UDC 621.97

# Progress of Metal Forming Processes

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The areas of scientific investigations of Metal Forming Department as well as new competitive technologies of high-quality metal products manufacture are presented in the paper.

Keywords: METAL FORMING DEPARTMENT, TUBE MAKING THEORY, SIMULATION

## Introduction

Ukraine is among leading metallurgical states of the world, it has a developed machine-building industry. Scientists and specialists of high schools, scientific research institutes, project institutes and plants are a powerful scientific potential in the field of metal forming. The Ukrainian scientific school of metal forming has several centers in large industrial cities of the country (Dnipropetrovsk, Kyiv, Donetsk, Zaporizhzhya, Kramatorsk, Kharkiv, Dneprodzerzhinsk, Lugansk, Mariupol, Alchevsk, Vinnitsa, etc.).

Rolling, tube, forge-stamping and drawing shops and plants operate in Ukraine on the basis of metal forming processes and produce hardware of different shape and size from various alloys. Ukraine makes the following metals: iron, aluminum, zinc, cuprum, titanium, chromium, nickel, etc. and also articles from them.

## Results and Discussion

Usually, long articles like strip, tubes, rolled wire, section bars and also large articles like wheels, axes are fabricated in shops of metallurgical plants. Various hardware are fabricated also in forge-stamping, extrusion plants of various engineering works. Differnt kinds of rolling, drawing, forging, press forming and pressing are used at iron & steel plants.

A variety of applied metal forming processes for various manufactures led to a specific specialization of scientific divisions and chairs. Today, more than 30 chairs of high schools, laboratories, departments of research institutes of Ukraine work in the field of metal forming.

Primary areas of scientific investigations of Metal Forming Department in National Metallurgical Academy of Ukraine are following:

- physical and computer simulation of two- and three-dimensional metal forming processes;
- control of metal forming processes, forecasting structure and properties of hardware;
- friction and lubricants in metal forming processes;
- hot and cold rolling of sheet steel and section;
- seamless and welded tube making processes;
- forging, press forming, drawing processes;
- extruding of aluminum alloy sections;
- gas-dynamic sputtering of powders;
- equipment of metal forming shops.

Metal Forming Department is in communication with universities, enterprises and corporations of Russia, Poland, Slovakia, Croatia, Germany, Sweden, China, Belarus, Moldova and other countries, and also with E. O. Paton Electric Welding Institute, Z. I. Nekrasov Iron & Steel Institute of National Academy of Sciences of Ukraine, State Enterprise "Ya. Yu. Osada Scientific Research Tube Institute", Academy of Sciences of High School of Ukraine, ITA (International Tube Association) [1-7].

Theory of rolling processes was investigated in proceedings of Metal Forming Department: conditions of roll bite were defined, lubricating action theory while rolling was created; power conditions of rolling, constituents of energy balance were considered; distribution of contact

stresses at rolling was studied experimentally and theoretically; methods of roll pass design calculation were explicated; the fundamentals of repetitive rolling theory were created, the scientific fundamentals of thermalmechanical treatment of strips, reinforcing bar, rolled wires, spheres, wheels were worked out.

Theory of hot and cold continuous plugless and plug rolling of tubes was explicated; mathematical models of rolling processes were created taking into account change of flow characteristics of material, friction conditions when using lubricants and power interaction of continuous mill stands; methods of calculation and optimization of strain conditions were developed, and conditions of strip and tube rolling with a high precision were defined.

The favorable stressed state, extended temperature range allow rolling all known metals and alloys on tube cold-rolling mills, including hard-to-deform ones. Advanced development of technology and equipment for tube rolling on tube cold-rolling mills allowed improving accuracy of geometrical sizes up to the level of cold-drawn pipes.

The current high-duty cold rolling mill with application of new construction modules with the use of pneumatic balancing unit was developed. The modular approach to new mill designing allows solving the problems related to reconstruction of out-of-date tube cold-rolling mills.

In 2006-2008, Dneprovskiy Tube Plant in cooperation with JSC “Elektrostal Heavy Engineering Works” and with the participation of National Metallurgical Academy of Ukraine reconstructed 15-stand reducing mill as a part of pipe-rolling plant PRP-80. One more 15-stand reducing mill of similar construction with individual roll drive was installed earlier. After reconstruction, pressure reduction of pipes was carried out in both mills simultaneously, and the first 15 stands rotate about rolling-axis in relation to others by 30 angle degrees.

Pipe rolling technology in the mill of this construction (table of rolling, roll drafting, high-speed conditions of pressure reduction) was developed for tubes with diameter from 21 to 89 mm and wall thickness from 2.3 to 14.0 mm. High-speed conditions of pressure reduction were calculated in such way that there was no tension between sections (free rolling), because of structural features of 30-stand reducing mill PRP-80. Application of such high-speed conditions of pressure reduction together with system "mobile wave" and preparation of draught pipe ends on continuous mill allows reducing the length of “thickened” pipe ends up to 30-50 %, which are inevitably formed at pressure reduction with tension.

The scientific fundamentals of cold continuous repetitive rolling of superthinwalled pipes were explicated. Strained condition of pipe with nonuniform wall thickness at plugless rolling of pipes made of metals with various hardening intensity was described with application of finite element method.

The scientific fundamentals were created and technologies of various hardware manufacture with optimum conditions of strain and thermal treatment with application of forging, press forming and pressing processes were developed. Effective conditions of metal strain when forging and die forging were worked out. A variety of forging operations (smith forging, piercing, closing, etc.), their simulation and experimental investigation allow developing resource-saving technologies.

Simulation of various drifting technologies, laboratory and industrial experiments allowed avoiding errors when working out technology of wheel and wheel tread manufacture by smith forging. Simulation of metal forming processes also enables to avoid tool adjusting and doubling tests in the process of forming of various types of wheels.

Effect of pressing tool geometry and temperature-speed parameters of the process on temperature, pressing force, mechanical properties and metal structure of sections and pipes made of aluminum and magnesium alloys (AA7070, AA6060, AA6082, A231B) was defined. Effect of calcium concentration, elongation ratio, billet temperature on power parameters of pressing, mechanical properties and structure of small-diameter pipes with wall thickness 0.4-0.7 mm made of magnesium alloys of system Mg-Sa was established. Methods of moulded articles production with large cross-section and uniform fine grain structure of metal with the use of angle pressing were developed.

Billet continuous casting with the use of soft reduction in roll stands of secondary cooling zone was simulated, straining conditions were suggested.

Implementation of processes of thin hot-rolled strips rolling in the endless rolling mill train of casting-rolling units on the basis of thin slab technology requires considerable investment costs.

Casting-rolling of flat-rolled steel is of

greatest interest.

It is obvious that advanced process of thin steel strip casting-rolling should have the priority development with the use of concessionary terms in the industrial policy in Ukraine. It will allow scientists, designers, process planners and machine engineers to construct a domestic advanced cast-rolling plant.

Now, possibilities and requirements to investigations and developments in the field of metal forming have changed. Computer simulation of metal forming processes (rolling, press forming, forging, pressing, etc.) with the application of numerical methods of solution of metal forming boundary problems is developed in Ukraine. Original finite-element programs for analysis of processes with two- and three-dimensional metal flow are created. It allows solving problems of design and control of various processes and forecasting metal product properties.

Alternative methods of solution of metal forming boundary problems are being worked out currently. Development of process theory enables to develop advanced technologies of high-quality hardware manufacture with application of computer control.

### Conclusions

Today, iron and steel industry requires substitution of out-of-date ineffective technologies and equipment by advanced ones that can be created by domestic machine-building plants under conditions of economic crisis.

Development of theory of metal forming processes, use of information technologies, upgrading equipment of departments, computer control allows developing modern high-quality metal products manufacture technologies from various materials.

In addition, scientific and technical titles, including the leading Ukrainian journal "Metallurgical and Mining industry" should be of paramount importance and connect science and production.

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*Published in Russian
**Published in Polish

Received February 02, 2010

### Развитие процессов обработки металлов давлением

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Приведены основные направления научных исследований кафедры ОМД, а также и новые конкурентоспособные технологии производства металлоизделий высокого качества.