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# *Structural Investigation of a High-Chromium Material Used as an External, Working Layer of a Bimetallic Mill Roller*

**Peter Ivanov**
*"CENTROMET" JSC*
Vratza, Bulgaria
petarv@abv.bg

**Ivan Georgiev**
*Institute of Metal Science, Equipment and Technologies with Centre of Hydroaerodynamics "Acad. A. Balevski"*
*Bulgarian Academy of Sciences*
Sofia, Bulgaria
ivan_georgiev51@abv.bg

**Angel Velikov**
*Institute of Metal Science, Equipment and Technologies with Centre of Hydroaerodynamics "Acad. A. Balevski"*
*Bulgarian Academy of Sciences*
Sofia, Bulgaria
anmabg61@gmail.com

***Abstract* - The bimetallic mill roller has been produced by the method of vertical axis centrifugal casting. The processes, accompanying the formation of the structure of the external (working) layer from high chromium material of the bimetallic roller have been investigated. A mathematical model for the geometry of the working layer was created. By using the MAGMA Soft software package, simulations of the processes of casting and crystallization have been made. A metallographic assessment of the microstructure has been made.**

***Keywords* - metallographic assessment, simulation, thermodynamic state**

## I. INTRODUCTION

The development of construction worldwide requires the introduction of new characteristics for the materials used in the construction of buildings. This in turn increases the challenges facing the ceramic industry - new raw materials (combinations of different types of clay) are introduced into production, which have radically different abrasive parameters than traditionally used ones.

Mixtures for production of roof- tiles and bricks are ground by machines similar to the one shown in Fig. 1.

Manufacturers of ceramic construction products have to constantly look for a trade-off between durability and peripheral roller speed to maximize the productivity of the technological process.

In the manufacture of rollers for machines for the ceramic industry through stationary (bottom) casting, the currently optimal option has been found by using cast iron with a high chromium content (over 20%) and a hardness exceeding 700 HV, and as a result the rollers made of such material has a significantly higher wear resistance than the rollers made of the widespread chilled, chilled spheroidal-graphite (ductile) and bainitic cast irons, while maintaining the same peripheral speed of 20 m/sec [1,2,3].

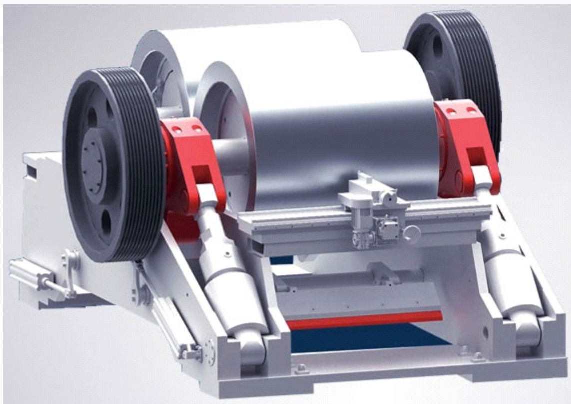

Fig. 1. Grounding machine

The final structure of each cast material is bearer of the physical parameters of the casting. The requirements for the exploitation properties of the casting of a type " roller" are that the external work surface must be of high hardness and wear resistance, while the internal connecting and base surface must be with a good workability and to withstand the heavy workloads. It is these requirements that lead to the idea that the casting must be made of two types material: the external work surface of a durable cast iron (in this case, high Cr content) and internal of a grey cast iron. Having in mind the difficulties at machine

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processing, an additional requirement is set - the external surface to be in shape and dimensions as close as possible to those of the finished roller. This type of two-layer casting can be accomplished by applying the method of vertical axis centrifugal casting by successive pouring of the melt .

## II. MATERIALS AND METHODS

In the production of "CENTROMET" JSC, a successfully working prototype of a bimetallic mill roller with a vertical axis of and an external working layer of cast iron with a high content of chromium (over 20%), was produced.

For this purpose a special moulding equipment was constructed and made according to the desired configuration of the casting. The parameters of the casting mould are internal diameter 1,24m and height of the cavity in the mould 0,96m.

The values of the technological parameters for forming the cast were determined, namely: the amount of the melt for the first and second layer, the mass rates of melt pouring into the cavity of the metal mould, the type and thickness of the heat-resistant and thermally insulating coating on the working surfaces of the vertical shape, the pouring temperatures of the two types of melt, the angular velocity of the mould at forming of the casting (300 $s^{-1}$) , and the pause after the end of pouring of the first layer and the beginning of pouring of the second one (table 1). A mathematical model of the geometry of free surface of the first layer of melt at a constant angular velocity of formation , volume of the melt and pressure of the liquid metal on the solidified layer of the casting, has been created.

TABLE 1 TECHNOLOGICAL PARAMETERS

| *layers* | *m, kg* | *ρ, kg/m³* | *casting/flooding time, s* | *pause of flooding, s* | *number of steps* |
|---|---|---|---|---|---|
| ***1*** | 2100 | 6835 | 30 | 0 | 40 |
| ***2*** | 1900 | 6897 | 27 | 280 | 30 |
| ***3*** | 1300 | 6897 | 23 | 307 | 30 |
| ***4*** | 2676 | 6897 | 100 | 350 | 30 |

Specialized software has been developed for calculation the free surfaces at a multilayer system and applying the method of sequential pouring of the melt (Fig.2 and Fig.3).

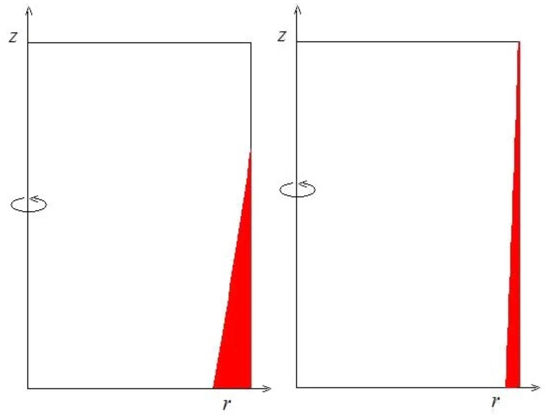



Fig. 2. Calculation the free surfaces at a multilayer system

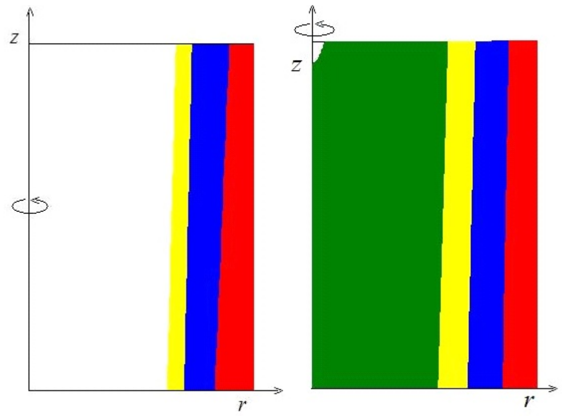
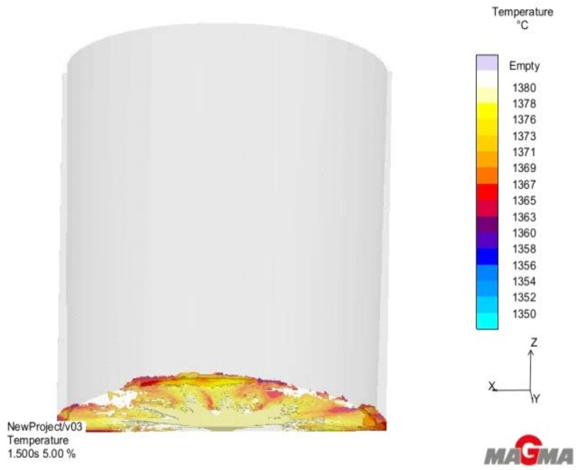



Fig. 3. Calculation the free surfaces at a multilayer system and applying the method of sequential pouring of the melt

## III. RESULTS AND DISCUSSION

### *A. MAGMA Soft simulation*

Simulation of crystallization and arising stresses was made by the help of (Fig.4).



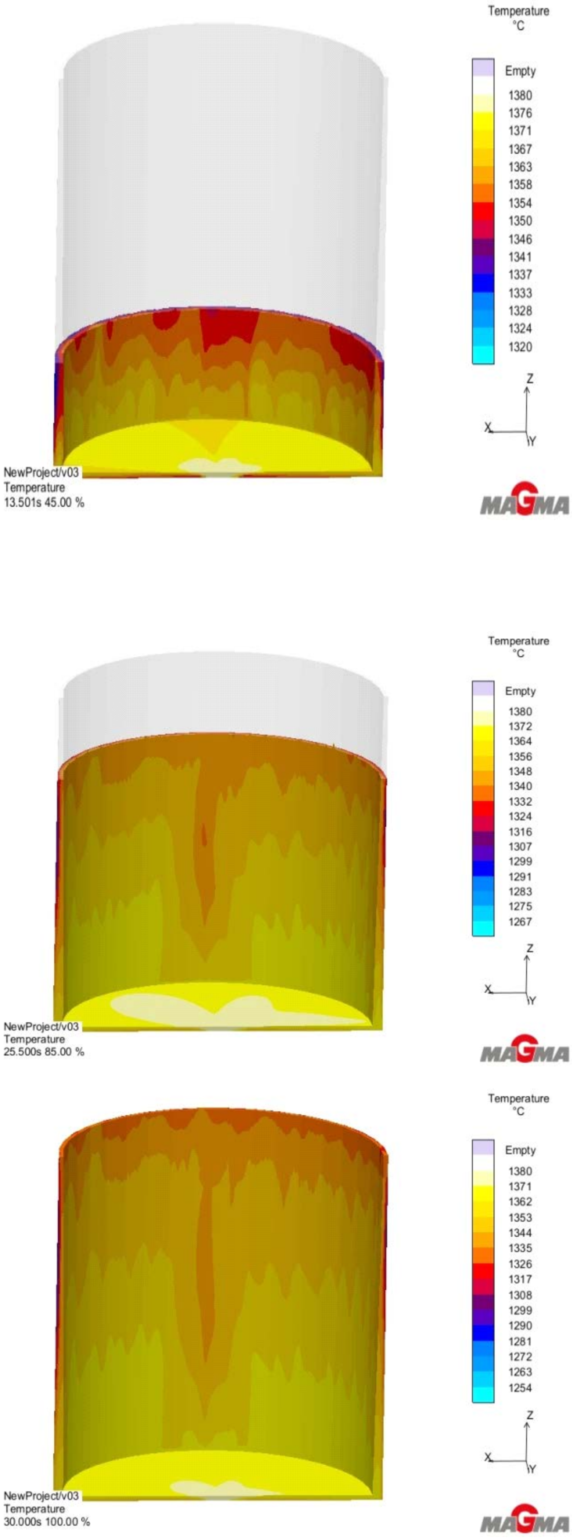



Fig. 4. Simulation of crystallization and arising stresses

Simulation of the thermodynamic state of the system in the different stages of casting was performed.

A simulation of the processes of structure formation was performed.

*B. Microstructure of the external (working) layer made of material with high chromium content*

From the cast, a sample was cut, which was prepared according to the standard methodology for metallographic observations. The metallographic analysis was performed with an OPTON metallographic microscope.

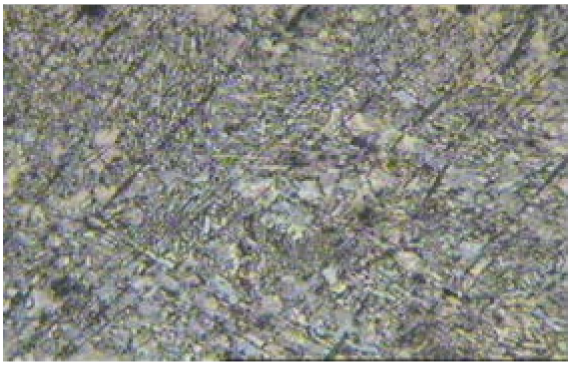


Fig. 5. I layer - Chromium carbides + metal base - x50

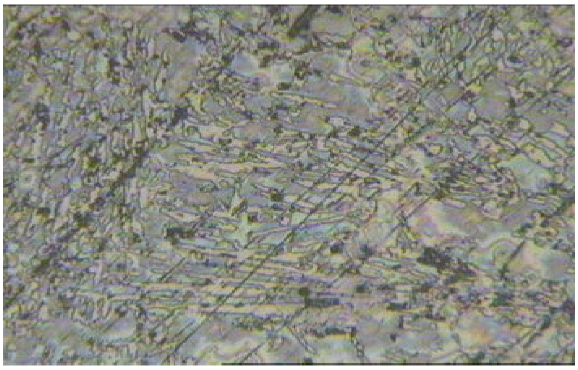


Fig. 6. I layer - Chromium carbides + metal base – x100

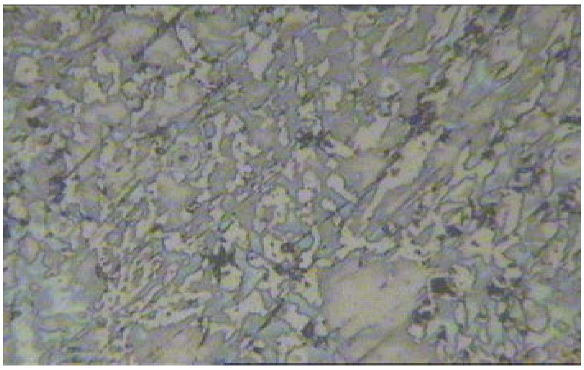


Fig. 7. I layer - Chromium carbides + metal base – x200

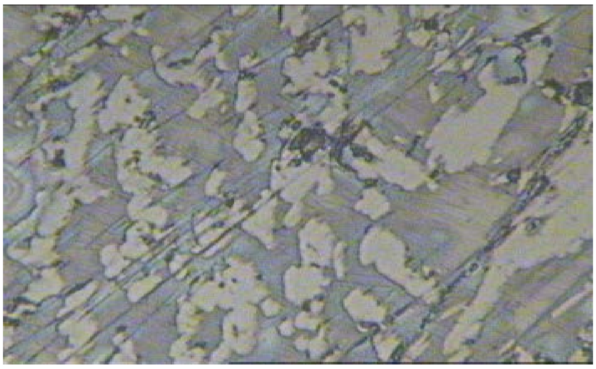


Fig. 8. I layer - Chromium carbides + metal base – x500

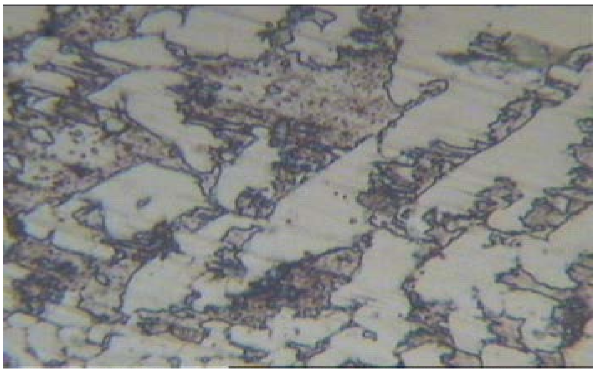


Fig. 9. I layer - Chromium carbides + metal base – x1000

## IV. Conclusions

1. A material with a hardness of 730 ± 30HV was obtained.

2. The structure confirms that the working layer of such material will have the necessary wear resistance, which is the aim of this research.

3. The working properties of the obtained material are confirmed by testing the mill roller in real, production conditions.


## Acknowledgments

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