scheme of rolling stand action is presented on figure 1. Construction of rolling stand and mechanism, which is responsible for axial rolls movement is original and patented solution [5]. Other parameters of rolling process – height reduction value and rolling velocity – are also regulated.

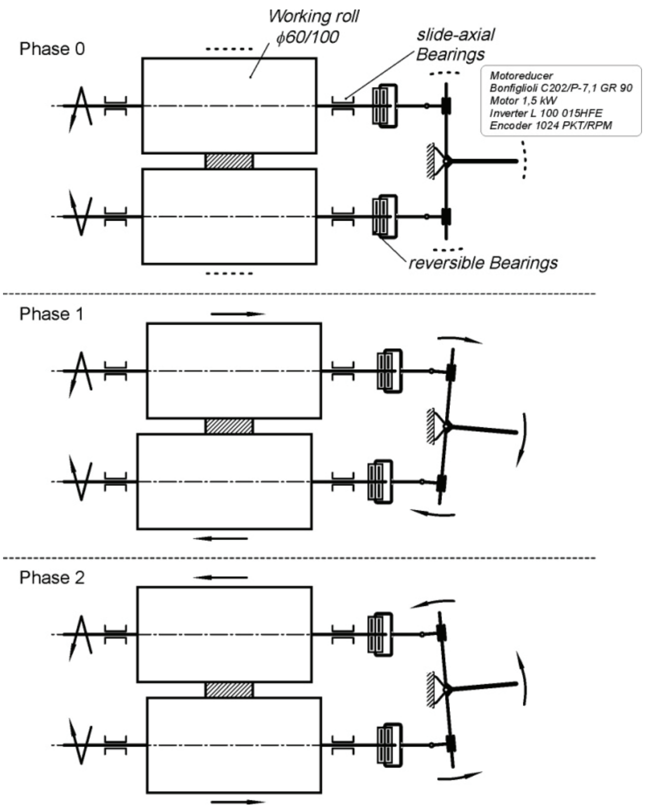

***Fig. 1.** Kinematic scheme of rolling mill with cyclic, transverse rolls movement [6].*

Gaining of strain path change effect depends on the way of additional rolls movement transfer to deformated material. Because of this special groves were made on surface of working rolls – figure 2. These groves causes friction coefficient increase between working rolls and the strip and ensure appropriate material flow conditions in transverse direction to direction of rolling.

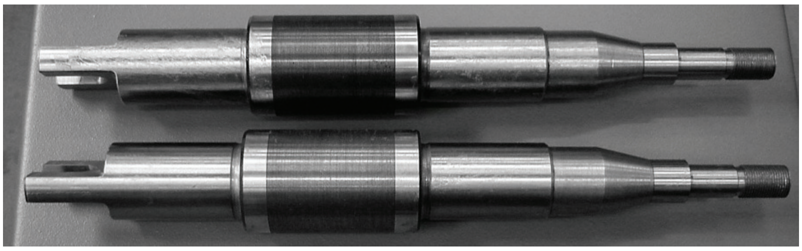

***Fig. 2.** The working rolls with special groves.*

3. MEASUREMENT OF MEFASS ROLLING PROCESS PARAMETERS

Mechanical working processes with the change of the strain path are characterized by complexity of proceeded phenomena, which are not recognized and explained. The main reason is dynamism of forming process parameters changes.

One of the main aims of rolling mill construction was to obtain the largest number of information about proceedings of forming process. The rolling mill was equipped with system, which allows to measure and acquire the most important parameters of forming process such as: rolling force, rolling torque, axial force and rotational speed of working rolls. Scheme of measurement system is presented on figure 3.

The most important element of measurement system is signal amplifier combined with analog-digital converter. This 12-bit converter allows to use up to 16 channels, which process the analog signal in range from -5V to 5V, to digital signal. Sampling frequency of this converter amount 10kHz. Thanks to this configuration it is possible to:

- trace the data in the real time,
- record the data on computer hard disk,
- calculate the value of rolling power and power of working rolls axial displacement,
- prepare of graphic presentation of measured parameters.

Measurement system is controlled by computer software NEXTVIEW 3.4. This software allows to set the basic parameters for the system:

- settings of signal channels,
- settings of the buffer,
- settings of sampling frequency.

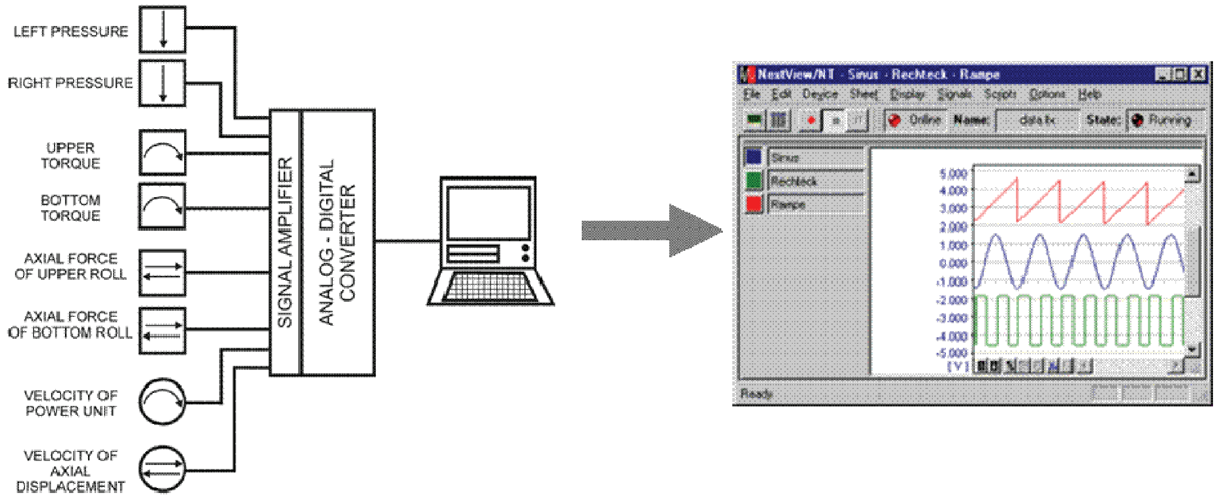

Fig. 3. Measurement system of laboratory rolling mill with cyclic, axial rolls movement.

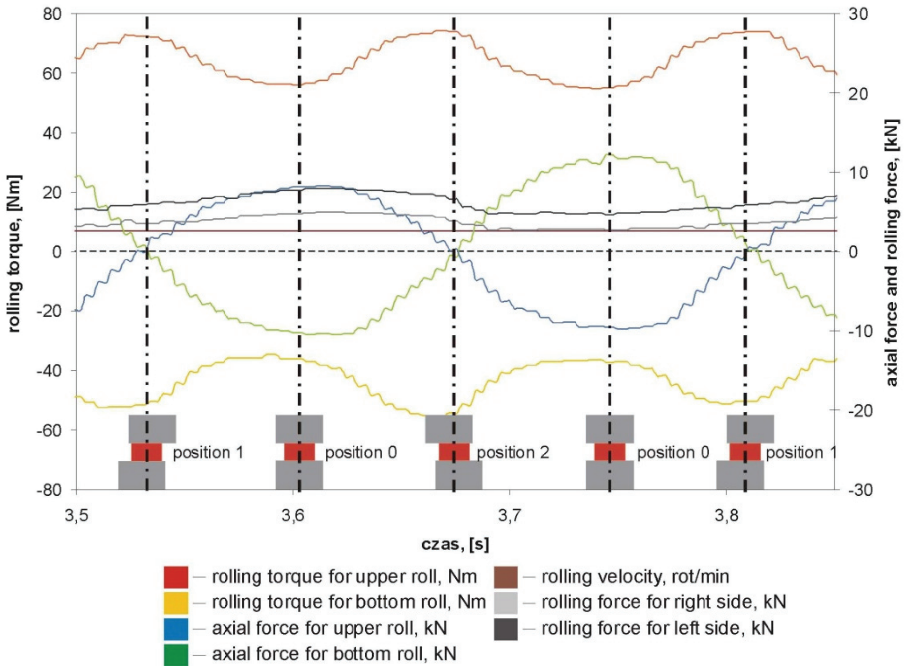

Fig. 4. Changes of parameters during MEFASS rolling process [6].

In the NEXTVIEW software functions of data processing e.g. FFT analysis, differentiate functions, data thinning functions are implemented.

4. EXAMPLE OF RESEARCH RESULTS

The research of MEFASS rolling conducted within work [6-8] focused on proceedings of the process. Changes of process parameters caused by cyclic, axial rolls movement was analyzed. Correlation between oscillation of MEFASS rolling parameters and position of working rolls during the process was observed.

The course of axial forces for upper and lower roll had identical shape, but differed by a symbol. Intersection points of axial forces diagram are the points where axial forces equals 0 – working rolls were in position of maximum displacement. Maximum value of axial forces were recorded, when the rolls were in the centre position – rolls displacement was equal 0. Changes of axial forces have close relation with behavior of other MEFASS rolling parameters.

The courses of rolling torque for upper and lower roll are symmetrical, but differed by a symbol. It is the effect of opposite directions of each roll movement. Maximum and minimum values of rolling torque are shifted in comparison with maximum and minimum values of axial forces – maximum value of rolling torque was recorded, when values of axial forces were equal 0 (for maximum displacement of rolls) – figure 4, position 1 and 2. Rolling torque is product of pressure force and the arm of force action. The value of pressure force arm is constant therefore changes of rolling torque are caused by changes of pressure force during the process.

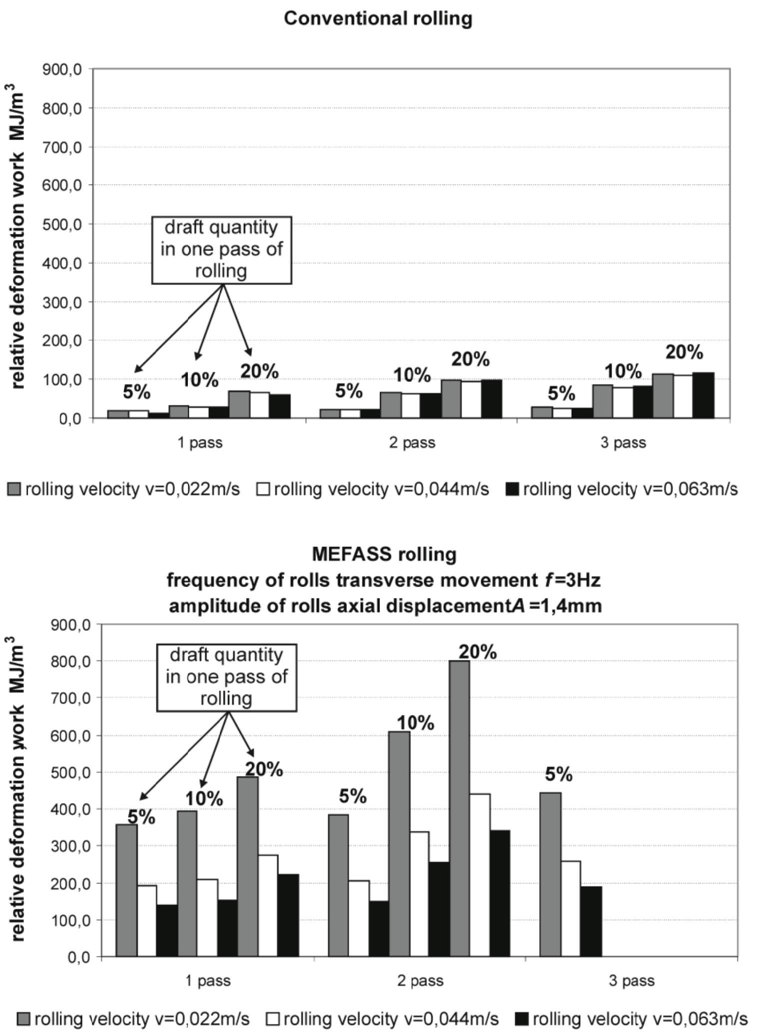

Fig. 5. Comparison of deformation work between conventional rolling process and MEFASS rolling process [8].

The issue of deformation work was also took in presented research. This topic is very interested because it was not considered by others researchers. It was caused by insufficient equipment of laboratory stands and lack of conviction about necessity of these research. However our experience indicates that this factor can be crucial for eventual industrial application of this processes.

Thanks to acquired data calculation of deformation work during MEFASS rolling process was enabled. Methodology of this calculation was presented in paper [8]. The research results showed, that amount of work necessary to deform the material in MEFASS rolling process is manifold higher then work during conventional rolling. Deformation work in conventional rolling is the work necessary to rotate the working rolls. In MEFASS rolling, beside "conventional work", it is necessary to deliver the work for cyclic, axial movement of working rolls. Dynamics of the movement as well as additional forces cause increase of the energy used during this process.The deformation work difference between conventional rolling process and MEFASS rolling can amount from dozen to hundreds percents – figure 5.

5. SUMMARY

The research of rolling process with cyclic change of the strain path conducted up till now allows to create characteristic of this process. On basis of these research the most beneficial settings for conducting the MEFASS process were picked out as well as calculation of deformation work was made.

Presented research can be done only with measurement and recording the most important parameters of forming process. Measured parameters were refer to obtained effect during the forming process: changes of strip geometry, properties of tested material change or thermal effect in deformed material.

Plenty of phenomena, which occurs during the MEFASS rolling process, requires further explanations. Therefore it is necessary to extend the measurement system about some new possibilities, such as measurement of rolls axial displacement in actual time.

Similar modifications should undergo all of laboratory stands, where now are conducted the research of modern and non-conventional metal forming processes.

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KOMPUTEROWE SYSTEMY POMIAROWE W BADANIACH NIEKONWENCJONALNYCH PROCESÓW PRZERÓBKI PLASTYCZNEJ

Streszczenie

Procesy SPD (z ang. Severe Plastic Deformation – Duże Odkształcenie Plastyczne) są jedną z nowych metod kształtowania plastycznego metali. W Katedrze Modelowania Procesów i Inżynierii Medycznej Politechniki Śląskiej są prowadzone obecnie badania tego typu procesów. Badania dotyczą dwóch metod niekonwencjonalnego odkształcania metali: ściskania z oscylacyjnym skręcaniem oraz walcowania z cyklicznym, poosiowym ruchem walców. Cechą charakterystyczną tych metod jest znaczący udział naprężeń ścinających w procesie odkształcania, wywołany przez dodatkowy ruch narzędzi. W związku z tym te metody kształtowania zostały określone mianem procesów MEFASS (z ang. Metal Forming Aided by Shear Stresses – Procesy Kształtowania Metali Wspomagane Naprężeniami Stycznymi).

W artykule omówiono budowę walcarki z możliwością cyklicznego, poosiowego ruchu walców. Szczególną uwagę poświęcono problemom pomiaru parametrów procesu. W artykule przedstawiono budowę oraz możliwości systemu pomiarowego walcarki.

W artykule zostały również zaprezentowane wyniki badań procesu walcowania z cyklicznym, poosiowym ruchem walców. Wyjaśnione zostały zaobserwowane korelacje pomiędzy oscylacjami parametrów procesu walcowania MEFASS a położeniem walców roboczych w trakcie procesu. Przedstawiono również obliczenia wartości pracy odkształcenia wykonane na podstawie pomiarów parametrów procesu. Problem pracy odkształcenia w niekonwencjonalnych procesach przeróbki plastycznej nie był jeszcze omawiany w literaturze polskiej i zagranicznej.

Submitted: October 30, 2008
Submitted in a revised form: November 21, 2008
Accepted: November 21, 2008