

## DEVELOPMENT OF CALIBRATION OF ROLLING ROUND STEEL № 40 FROM 150 x 150 MM BILLETS IN 320 JSC „SSGPO“ MILL

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### ABSTRACT

*This paper presents results obtained in the course of development of new calibration rolls for rolling round steel № 40 in 320 JSC „SSGPO“ mill. There is an untapped potential of the rolling mill capacity during the production of round bars with a diameter of 40 mm from initial 120 mm × 120 mm billets. The solution of this problem refers to the mill translation to production of round steel with a diameter of 40 mm from initial 150 mm × 150 mm billets. Such technological scheme will provide the transfer of specimens unsuitable for the production of rolling round steel with a diameter of 100 mm to that of round steel with a diameter of 40 mm. The rolls calibration is checked to show that the existing rolling equipment can be used without any reconstruction. Furthermore, round bars with a diameter of 40 mm produced on the ground of 150 mm x 150 mm billets meet fully the requirements of GOST in respect to the geometrical parameters.*

*Keywords:* rolls calibration, round bars, steel.

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### INTRODUCTION

Currently, two calibration schemes of round steel rolling are applied on 320 of JSC “SSGPO” mill. They produce rods of diameters of 40 mm and 100 mm from initial 120 mm × 120 mm and 150 mm × 150 mm [1] billets, correspondingly. Despite the stable operation of the mill, the technological mode has two serious drawbacks:

1) The first one refers to the rolled billets requirements and appointment. Round billets with a diameter of 100 mm are produced from 150 mm × 150 mm one. They are used as the grinding rods of the rod mills of JSC “SSGPO” factory complex. They must have a strictly regulated chemical composition (65G steel quality) and geometric dimensions. Billets with deviations in the chemical composition lead to breakage of the rods during iron ore grinding and hence to an emergency stop of the mill. At the same time rolled round steel with a diameter of 40 mm is made from initial 120 mm × 120 mm billets from steel of ordinary SH3 quality. It is used for the production of thermally hardened grinding balls

with a diameter of 40 mm. The technological scheme of production leads inevitably to a certain amount of steel 150 mm × 150 mm billets, whose chemical composition is unsuitable for the production of grinding rod with the diameter of 100 mm. These rejected specimens are sent back to the facility. But 65G grade steel can meet the requirements imposed on SH3 as their chemical compositions are very similar.

2) The second drawback refers to the fact that although it is technically possible to roll round steel with a diameter of 40 mm on the ground of initial 150 mm × 150 mm billets, the rolling process is carried out with 120 mm × 120 mm billets. This decreases significantly the productivity of the rolling equipment. The production data analysis shows that 250 - 350 specimens of round steel with a diameter of 100 mm are produced daily. The figure pointed out coincides approximately with that (250 - 330) of round steel specimens with a diameter of 40 mm. But the weight of the initial billets differs greatly - those of 120 mm × 120 mm have a length of 2 m and weigh 221 kg, while the 150 mm × 150 mm

billets of the same length weigh 345 kg.

Based on the foregoing, it can be concluded that the production of round bars with a diameter of 40 mm from initial 120 mm × 120 mm billets presents an untapped potential of the rolling mill production capacity. Both problems can be solved by translation the mill to the production of round steel with a diameter of 40 mm on the ground of initial 150 mm × 150 mm billets. Thus specimens unsuitable for rolling round steel with a diameter of 100 mm can be used for the production of round steel with a diameter of 40 mm.

The main areas of research focus at the calibration systems, which allow alignment of the relative compression and load on the stands drive, increase of the stripes stability in round calibers and their durability, improvement of the finished products surface quality [2 - 5]. There are also studies on new systems of calibers using computer simulation [6 - 9]. The metal strain state during shape rolling is usually analyzed by modeling using the finite element method. Thus the scheme of deformation is revealed.

#### **New calibration of the rolls**

As noted above, the average mill capacity in both rolling cases is almost identical. The reason is that the crate that determines the productivity of mill 320 is the first breakdown crate trio 500. When rolling both types of blanks, the length of pauses between passes is the same, because the time spent on rolling in the subsequent passages and the duration of the roll canting are the same. The value of reductions in the mill transfer to new calibration will be taken at current values, while the necessary cross-section for the last finishing pass will be determined through the use of additional rolling stands of the finishing group. According to the current technology a procurement section of 14400 mm<sup>2</sup> is rolled to a round section of 1256 mm<sup>2</sup> for 9 passages with a total stretching  $\lambda_{\Sigma}$  = to 11,5 and an average stretching in a single pass  $\lambda_{AV}$  = 1,31. The new technology procurement section of 22500 mm<sup>2</sup> needs to drive a round cross-section of 1256 mm<sup>2</sup> with a total stretching  $\lambda_{\Sigma}$  = 17,9 with a similar average stretching in a single pass. This will require 11 passes.

The initial data for the development of new calibration rolled round steel with a diameter of 40 mm is as follows:

- the calibration is developed for a combined 320

mill MPZ JSC "SSGPO", the first crate is a breakdown crate trio 500;

- the initial specimen is a continuously-cast billet with cross section of 150mm×150 mm;

- the final product is a round bar with a diameter of 40 mm, of B2 GOST 2590-2006 accuracy class used as an initial billet in a ball mill 30-60 for obtaining thermally hardened grinding balls with a conditional diameter of 40 mm;

- the material of the round steel with a diameter of 40 mm refers to SH3 on TU MPZ (similar to 60 GOST 1050-88 steel grade);

- number of passes - 11;

- all rolls of the mill have a bearing on rolling bearings;

- the rolls material in all stands - cast iron.

The calibration of round steel rolls with a diameter of 40 mm from 150 mm × 150 mm billets is obtained on the ground of the calculations carried out (Fig. 1).

The calculated data is summarized in Table 1. Here the height of the caliber stands for the depth of the roll incision, while the height of the metal characterizes the entire height of the two rolls with a gap between them.

The assessment of the mill capacity is shown. The mill capacity will increase by more than 37 %, from 7.7 t/h to 10.6 t/h, during the transition to the calibration developed. Therefore, the proposed calibration is economically advantageous and effective solution. However, before recommendation for implementation, the proposed calibration of rolls must be checked for mandatory compliance with conditions referring to the permissible values of the power parameters (with the exception of an equipment failure) and those attributed to the shapes and dimensions of the final plant product (to prevent geometry defects).

#### **Estimation of the energy-power parameters**

The energy-power parameters in the course of shape rolling are calculated by the imaginary strip method, which is based on the assumption of replacing the billet with a shaped cross-section by one with a cross section of a rectangular shape [10]. The square of the imaginary strip is equal to that of the shaped metal. The results of the energy-power parameters calculation are shown in Table 2.

Table 2 shows that the billet in the furnace is heated to 1200°C. Then it cools to 1192°C on moving from the furnace to the 1st breakdown crate trio 500 C. The

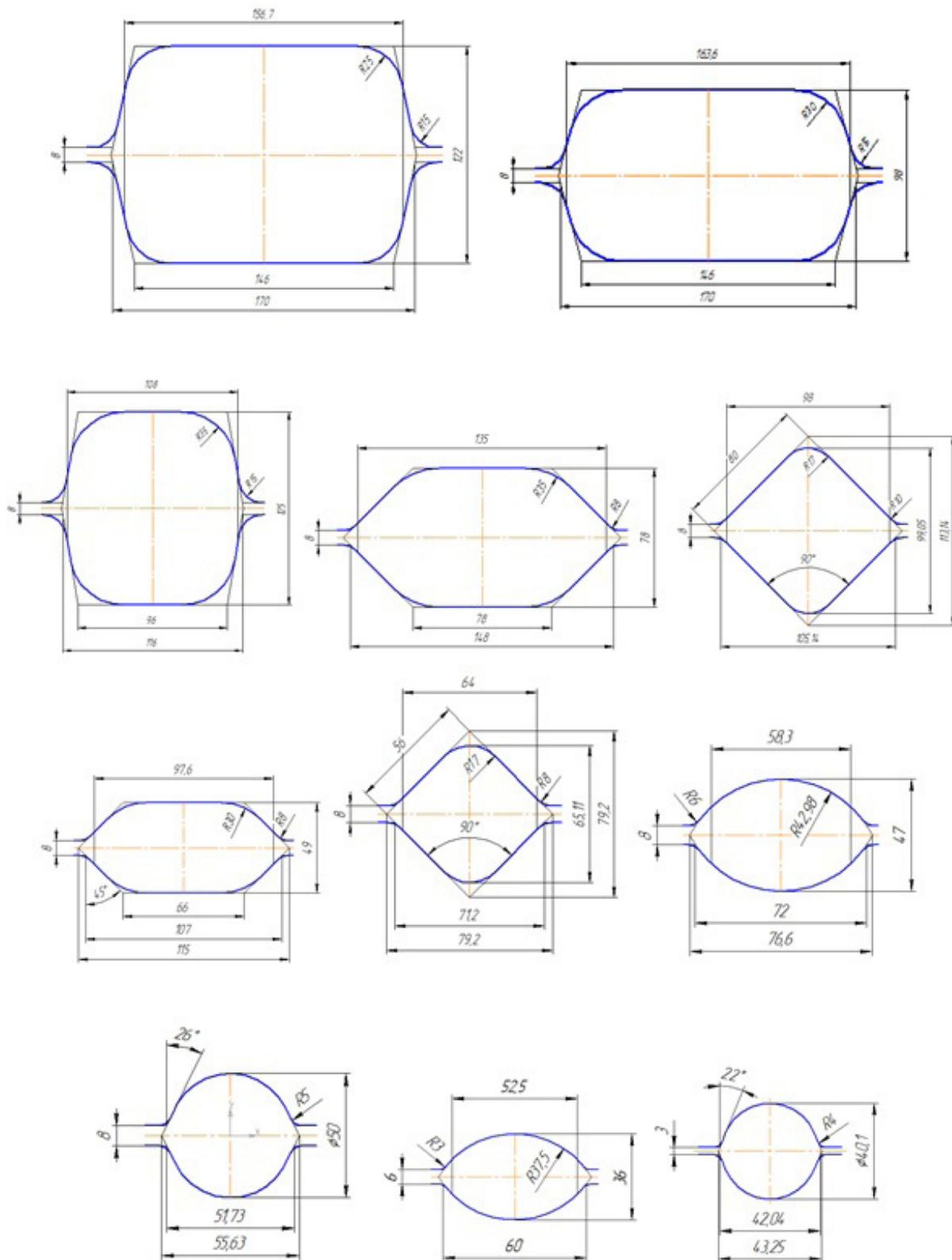


Fig. 1. Calibration of rolls for rolling round steel with a diameter of 40 mm from the billet 150×150 mm: a - after the 7th passage, b - after the 11th passage.

Table 2. Energy-power parameters of rolling of round steel with a diameter of 40 mm from initial 150 mm × 150 mm billets.

Crate	Pass	Metal		Temperature, °C	Deformation resistance, MPa	Average contact pressure, MPa	Rolling force, kN	Rolling torque, kN·m	Drive torque, kN·m
		H, mm	B, mm						
	0	150	150	1200					
500	1	122	156,8	1192	67,8	81,7	1019	77,6	124,4
	2	98	162,8	1185	71,5	83,7	1025	71,8	
	3	125	110	1181	74,1	93,3	863	74,2	
	4	78	140	1172	87,8	91	1074	89,2	
	5	99,1	98	1168	88,3	96,2	729	73,7	
	6	49	95,6	1154	99,6	104,4	808	62,6	
	7	65,1	64	1145	94,9	106,2	443	39,6	
420	8	47	57,8	1122	96,7	110,3	294	13,4	42,7
300	9	50	50	1087	111,4	142,4	252	9,3	27,9
	10	36	53,7	1078	126,4	145,2	303	10,5	
	11	ø 40		1070	126,9	155,5	241	9	

metal temperature equals 1070°C after last 11th pass. The finished round bars with a diameter of 40 mm cool down to about 1045°C passing from the finishing crate to the stepper fridge. Thus, the rolling of 150mm×150 mm billet to round steel with a diameter 40 mm by 11 passes proceeds in the temperature range valid for the implementation of the plastic deformation of steel, i.e. the rolling is completed prior to reaching the minimum allowable steel temperature of 950°C.

The energy-power parameters of rolling 150 mm × 150 mm billets to round steel with a diameter 40 mm are at an acceptable level. In particular, the values of the rolling torque do not exceed the permissible values of the drive torque. This suggests that the proposed calibration of the rolls can be implemented on the existing rolling equipment without any reconstruction required.

#### Estimation of the profile shape and size

In order to assess the conformity of the final profile shape and size to the requirements of GOST and to identify possible defects in geometry of the specimen

during the rolling, it was decided to conduct computer modeling of the rolling of round steel with a diameter 40 mm from initial 150 mm × 150 mm billets using the software package Simufact Forming [11]. For this a three-dimensional solid model of the specimen and the rolls was built with the application of in the KOMPAS program. Since the simulation does not provide the inclusion of all real conditions referring to the deformation process, the following assumptions are made:

1) the specimen is an isotropic and homogeneous body; it does not contain any defects, discontinuities or inclusions;

2) the specimen is made of steel SH3, which is an analogue of steel 60 according to GOST 1050-88. Therefore, AISI 1060 steel, which is analogue of steel 60, is chosen for the simulation;

3) the specimen size refers to 150 mm x 150 mm x 400 mm. It is divided into finite elements, while the base condition for the split is not the number of elements, but their volume accepted equal to 3 mm<sup>3</sup>. This corresponds to a high degree of accuracy. The result is a generated

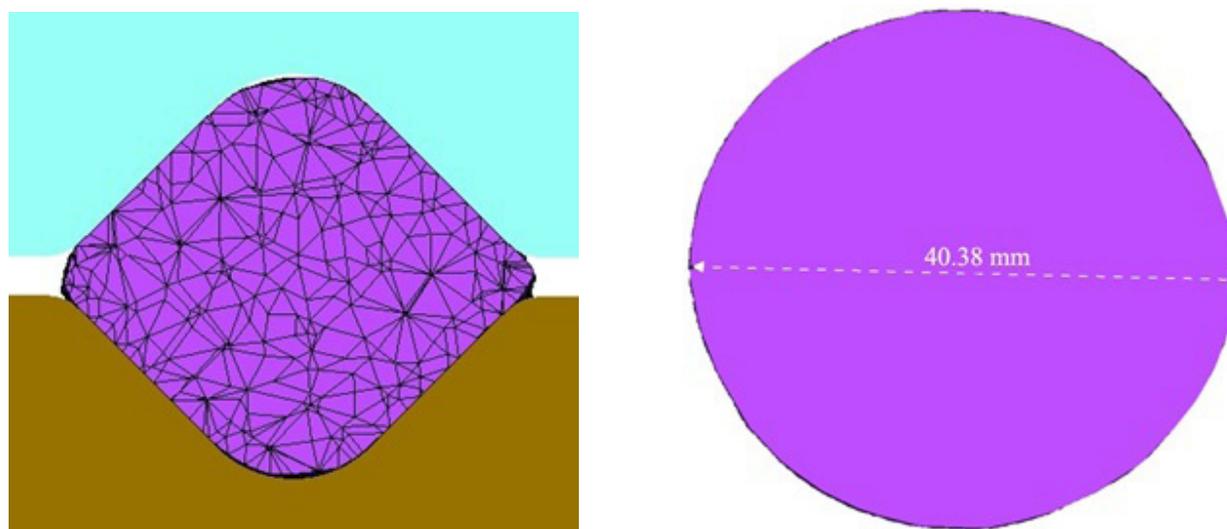


Fig. 2. Shape and size of a rolled profile.

mesh consisting of 3 000 000 finite elements;

4) the friction coefficients of the contact metal with the rolls in all the aisles are taken equal to 0.3.

It is agreed to consider the shape and the size of the profile after completing the 11<sup>th</sup> pass as well as the 7<sup>th</sup> pass, when the specimen emerges from the latest caliber of the breakdown crate. This choice is done in accordance with the calculated data (Table 1), that is the crate where the maximum stretching values are observed leading to the most intense deformation. The simulation results are presented in Fig. 2.

After the 7<sup>th</sup> pass the specimen conforms completely to the caliber shape. Caliber overflow and metal flowing to the side clearances is not detected. Any geometry defects in longitudinal direction (along the length of the specimen) are also not found. After the 11<sup>th</sup> pass of the specimen a cross section in the shape of a circle with a diameter of 40.38 mm is obtained. According to GOST 2590-2006, B2 accuracy class limit deviation is  $\pm 0.8$  mm for a diameter of 40 mm. Therefore, we can conclude that the proposed calibration allows obtaining the desired rolled diameter of 40 mm from the billet cross section of 150 mm x 150 mm meeting fully GOST requirements in respect to geometrical parameters.

## CONCLUSIONS

Square 150 mm×150 mm billets, technologically not applicable to the existing schemes of calibration of 320 MPZ JSC “SSGPO” mill and the presence of undeveloped potential production capacity of this mill

greatly deteriorate its performance. The solution of these drawbacks is the introduction of a new calibration for rolling of round steel with a diameter of 40 mm from 150 mm×150 mm billets not applicable for the production of grinding rods of a diameter of 100 mm. A new calibration can increase the performance of the mill by increasing the mass of the initial billet with approximately 37 %.

The newly developed calibration for obtaining round steel with a diameter of 40 mm fully conforms to the technical parameters of section mill 320 MPZ JSC “SSGPO”. The technology of rolling round steel with a diameter of 40 mm from initial billet 150 mm×150 mm billets has the following advantages over the current technology:

- the increased mill productivity will reduce the consumption of electric energy;
- improvement of the steel macrostructure quality with the elimination of the cast billet axial porosity – thus total stretching  $\lambda_z = 17,8$  is provided with no billets casting defects;
- unification of the mill calibration - the same blanks can be used to obtain steel with a diameter of 40 mm and 100 mm;
- elimination of 150 mm × 150 mm billets remelting determined by the chemical composition of the rolled round steel with a diameter of 100 mm.

The introduction of the technology will ensure improvement of the technological scheme of production of rolled products of MPZ JSC “SSGPO” eliminating all negative aspects of the current technological scheme.

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