

DEVICE AND EXPERIMENTAL STAND TO PROCESS PROFILES

BY RADIAL COLD ROLLING WITH ROLLER TOOLS

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Abstract: Processing by volumetric cold plastic deformation is performed by generation (formation) of surfaces through successive plastic deformations (displacements) of some material volumes, under the action of rolling tools. Deformation takes place at ambient temperature and modifies the initial properties of the material definitively, giving certain advantages compared to cutting processing: minimum consumption of material, high productivity, superior mechanical properties of the superficial layer generated, special quality of the surface obtained. The advantages of cold rolling fully occur in the case of processing on pieces such profiled surfaces as: thread, grooves, teeth, pieces which can be found in the automotive industry, aeronautics, electrical appliance equipment etc. The radial cold rolling with two roller tools is the most often used procedure and consists in imprinting the profile to be generated by rolling the semi-product between the two roller tools. The paper presents a solution patented by authors to obtain a device to roll with two roller tools, which is mounted on the transversal sledge of an universal lathe. This device can be used, in terms of economic efficiency, to obtain the different types of profiles (by changing the tools roller) carried on the parts in small series. Also, the paper presents an experimental stand which allows measuring in real time some process parameters: rolling force, penetration of the rollers in the piece, rotations of the piece and of the two roller tools. These values are taken over by the measurement system as time functions and introduced in the memory of a computer for further processing. Thus, the stand can be used for experimental development of experimental research in the process of radial rolling with roller tools (determinations of evolution laws of process parameters, establishment of process analytical models, validation of numerical models of the process and so on).

Keywords: radial cold rolling, device, experimental stand

INTRODUCTION

Radial rolling with two roller tools is a proceeding frequently used in industry to obtain pieces with thread, teeth, circular grooves or other shapes, within serial production. For the rolling process there are used special machines on which the piece, a cylindrical bar with a specific diameter, is placed on a ruler between the two rollers which rotate with the number of rotations n_r , fig. 1 [1, 2, 3]. At the contact with rollers 1 and 4, piece 2 is engaged in the rotation movement. In the case of helical profiles, the piece moves axially on the support ruler 3 according to the pass of the thread made on the rollers.

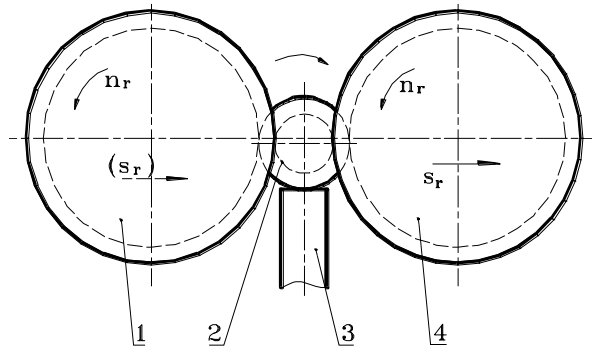


Figure 1. Scheme of processing short profiled surfaces by copying with two rollers by in-feed method

To ensure the quality imposed to the rolled profiles, the machine-tool used must have the following basic characteristics [1, 2, 3]:

- a static and dynamic rigidity which ensures minimal elastic deformations of its elements under the influence of the deformation forces, which can have important values;
- high geometric precision;
- a cooling-lubricating unit reducing thermo deformations.

The technological schemes obtained on rolling machines by copying with two roller tools are:

- rolling with two profiled rollers by in-feed method;
- rolling with two profiled rollers and axial feed of the semi-product;
- rolling with two profiled rollers and tangential feed of the semi-product.

Using the specialized machines for cold rolling is efficient only for series production. For this reason, the researchers [1, 2] have focused on developing special devices, which can be used efficiently on universal machines. As well, the current researches are oriented to simulate the cold rolling process in order to improve its performances [4, 5, 6].

This paper presents a constructive solution patented by authors [7] of a device which allows the processing of profiles by in-feed method with two rolls and a experimental stand for studying the radial cold rolling.

DEVICE FOR RADIAL ROLLING BY IN-FEED METHOD

In order to achieve the radial cold rolling by in-feed method on a universal machine, we opted for:

- a device placed on the transversal sledge of a universal lathe to carry the roller tools and the piece to be rolled;
- engagement of the piece in the rotation movement by the main shaft of the lathe with a special carrier (the piece being placed and set between the peaks of the lathe);
- development of the rolling forces using the energy of the oil under pressure and hydraulic engines mounted on the device.

Considering the difficulties raised by the engagement of the rotation movement on the lathe, the engagement of the piece was chosen as the rollers are free to rotate on their axes.

Piece 1 is oriented between the peaks and is engaged in the rotation movement by the main shaft of the lathe by carrier 2, fig. 2.

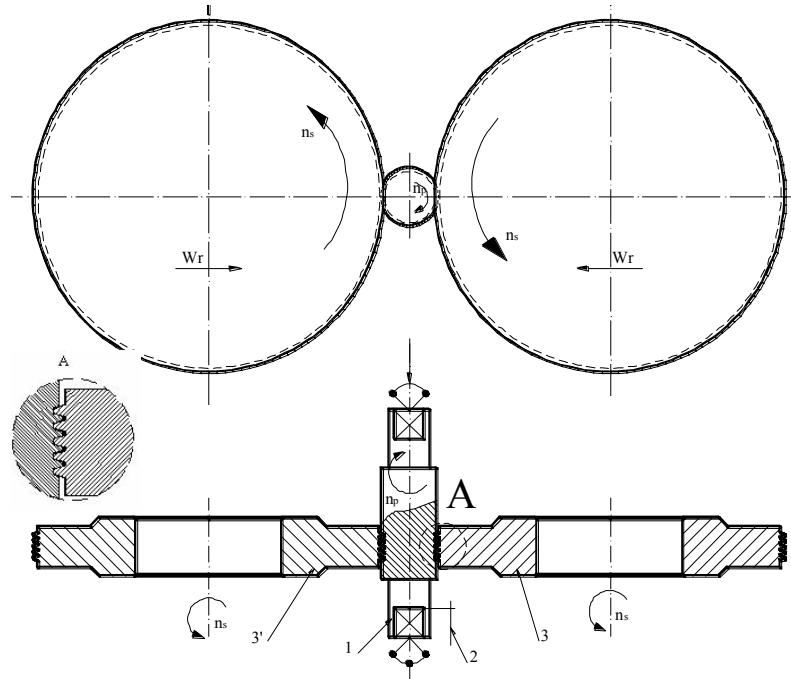
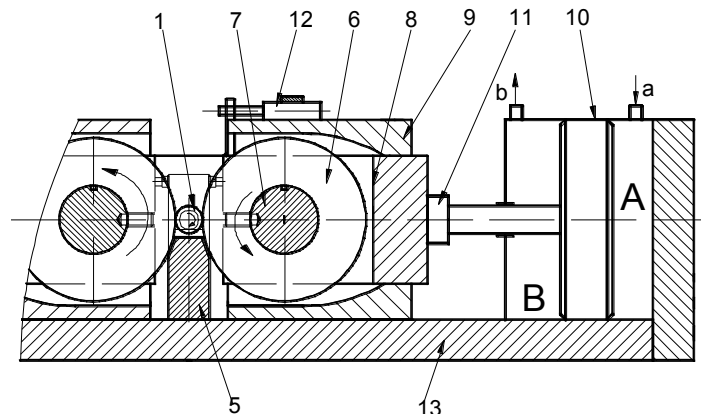


Figure 2. Scheme of the radial rolling process used

In order to obtain the profile, the two rollers 3 perform the movement of radial penetration (in-feed method) at the same time with the rotation of the piece. The rollers have the same diameter D and rotate with the same number of rotations n_r and their profile is conjugated to the generated one. The deformation process takes place as a result of the penetration of the rollers in the semi-product which makes the material move parallel to the surfaces of the tool which is in contact with the semi-product. The width of the roller tools is equal to the length of the profile to be processed.

The rolling device designed to be mounted on the carrier of lathe SN560 and patented by authors [7] is presented in fig. 3. The piece to be rolled 1, with a special construction, is oriented between peaks 2 and 3, set in the main shaft, the loose headstock, respectively, and is supported additionally by ruler 5. The rolling process takes place with two rollers 6, the device being designed symmetrically to the piece to be rolled. The roller tools can rotate freely on axes 7 which are set on the loose tool-holder sledges 8. The tool-holder sledges can move in guides 9. The piece is engaged in the rotation movement by carrier 4 set on the top of the lathe headstock.



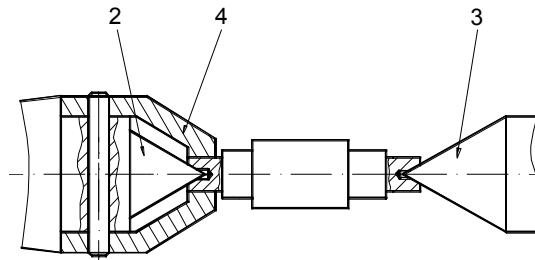


Figure 3. Constructive scheme of the device for radial rolling by in-feed method

The displacement of the tool-holder sledges is performed by hydraulic engines 10. The rolling process is produced by rotating the piece with a number of rotations n and radially pushing the roller tools on the piece to be rolled using the two hydraulic engines. The radial clamping forces can be varied by varying the work pressure of the engines. In order to control the limits of displacement of the sledges on radial direction there are used buffers with dimensions corresponding to each rolled piece limiting the displacement of the sledges and therefore the depth of penetration of the tools in the pieces on radial direction.

A picture of the rolling device mounted on lathe SNA 560 is presented in fig. 4.

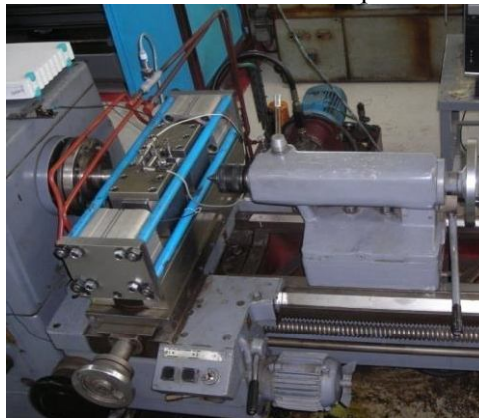


Figure 4. Picture of the rolling device assembled on the lathe SNA 560

EXPERIMENTAL STAND FOR STUDYING THE RADIAL COLD ROLLING

In order to study the radial cold rolling, the experimental stand should to allow:

- the realization of some complex circular profiles by radial rolling with two roller tools by in-feed method;

- the variation and measurement in real time of process parameters.

Thus, the functions that the stand has to perform and the solutions chosen to achieve them are the following [8]:

- performing the rolling process (rolling the piece, applying the rolling forces, placing and engaging the piece) and varying the process parameters within the established limits, using the SNA 630 lathe and the device specially designed for radial rolling by in-feed method;

- measuring in real time the radial rolling forces;

- measuring in real time the displacements at the penetration of the tools on radial direction;

- measuring in real time the number of rotations made by the piece and tools to perform the process;

- adjusting the calibration time;

- commanding the end of the process.

The block scheme of the experimental stand can be seen in fig. 5.

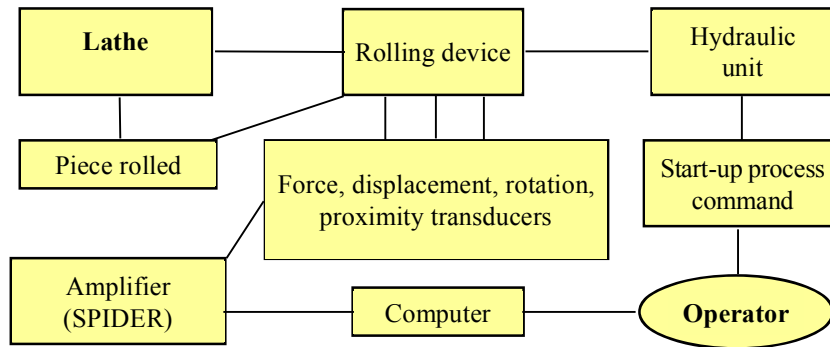


Figure 5. Block scheme of the experimental stand

The piece to be rolled is placed and set between the peaks of the lathe and is additionally supported by rests belonging to the rolling device. The transducers are mounted on the device and are connected to the amplifier SPIDER which is connected to the computer. The hydraulic unit operates the engines of the device. The command to start the process is made by the operator, while the command to stop it is performed automatically by the inductive transducer at stroke end (proximity transducer).

The four values measured in real time, rolling force, penetration of the roller tools in the piece, rotations of the piece and of the roller tools, are taken over by the measuring system as time functions and introduced in the memory of the computer for further processing.

The method used to determine the components of the deformation forces at cold rolling with two roller tools is based on the measurement of deformations of some elastic bodies with the help of an electric parameter. The deformations measured have to belong to the deformation forces of the process and the elastic elements introduced have to be on the direction of the deformation force. Thus, the stand provides rest 2 for the force transducer 7, the pressure head 3, the spherical washer 5, the bushing 6, which is milled so that it allows for the force transducer to be assembled on the stand, fig. 6.

Under the action of the forces which appear during the deformation, the elastic elements of the stand exposed to compression and their elastic deformations recorded in the data acquisition system will be proportional to the value of the deformation force. The strain resistive transducer used is of the type KMR 200KN. It is connected in full bridge and has the following characteristics: nominal force $F_N = 200 \text{ kN}$, sensitiveness 2 mV/V , transducer resistance $R = 350 \pm 5\% \Omega$.

The radial displacement of the tools is recorded with a displacement transducer WAL20 made of a set part and a loose one. The scheme to assembly the displacement transducer is presented in fig. 7. The body of the transducer 4 (set part) is placed on the guiding plate 3 and the rod 5 (loose part) of the transducer is assembled with the help of a support on the tool-holder 6, so that it moves simultaneously with it. Rollers 1 and 1' are moved with the help of the tool-holders with the radial speed w_r , thus, penetrating the semi-product 2.

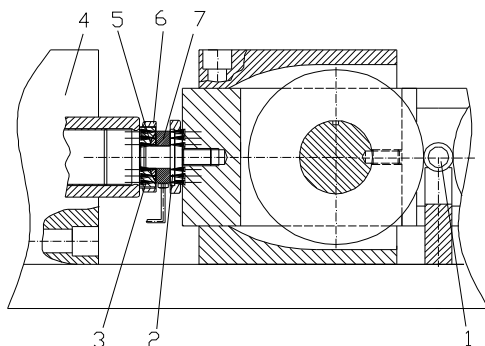


Figure 6. Scheme to assembly the force transducer

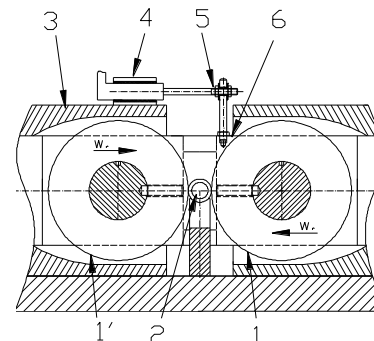


Figure 7. Scheme to assembly the displacement transducer

The rotations of the tools were measured with the help of a contactless inductive transducer. In order to record the rotations of the tool a disc with bores was stuck on it. The transducer sends the impulse

to the amplifier (Spider) and the rotations of the tool are registered in the computer at each crossing of the bores in front of the transducer.

Calibration profile (the rotations of the piece without radial feed of the tools - at the end of penetration) are controlled by a proximity transducer at stroke end commanding the interruption of rolling.

The four transducers (force, displacement, rotation and proximity) are connected to the strain bridge SPIDER 8, which allows measuring and acquiring data from the four channels simultaneously. The frequency of data acquisition (the corresponding signal sampling) will be established considering the short period to perform the rolling process (it has values under a second).

EXAMPLE OF THE USE OF THE EXPERIMENTAL STAND

The tests performed confirmed the correctness of the assembly. For example, the data recorded allowed determining the size and evolution in time of the deformation forces and the displacement of the roller tools when processing a circular profile in axial section corresponding to thread M20 on a piece made of OLC35 [6, 8]. In both cases the number of rotations of the piece was varied, thus obtaining peripheral speeds of 11.81, 23.62, 47.25 and 94.5 m/min. The corresponding graphs are presented in fig. 8 and 9.

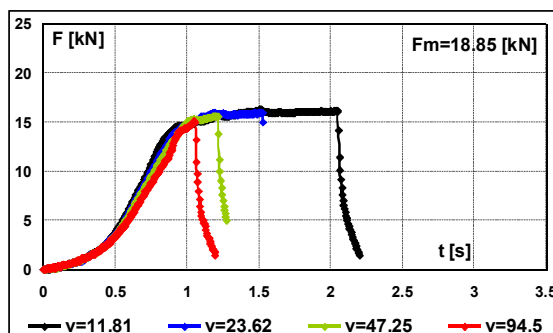


Figure 8. Evolution of deformation forces

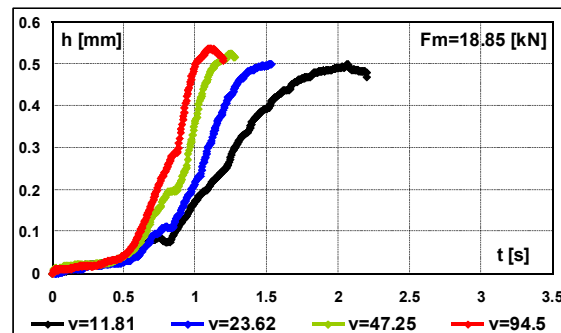


Figure 9. Shape of penetration curves

CONCLUSIONS

The device designed, developed and patented by the authors allow processing by radial cold rolling of complex profiles using an universal lathe. Thus, this method of processing can be used efficiently in small production.

The use limits are connected to the range of number of revolutions developed by the lathe, the maximum pressure in the hydraulic system, which determines the value of the maximum rolling force, as well as the rigidity of the device to be rolled.

The stand designed allow performing the deformation process by radial rolling with two roller tools of some circular profiles with complex shapes on pieces made of different materials. There can be measured in real time the force of radial rolling, the radial penetration of the roller tools and the number of rotations made by the piece and tools to obtain the profile.

Processing the experimental data by the graphic representation of the dependences of values specific to the process on the input parameters varied can be followed by the application of the regression analysis to determine some process functions, which allow interpreting the results obtained and the characterization of the deformation process. A law of evolution in time of values h – displacement of roller tools and F – deformation force has to be established in order to obtain general analytical models at the level of a material – profile couple, therefore, making possible the extrapolation of the results of researches to points in which no experiments can be performed. In addition, these laws of evolution can be used to make the numerical model of the process and validate the results of the model simulation.

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