Comparative effectiveness of steel degassing when degassing at the plants RH and VD

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The main task of the degassing process: the maximum removal of the gases from steel. The circulation (RH), cyclic (DH) and ladle (VD) degassing received the most advancement in the metallurgical practice.

The secondary metallurgy treatment of the Byelorussian Steel Works steel melting plant represents the circulating vacuumizer RH, ladle vacuumizer VD and the facility "ladle-furnace". The steel melting process is made in 100-t arc furnace, the product mix consists of alloyed constructional, carbon steel, qualified and cord steel. The secondary metallurgy treatment peculiarity is that both vacuumizers are provided by one system of vacuum pump, that secure discharging less than 1, 0 Mvap. The system of vacuum pump consists of 5-step stream-jet vacuum pump with two water ring pumps with power 300kg/h when 0,7 mVag, and 120 kg/h when 200mVag. The alternate using of the vacuumizers VD and RH is provided by sliding shutter. In such a conditions the skill interest represents the effectiveness metal comparison using two types of vacuumizers. The secondary metallurgy treatment is realized by two diagrams.

1. Steel melting shop → ladle furnace→ VD→ ladle furnace→ CCM
2. Steel melting shop → ladle furnace→ RH→ ladle furnace→ CCM

It is evidently (1;2) that degassing of unkiller steel is more effective than deoxidized steel because of more intensive carbon oxidation and increasing of bubbles penetrating the metal. Thereby the degassing of underoxidate carbon steel (cord) and alloyed steel is researched. The degassing effectiveness of melt is appreciated by carbon because unlike of nitrogen and oxygen its concentration doesn’t depend on complicated physiochemical deoxidational processes, formation and removal of non metal inclusions (nitrid and oxide), and carbon brought by alloyed may be taken into consideration when composing a balance.

The modern express-method of contents carbon changing is used in the experiments by system "Hidris" of the company "Electro-Nite".

The degassing when handling in the vacuumizer RH

The circulation vacuumizer RH has fittings with an internal diameter 320 mm. The argon is put into the suction fitting, the intensity is 400-500 l/min. The linear speed of liquid metal circulation through the fitting is 100m/sec and corresponds to mass flux average 35t/min. Therefore, the duration of degassing period when the cast of 100 t goes through the vacuumaizer, is not more than 3 minutes. As is determined by the tests, during the fifth degassing cycles (15 min.) the degassing level refering the carbon is 85-92% of initial content. In this immediately after the material addition to vacuumizer not considerable increase of carbon concentration is noted, thereupon that material that contains carbon and ferroalloys have some quantity of humidity. In this connexion the
period of duration from the moment of material addition to the vacuumizer up to the end of degassing process should be not less than 6-7 minutes.

Basing on technological expediency, it is necessary to make an addition to 5-7 minutes in the working exhaust at the camera after the vacuum deoxidation, which can be fixed with a gas analyzer according to the gas off diagram.

The gas off analysis diagram when degassing of steel shows that up to the 17-20 min. of all deoxidizer and carbonizer, the quantity of CO and CO₂ is decreasing and is closed to 0. Beginning from the 20-th minute, the degassing is only aided to metal agitation and equal adoption of materials put before.

On the strength of a/m we can say that the process of unkillod cord steel degassing (degassing on RH) takes not more than 20 minutes. When measuring the carbon contents during the degassing process we have a kinetic equation of the degassing process:

For cord steel:
\[
\ln\left(\frac{[H]}{[H]_0}\right) = -0.082t - 0.020
\]

Where \([H]\) - the carbon contents in the metal at the moment t. ppm;
\([H]_0\) – the carbon contents in the metal before the ferroalloys additions, ppm;
\(t\) – degassing time, minutes

for alloyed steel:
\[
\ln\left(\frac{[H]}{[H]_0}\right) = -0.078t - 0.031
\]

The degassing when handling in the vacuumizer VD

The basic diagram when steel is handling in the vacuumizer "VD" is a technological diagram "Steel melting shop → ladle furnace → VD → ladle furnace" and an essential slag removal before the degassing. During the handling an argon blowing with bared metal mirror was done. After cast handling at the vacuum degassing plant "VD" it was done the addition of lime and calcium fluoride was done to close the arc when heating the metal at the "furnace ladle", the quantity of additions is 300-400 kg and 80-100 accordingly.

The technological diagram "Steel melting shop → VD → ladle furnace" was used as a stand by technology to assure a serial casting. The correction of chemical composition and slag induction at the plant "furnace ladle" was done after the degassing.

The average contents of carbon in metal before CCM is:
- according to the technological diagram "Steel melting shop → ladle furnace → VD → ladle furnace" - 2, 0 ppm
  - according to the technological diagram "Steel melting shop → VD → ladle furnace" - 2,1 ppm
The average metal handling period at the degasser "VD", taking into consideration the time of steel teeming ladle change to degasser and backward and time of slag removal, is:

- according to the technological diagram "Steel melting shop → ladle furnace → VD → ladle furnace" - 63 min.
- according to the technological diagram "Steel melting shop → VD → ladle furnace" - 48 min.

The metal temperature drops during the period of degassing (when changing the steel teeming ladle and slag removal) is:

according to the technological diagram "Steel melting shop → ladle furnace → VD → ladle furnace" - 70-80°C.

For steel degassing at the vacuumizer VD the following kinetic equations are received:

For alloyed steel:

\[ \ln\left(\frac{[H]}{[H]_0}\right) = -0.041t - 0.011 \]

For cord steel:

\[ \ln\left(\frac{[H]}{[H]_0}\right) = -0.028t - 0.004 \]

The result of these kinetic equations is that the degassing reaction speed constant at the vacuumizer RH in all cases is higher than for vacuumizer VD.

Besides it is determined that the addition of 150 kg of lime and 40 kg of calcium fluoride leads to carbon content increase on 1 ppm, and the addition of silicocalcium wire increases \([H]\) on 0.5-1 ppm, it depends on the additional wire.

The hydrogen content change at ferroalloy addition is shown at the picture.

Basing on obtained data we have an empirical equation of hydrogen content dependence in steel when adding ferroalloys

\[ \ln\left(\frac{[H]}{[H]_0}\right) = -0.0003m - 0.027 \]

Where \([H]\) - the hydrogen content in the metal after ferroalloys addition, ppm;
\([H]_0\) – the hydrogen content in the metal before the ferroalloys additions, ppm;
\(m\) – ferroalloys added mass, kg
The trial rolled products analysis showed that the rejected materials possibility, when making the ultrasonic check, is considerably increasing when the carbon content in the metal for carbon steels is more than 4 ppm. For alloyed steels this level is 2,0-2,5 ppm depending on rolled products diameter. When the hydrogen content value is more than 4 ppm, it is necessary to make an antiflocculant rolled material machining at the cooling pit.

At the same time the set min. values of hydrogen content in cord steel less than 2,0 ppm, in carbon steel less than 4,0 ppm and in alloyed steel less than 2, 5ppm, can be obtained during degassing both at RH and VD.

**SUMMARY**

More high degassing melt speed at circulation degassing depends on bigger contact surface of metal and dispersed phase comparing with ladle degassing as a result of big quantity of Co bubbles flouting, argon and metal flowing by way of buttons.

The limit hydrogen content in metal when degassing at RH and VD can be compared, but it is secured under an extract on vacuum when handling on VD. The complete machinering in the circular vacuumaizer (including necessary manipulations with the ladle) is 30 minutes, in VD 50-70 minutes.

**LITERATURE**