INVESTIGATION AND OPTIMIZATION OF IRON DEFORMABILITY

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The goal: Widening the area of using the deformed iron for automobile and machine-building parts as an effective competitive alternative to steel roll stock.

The intensive fundamental applied investigations devoted to the development of new materials and improvement of technologies designed for production of piston rings are now underway in both research institutions and scientific centres of great world manufacturing companies.

The universally recognized leaders of world market are AE "GOETZE" Company (Germany) with the scientific center in Burscheit and «DAROS INDUSTRIAL RINGS» (Sweden, Geteborg). In CIS countries the leaders of piston ring manufacturers are Michurin Plant of Piston Rings (Michurinsk), Kostroma Plant "Motordetal" (Kostroma), Odessa Plant of Piston Rings and Stavropol Plant of Piston Rings "Stapri" (Stavropol).

Regardless the continuous search for new technologies most of the companies face the problems associated with the quality of piston ring billets. For instance, even the market leader AE "GOETZE" use only two end portions because of casting porosity in the billet center which results in that more than 70% of metal is to be remelted.

The SSI Physical-Technical Institute of NAS of Belarus has developed and offers in principal new technology for obtaining piston ring billets based on the use of plastic deformation.

High-quality billets are obtained by subjecting iron castings heated to high temperatures to plastic deformation on conventional presses using special-purpose press tools.

Benefits of press-forged iron ring billets:

1. Stable and homogeneous quality throughout the entire height. Porosity characteristic of a middle portion is absent. Pores and cavities are eliminated to a depth of 3 mm.
2. High accuracy of shaping. Allowances for machining are minimum and equal to tenths of mm as compared to those for casting (which amount to 5 mm).
3. Mechanical properties of press-forged iron are 1.5 to 2 times higher as compared to those of a casting.
4. The broadest spectrum of obtained structures provides greater possibilities for controlling mechanical and operating iron properties. The structure that is formed on external, end and internal ring surfaces is highly suitable for the conditions at which both compression and oil control rings are operated.

The press-forging technology of billets intended for manufacturing sealing transmission rings has been developed at the Physical-Technical Institute of National Academy of Sciences of Belarus and is now implemented at one of the greatest machine-building enterprises of Belarus.

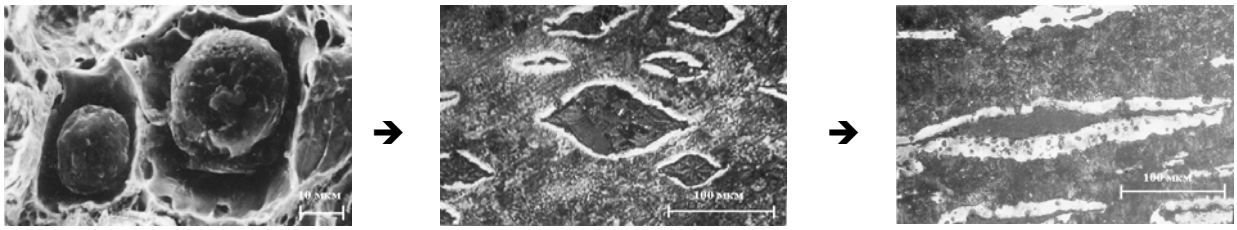
Advantages of rings made from deformed iron over cast rings are as follows:

1. Any damage is eliminated during assembling and operation.
2. In transmission the oil loss is decreased 4-7 times.
3. Elasticity of rings on compression is increased by 55%.
4. Disruptive tension force is increased by 103%.
5. Ultimate elongation is increased by 85%.

6. Wear of mating part is not increased due to formation of specific fiber graphite inclusions in iron.

Field of application. The most wide range of engines, transmissions and compressors.

Designated purpose. Cardinal improvement of quality and operating characteristics of piston and sealing rings due to 1) complete elimination of casting defects in a billet macrostructure; 2) formation of a superfine iron structure with a specific morphology; 3) formation of graphite inclusions of new unusual shape. Some photos of microstructures and billets are given in the enclosed.



Principle: An iron billet heated to high temperatures in a special-purpose press tool is subjected to plastic deformation. The serial press-forging equipment is used as there is no need in a special one. The know-how is in the iron compositions, processing parameters and design of a special-purpose press tool.

The principle of processing is in that an iron billet heated up to the temperatures of 900-1000°C and placed in a special-purpose press tool is subjected to plastic deformation. The process is carried out on serial press-forging equipment.

Process benefits are as follows:

1. Possibility to process items with near-net shapes and minimum allowances for machining (up to thousandths of mm as compared to those of castings that amount to 5 mm).
2. With increasing the degree of deformation graphite inclusions take unusual fiber shape and a metallic iron matrix is substantially refined.
3. After iron subjecting to deformation its mechanical properties are significantly increased (up to 2.5 times) approaching the level of alloyed steels. For instance, $\sigma_в$ on tension can be 1200 to 1400 MPa.

The intellectual property of the development is legally protected.
There are 5 groups of «know-how»:

1. Alloying diagrams.
2. Preliminary thermal treatment for improvement of deformability.
3. Design of press-forging tool.
4. Temperature-force parameters of deforming.
5. Finishing thermal treatment.

Ongoing development state. R&D works have been performed. The determination is made of the optimum iron compositions that ensure combination of acceptable deformability with perfect operating properties as well as of the thermal pretreatment parameters, temperature-force deformation parameters and those of a final thermal treatment. The requirements imposed on the optimum iron structure are formulated for ring billets in as-cast, press-forged and heat-treated states. The efficient special-purpose press tool is developed and made for producing ring billets 40 to 128 mm in diameter. Now the work is underway to produce billets

128 mm and above in diameter. The technology is already developed and pilot lots of billets are produced. The billets have been used for fabricating pilot lots of rings. At the Certification Testing Centre the rings have been subjected to full-scale bench testing (analogue of 300 000-km run).

Possible innovation solutions. Based on obtained successful results of producing rings for one of the automobile models the production of piston ring billets seems most perspective in the following automobile and engine-building industries:

1. Full-scale production of a serial engine model. This can be absolutely new model just designed from the very beginning.
2. Single-scale production of especially heavily loaded and expensive engines, for instance, for racing cars.

We suggest the development of technologies for manufacturing analogous parts. The expenditures can include acquisition of materials, development of design documentation, fabricating of special-purpose press tools, optimizing the technology, training of personnel and author's supervision. We are interested in having a partner for scientific collaboration through undertaking joint researches. We are in search for an investor for bringing the technology to actual industrial-use level and joint selling of rings of typical sizes already mastered by us (40 to 128 mm) as well as of some others.

Assessment of market. The annual demand of Belarus in piston rings for new engines as well as in the form of spare parts for secondary market is above 2 million pc. The leaders of the world market of rings such as Goetze and Glico assess that their annual demand in rings is dozens of millions of pc.