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ANALYSIS AND DEVELOPMENT OF FOOT ROLLER UNIT OF THE SECONDARY COOLING ZONE OF BILLET CONTINUOUS CASTING MACHINE

Abstract. *The secondary cooling zone of the continuous casting machine is designed to solidify and support the casted slab. During solidification combined stresses cause buckling of ingot skin. Determining the design parameters of the continuous casting machine to achieve high quality and productivity is still of current interest. Thus, upgrading of the continuous casting machine equipment in order to produce the billets of high quality is a priority. The purpose of the study is to analyse and develop the foot roller unit of the continuous caster secondary cooling zone*

Key words: *continuous casting machine, secondary cooling zone, billet, foot block, stress-strain state*

Introduction

The process line operation is limited by the service life of roller guides. When rollers come in contact with hot metal they are exposed to cyclic thermal stresses and mechanical loads from the ferrostatic pressure of liquid steel. It, in turn, leads to wear, cracking, and sometimes to breakage of the rollers [1], therefore, when choosing an inter-repair period, it is necessary to pay special attention to increasing of the roller resistance to wear [2] and fatigue strength, which significantly depend on the correct choice of material.

The cooling mode is to provide the minimum duration of slab complete solidification and the absence of surface and internal defects, while the water consumption during the casting of killed steel is from 0.4 to 1.0 m^3/t at a withdrawal speed of 1.0-1.4 m/min.

Ferrostatic pressure of liquid metal can cause buckling along the slab edges. To prevent this frames with the foot rollers located on all four sides of the slab are installed in the secondary cooling zone.

The hardness of the slab grows, as the distance from the mould and the thickness of the solidifying skin increases that is why the diameter of the rollers in downstream sections becomes bigger.

Analyzing the data of the macrostructure control of the continuously cast billet manufactured by the CCM using the records on the distribution of intrashop rejects supplied by quality control department of MSP for a period of one year, it can be concluded that the main defect in the shape of the billet is the wrong geometrical parameters of the billet section [3].

During the production, process breakouts happen in the area between the mould and foot roller unit of the secondary cooling zone after the billet leaves the mould. Failure to comply with casting modes as well as design deficiencies of secondary cooling zone units with regards to the distance between the mould and the first line of cooling zone rollers, the first line and the second line rollers, the second line rollers of the secondary cooling zone and the first roller of the bending area are the main reasons for the breakouts. The big distances cause buckling of the billet between the rollers. The resulting defect (buckling) is an obstacle for the billet drawing and it leads to the formation of cracks through which the molten metal leaks out, and the manufactured slab is treated as reject.

The existing foot rollers of the mould manufactured by VAI FUCHS have been analysed to determine the effect of the design of the roller unit located under the mould on the geometric parameters of the billet. The hanger consists of a base, which is attached to the bottom plate of the mould. The support brackets of the angle section are fixed to the base, equipped with two rows of holes into which the roller assemblies with axes and plain bearings are installed. The brackets are installed with respect to the foot roller base, taking into account the basic radius of the continuous caster. Nozzles of the billet cooling system are attached to the base. The water is supplied between the rollers.

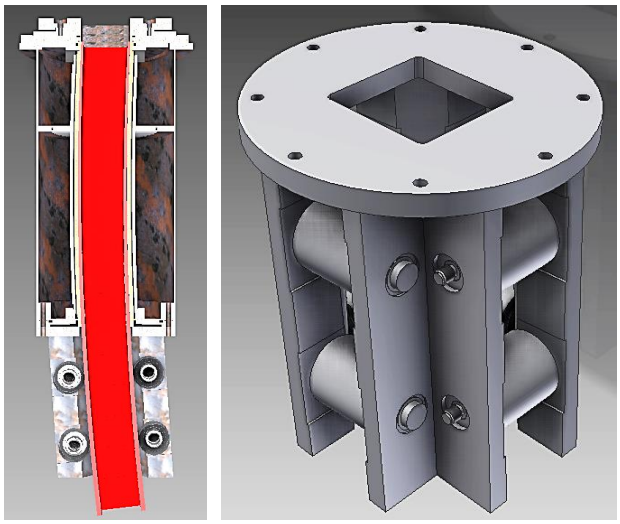

Fig. 1. The foot roller unit with two lines of rollers

To reduce the bearing pressures between the rollers and the billet leading to the deformation of the billet surface and geometry, it is proposed to change the design of the roller hanger of the mould secondary cooling zone.

Three lines of rollers are to be installed instead of two ones taking into account the basic dimensions of the base and brackets, thus the distance between the rollers

will become smaller but the geometric parameters of the metal structure will remain unchanged.

Fig. 2. The foot roller unit with three lines of rollers

Analysis of the stress-strain state of the rollers of the existing and proposed design of the mould hanger unit of the billet caster is performed in the Ansys Workbench.

Figure 3 shows the final results of the calculation of the stress-strain state of a 3D model of a mould, equipped with a hanger unit with two lines of supporting rollers; it shows the maximum values of the calculated parameters (deformations in the billet - $2.5277 \cdot 10^{-6}$ m, equivalent stress (von Mises) – $8.5062 \cdot 10^{6}$ Pa).

The same measures have been taken as in case with the hanger unit with two lines of supporting rollers. The size of the rollers and the dimensions of the hanger unit remained the same, the pitch of the roller belts has changed. A computer model has been developed in Autodesk Inventor solid-state modelling, an analysis of the computer model of the hanger roller unit has been performed in the Ansys Workbench, as a result of which a image of the stress-strain state of the object has been obtained.

Figure 4 shows the final results of the calculation of the stress-strain state of a 3D model of a mould, equipped with a hanger unit with two lines of supporting rollers; it shows the maximum values of the calculated parameters (deformations in the billet - $1.792 \cdot 10^{-6}$ m, equivalent stress (von Mises) – $5.2872 \cdot 10^{6}$ Pa).

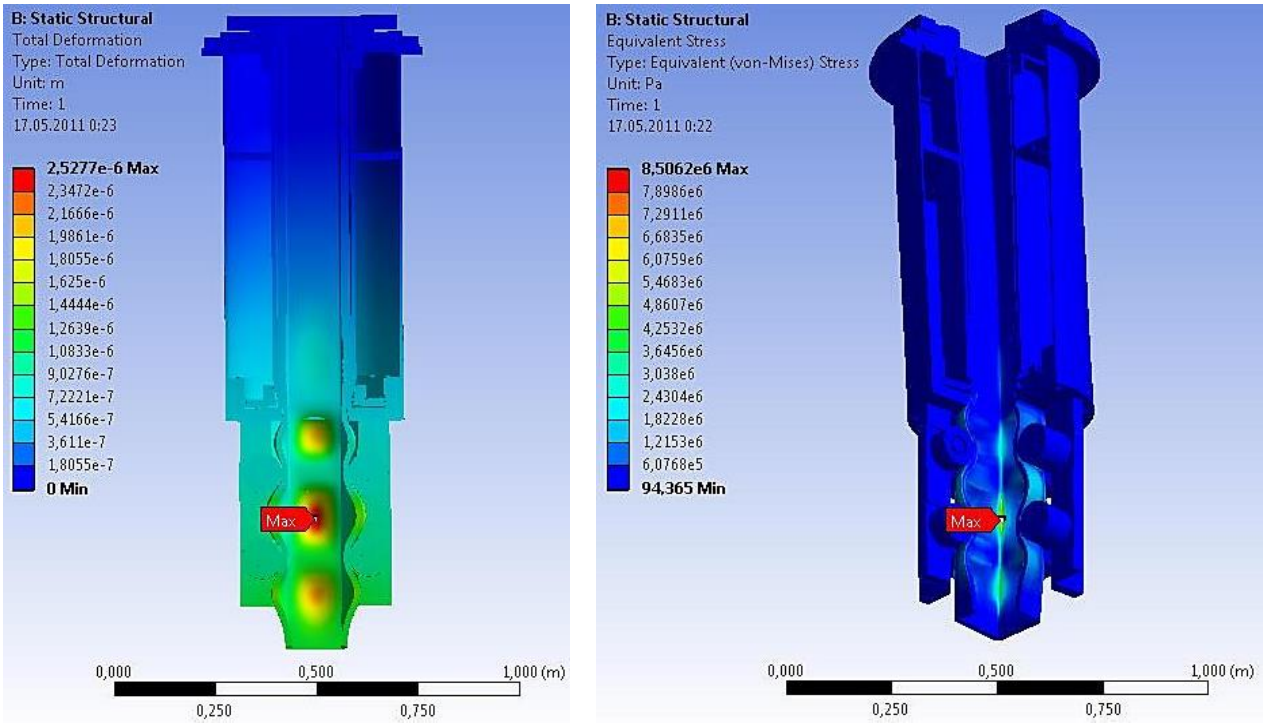

Fig. 3. The calculation results of the stress-strain state of a 3D mould model with a hanger unit with two lines of supporting rollers

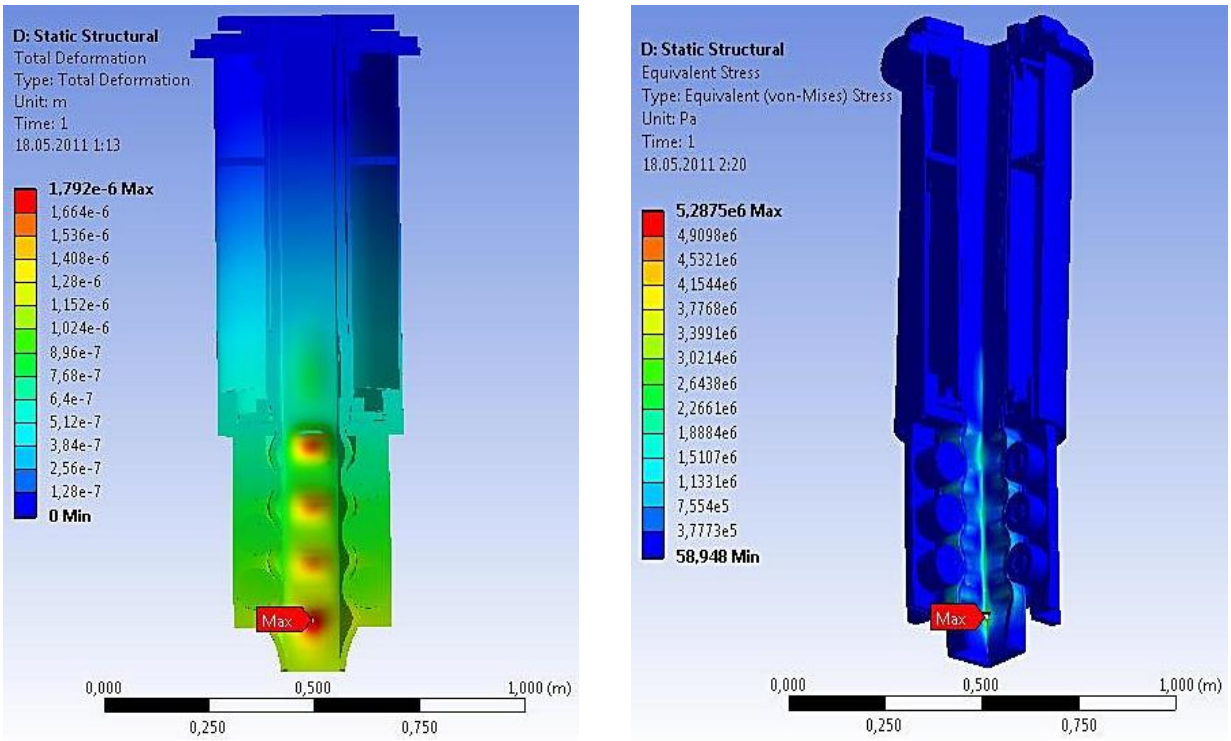

Fig. 4. Image of the stress-strain state of a 3D mould model with a hanger unit with three lines of supporting rollers

According to the results of the calculation, it can be seen that the main load is applied between the first line of rollers and the base and downstream the third line as well. The maximum values of deformation can be observed in the outer radius of the billet (the maximum value is reached after the third line of rollers), and the maximum pressure can be detected at the adjoining edges (downstream the third line of rollers). The calculations show that the total deformation of the billet and the hanger has decreased by 30%, and the resulting equivalent stress - by 38%.

The change in the design of the hanger unit of caster secondary cooling zone has led to decrease in the load at the contact points with the casting billet.

The hanger roller unit has been manufactured (Fig. 5), the necks of the rollers have been cladded using friction method to increase their strength and reduce their wear [5], and it is planned to use this equipment in the production process.

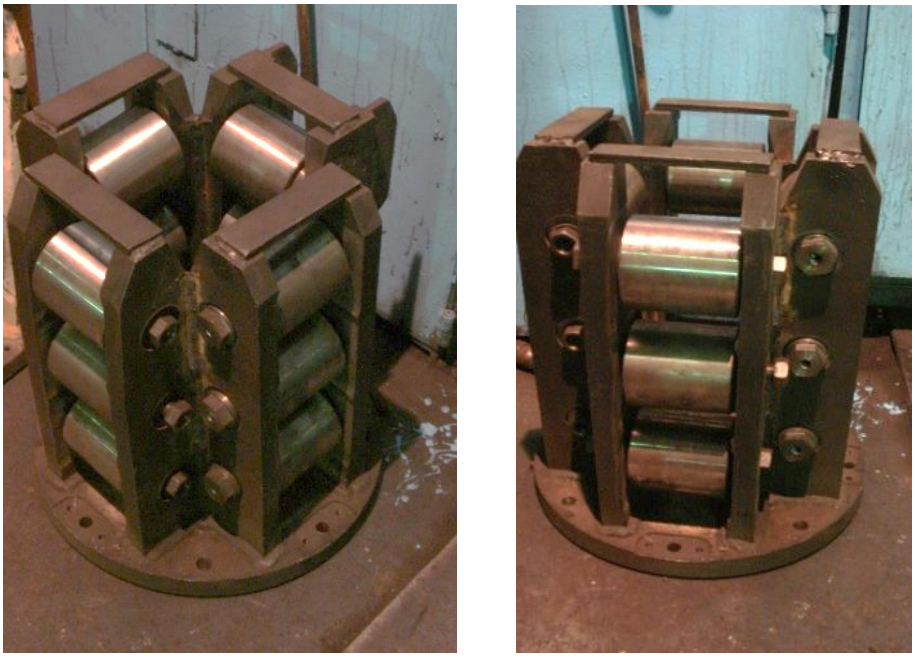

Fig. 5. Three section hanger roller unit of billet caster secondary cooling zone

Conclusion

The analysis of the patterns of the stress-strain state of the billet with a liquid core and the rollers located in the area of billet output from the mould has been carried out; it has showed that the area between the first and the second lines of the roller unit is subjected to the main load, the maximum equivalent stresses at this area correspond to $\sigma_{vonMises}$ = 5.2872 10^6 Pa - for a hanger unit with three roller lines and 8.5062 10^6 Pa - for a hanger unit with two roller lines. Stress-strain state of a 3D model of a mould with the hanger unit with three lines of supporting rollers – the deformation in the billet is 1.792 10^{-6} m, the equivalent von Mises stress is $\sigma_{vonMises}$ = 5.2872 10^6 Pa; the deformation in the billet is 2.5277 10^{-6} m, the equivalent von Mises stress is $\sigma_{vonMises}$ = 8.5062 10^6 Pa for the hanger unit with two lines of supporting rollers. It can be concluded that even in case of significant failure to comply with the technological process (casting speed, cooling modes, chemical composition, melt temperature, etc.), the resistance to change in the geometric parameters of the billet at the areas of maximum stress-strain state [4] is increased by 30%.

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INFORMATION ABOUT THE PAPER IN ENGLISH

ИССЛЕДОВАНИЕ И СОВЕРШЕНСТВОВАНИЕ ПОДВЕСНОГО РОЛИКОВОГО БЛОКА ЗОНЫ ВТОРИЧНОГО ОХЛАЖДЕНИЯ СОРТОВОЙ МАШИНЫ НЕПРЕРЫВНОГО ЛИТЬЯ ЗАГОТОВКИ

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Аннотация. Зона вторичного охлаждения машины непрерывного литья заготовок предназначена для затвердевания и поддержки отливаемого слитка. При затвердевании происходит воздействие силовых факторов, вызывающих выпучивание корки слитка. Актуальными являются задачи, связанные с определением конструктивных параметров машины, направленные на достижение высоких показателей качества и эффективности производства. Таким образом, совершенствование оборудования машин непрерывной разливки, направленное на выпуск заготовок повышенного качества, является актуальной задачей. Целью исследования является совершенствование конструкции подвесного роликового блока зоны вторичного охлаждения МНЛЗ.

Ключевые слова: машина непрерывного литья заготовок, зона вторичного охлаждения, сортовая заготовка, подвесной блок, напряженно-деформированное состояние

Ссылка на статью:

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