The process of production of a continuously cast billet with a 180 × 180-mm cross section made of SWRY11 or sv08A steel was put into operation in the oxygen-converter plant of ChMK from March to June in 2011.

114 heats were performed to adjust this process. The complexity of the problem consisted in the necessity of providing a high capacity of the continuous caster and a high-quality macrostructure of billets, including the absence of gas bubble defects, at a limited grade aluminum content (no more than 0.01%).

The following basic problems were solved during the adjustment of the process of production:

(1) We determined the quantity, temperature, and chemical composition of cast iron required for making SWRY11 and sv08A steels in a converter. For the process in a converter to be stable, cast iron for making SWRY11 and sv08A steels must have a stable chemical composition and temperature. In the case of three working blast furnaces, this requirement is met only using a mixer. The consumption of cast iron per heat should be at least 910 kg/t and its minimum temperature should be 1320°C. The chemical composition should provide the required caloricity during a heat. This imposes limitations on the silicon content (no less than 0.7%) and the manganese content (no less than 0.4%). The sulfur content should be at most 0.025% in making “pseudounkilled” steel: this makes it possible to decrease the time of processing in a ladle–furnace unit (LFU) to 40–60 min.

(2) The first and second cutoffs of converter slag using the MONOCON cones and system was adjusted. As a result, we decreased the quantity of slag entering into a ladle in tapping to 0.7–1.0 t. The slag cutoff efficiency depends on the state of converter tap-hole and the converter slag viscosity.

(3) We determined the quantity of deoxidizers to be entered into a ladle in tapping from a converter. We gave preference to the addition of pig secondary aluminum in tapping, and the quantity of aluminum depends on the carbon content during the turndown of a converter and the final blow time, which should not exceed 40 s at a carbon content of 0.08% or more. At a lower carbon content, no final blow is allowable. We achieved stable initial LFU processing conditions due to a differentiated quantity of aluminum in tapping from a converter (consumption of 1.4—2.0 kg/t). The metal oxidation determined from the first heat sample was 20—100 ppm.

(4) The alloying of a metal by manganese- and silicon-containing materials is fully transferred to an LFU. For rough manganese finishing, siliconmanganese and carbon-containing ferromanganese should be used. If necessary, metallic manganese is used when the carbon content in a metal is close to the upper grade content. To decrease the “gas bubble” probability, it is necessary to obtain a silicon content in a metal in LFU that is close to the upper grade limit of 0.03%.

Owing to these measures, we were able to increase the assimilation of ferroalloys and the accuracy of manganese, carbon, and silicon content finishing.

(5) An aluminum grit is used to perform deep deoxidation of the slag in LFU and the FeO content in the slag is controlled. The grit consumption is 0.7—1.5 kg/t. The FeO content in the slag should be lower than 1% to create conditions for diffusion steel deoxidation and to achieve a high degree of desulfurization. The slag quality can be estimated from the rate of melt desulfurization in processing. The sulfur content should be decreased by 50% upon LFU processing.

(6) We used repeated (at least three measurements per heat) control of the metal oxidation during LFU processing and the correction of oxidation using dou-
ble or triple introduction of aluminum rods. As a result, the metal oxidation at the end of LFU processing is stably low (lower than 10 ppm) at a relatively low aluminum content. To provide satisfactory steel fluidity in the continuous billet caster, the last addition of aluminum to LFU should be performed 20 min (at latest) before the ladle is prepared for pouring. The primary products of steel deoxidation by aluminum are intensely removed immediately after the introduction of aluminum. As a result, we achieved $\frac{Al_{\text{oxyg}}}{Al_{\text{total}}} > 0.95$.

(7) The introduction of large volumes of a powdered wire filled with FK30 ferrocalcium improved the steel fluidity in the continuous billet caster. The wire introduction rate is 180–200 m/min, and the amount of introduced FK30 wire is varied from 500 to 800 kg/heat. Prominence was given to the quality control of the ferrocalcium powdered wire supplied to the metallurgical works.

At the initial stage of experimental works, we used a powdered wire filled with FK40 (40% calcium). The introduction of the wire was accompanied by swirling and slopping of the metal and slag in the ladle. To decrease the intensity of emission of calcium vapor along with oxide particles, we used a wire with a lower calcium content (FK30, 30% calcium).

To increase the efficiency of calcium processing, calcium should be fed after aluminum finishing. The distance from the end of the tribe apparatus guide to the melt in the ladle should be at most 400 mm, and a wire should be introduced into the metal vertically and close to the center of the ladle. The wire introduction rate for a KS 160 ladle is at least 3 m/s.

Satisfactory fluidity of steel with 0.01% aluminum can only be achieved if the metal contains 0.002% calcium or more. The assimilation of calcium by low-silicon low-carbon steel usually does not exceed 1%, and the degree of assimilation depends on the subsequent blowing and the time of metal residence in the ladle. The rate of removal of $\text{Al}_2\text{O}_3$ inclusions increases when the melt is processed by a calcium-containing wire, which is caused by the transformation of the inclusions into easy-to-remove liquid calcium aluminates.

The efficiency of calcium processing decreases when the sulfur content in a metal is higher than 0.014%. In this case, part of calcium is consumed to form refractory sulfide CaS, which promotes nozzle clogging along with alumina.

(8) To increase the seriation of continuous casting, SWRY11 and sv08A steels were cast in the continuous billet caster after casting of st1ps (SAE1006) steel.

The main problem limiting the capacity of the continuous billet caster was metal path clogging: about 30% of heats of SWRY11 or sv08A steel were terminated during implementation.

An analysis of the nozzle clogging material performed on a DRON-2.0 diffractometer showed that the main phases are refractory compounds $\text{CaAl}_2\text{O}_9$ (CaO $\cdot$ 6Al$_2$O$_3$) and CaS.

The main problem of the macrostructure quality of steel SWRY11 or sv08A billet with a 180-mm square cross section is gas bubbles. To decrease the gas bubble probability, the following conditions must be fulfilled during casting in the continuous caster along with the aforementioned requirements imposed on metal casting and out-of-furnace treatment.

To decrease the secondary steel oxidation in pouring from a steel-teeming ladle to a tundish, it is necessary to seal the joint of the protective tube and the collector of the sliding gate by a sealing fused insert and to arrange a uniform argon flow along the joint perimeter. A sealing fused insert is used to seal the joint of the submerged nozzle and the tundish nozzle. The level of protection against secondary oxidation can be esti-