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Table of Contents

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Prepared by: N. H. Ng

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Report No. - Metallurgy 1 -

CONTENTS

CHIN-SHU HSÜEH-PAO

ACTA METALLURGICA SINICA

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金属学報

ACTA METALLURGICA SINICA

Vol. 4, No. 3, September 1959

CONTENTS

Certain Problems Concerning Heat Flow through a Blast Furnace Hearth with Carbon Lining

Wan Shu-ming (萬 舒 民)
Institute of Chemical Metallurgy,
Academia Sinica

Radiant Heat Flow in the Hearth of a Combustion-type Furnace

Jen Shih-cheng (任 世 錚)
Northeast Institute of Technology

Change of Mechanical Properties in Rolling Heavy Rails

Chang Tso-mei (張 作 梅)
Gau Tze-ming (高 子 明)
Lei Ming-foo (呂 萌 福)
Institute of Mechanical Engineering,
Academia Sinica

Effect of Cold Process on the Heat Resistivity of Austenite Heat Resistant Steel

Chu Jih-chang (朱 日 彰)
M. L. Bernstein

Certain Structural Changes in Texture of Cold-drawn Copper Wire

Yang Sien-min (楊 先 敏)
Yang Bing-chi (楊 本 祺)
Cheng Kuan-hsi (陳 匡 時)
Lui Cheng-hwan (刘 辰 环)
Koo Chuan-fan (顧 泉 芳)
Institute of Mechanical Engineering,
Academia Sinica

Top Quenching Method for Determining Quenching Permeability and Mechanical Property of Steel

Fang Chih-chung (方志忠)
The State-operated Shen-kuang (晨光) Machine Works

Temper Brittleness of Bainitic Steels

Tan Yü-hua (譚玉華)
Anshan Institute of Iron and Steel Technology

Desulfurization of Cast Iron by Electrolyzing Slag

The Institute of Foundry Practice,
Northeast Institute of Technology

Research Notes

Effect of Manganese-containing Carbide on the Determination of Unstable Non-metallic Inclusion in Steel

Lee Chin-yuan (李静媛)
Chao Shu-hsi (趙淑熙)
Institute of Metal Research,
Academia Sinica

ABSTRACTS

Improvement of Quality of Ball-bearing Steel

I. Effect of Smelting and Casting Practice on Non-metallic Inclusions in Ball-bearing Steel

This paper presents the first part of a study of the quality improvement of ball-bearing steel made in a basic electric furnace. The effect of deoxidation and casting practice on non-metallic inclusions in steel during the steel-making process was investigated.

It was found that non-metallic inclusions in ball-bearing steel could be noticeably reduced with the adoption of the following practices:

1. On slagging off before the reducing period, silico-manganese is added for preliminary deoxidation;

2. addition of crushed calcium carbide is then made to speed up the formation of carbide slag, which should be kept not less than 40 minutes;

3. after this, ferro-silicon powder or crushed calcium carbide is added for slag deoxidation;

4. slag must be white before tapping;

5. it is advisable to tap the slag first and then the liquid steel to render them thoroughly mixed in the ladle to facilitate further elimination of non-metallic inclusions, and

6. finally, add not less than 1/2 kilogram of aluminum per ton of steel.

Good quality ladle lining and runners should be tar-soaked in order to decrease the amount of exogenous inclusions. It was noticed that titanium nitride inclusions in the steel were due to the presence of titanium in ferro-alloys. The making of high quality ball-bearing steel calls for the use of titanium-free ferro-alloys.

Effect of Thickness and Thermal Conductivities of Blast Furnace Bottom Refractory Linings on the Temperature Field of the Bottom

The effect of the thickness and thermal conductivities of blast furnace bottom linings, cooling conditions and the hearth temperature on the temperature field of the furnace bottom was studied by means of the finite Hankel transform. The results are shown by curves. It is pointed out that in a bottom with multiple lining layers, the lower the thermal conductivity of the innermost lining and the higher the thermal conductivity of the outermost lining, the sharper the temperature gradient of the bottom and the smaller the heat loss. Cooling conditions and hearth temperature have a great effect on the temperature field in the bottom.

The author pointed out that the dependence of 1150° C in the furnace bottom on the inner and outer diameter of the hearth and the thickness of its lining layers should be further studied. The effect of the depth of the salamander on the temperature field, especially on the position of 1150° C, and on the temperature of the center of the hearth base, should also be studied further.

It is presumed that when higher thermal conductivity lining material is used as the innermost layer, it may have a "critical thickness". This means that below this thickness, it obeys the principle that the lower the thermal conductivity of the innermost lining layer, the sharper the temperature gradient. The case is reversed when the critical thickness is exceeded.

In a bottom with multiple lining layers, the lower layer with higher thermal conductivity than the upper one displays a "transitional" cooling effect, for which the layer has an effective thickness. This thickness may be a decreasing function of the ratio of the thermal conductivity of the lower layer to that of the upper layer.

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Certain Problems Concerning Heat Flow through a Blast Furnace with Carbon Lining

The effect of thermal conductivities, proportion and distribution of certain refractory lining materials in the hearth of a blast furnace, the cooling and the salamander on the temperature distribution and heat loss was reviewed. The temperature of the bottom having ceramic lining can be decreased by replacing its periphery with carbon lining, which displays a "transitional" cooling effect. This is the advantage of the high thermal conductivity of the carbon lining. The transitional cooling effect has certain effective limit. It is pointed out that the more the temperature of the bottom is to be decreased, the lower the thermal conductivity of the innermost material and the higher the thermal conductivity of the outermost lining layer. This is a very important principle in the problem. By this principle, we see that the transitional cooling effect of the carbon lining appears only when it is not used as the innermost lining. By the same reason, it is obvious that a higher thermal conductivity layer in the bottom, such as, a graphite layer, possesses an underhearth cooling effect.

It is suggested that a new approach to decrease the heat loss is to use a material with the lowest possible thermal conductivity as the innermost lining. A new cooling method, called cascade cooling which is described in this paper, calls for several lining layers in the bottom, of which the inner one has a higher thermal conductivity than the outer one.

It is pointed out that in the existing thermal model for the hearth, the salamander formed actually was not taken into account, and therefore, it is inadequate to describe the actual state of the hearth. This is a great defect of the existing thermal model experiment, but its improvement is described in the paper.

It is proposed that the dependence of the heat flow on the inner and outer diameter of the hearth and the thickness of its various linings should be studied, and that the effect of the lining thermal conductivity on the heat flow and the graphitizing of the carbon lining should be investigated further.

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Change of Mechanical Properties in Rolling Heavy Rails

The effects of roll pass design on the mechanical properties of rails and the changes in mechanical properties in the processes of rolling and the causes for these changes were investigated. The height and the angle of the wedge in the trapezoidal passes were also studied.

The results show that in the trapezoidal passes, a change in the height and the angle of the cutting-in wedge has little effect on the mechanical properties at the foot of the rails; hence it is better to use wedges with a smaller height and a greater angle. It is found that the effect of inhomogeneous deformation on mechanical properties is also small; hence the question of using two or four trapezoidal passes may be settled by consideration of the mill construction and the conditions of production only.

The mechanical properties of the bloom undergo considerable changes when it is rolled through the successive passes. After the second or the third pass, a lowering in mechanical properties is recorded, but after the sixth pass, the changes in mechanical properties become small. When the cooling rate is great, the rolling temperature has little effect on the mechanical properties. Hence, it is possible under this condition to increase the rolling temperature, the amount of reduction and the rolling speed in order to obtain a reduction in the number of passes used.

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Certain Structural Changes in the Texture of Cold-drawn Copper Wire

Diffraction patterns of cold-drawn copper wire obtained by means of W radiation are investigated. The expansion of interplanar spacing, the half-peak width of spots, the peak value ratio of the spot densities corresponding to (111) and (100) fiber axes, etc., are correlated to the amount of reduction of the cross-sectional areas. The difference of the yield-strength of wires of the same total percentage of area reduction and the different number of drawings may be accounted for by the structural changes shown by the difference in texture.

It is shown in the graph that the distribution of the spot densities corresponding to the (111) and (100) fiber axes approximately follows the Boltzmann type distribution law; i. e.,

$$f_{(hkl)} \propto e^{-KE_{(hkl)}} \text{ and } E_{(hkl)} \propto \Delta A/A$$

(the decrement of the wire cross-sectional area).

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The Temper Brittleness of Bainitic Steels

This paper presents a study of the occurrence of temper brittleness in bainitic structure. It is found that the tendency of temper embrittlement in the lower bainite is slightly less than that in the tempered martensite while that in the upper bainite is slightly greater than that in the pearlitic structure. The tendency of temper embrittlement of the tempered martensite is much greater than that of the pearlite. The temperature range of temper brittleness is 460 - 580° C for upper bainite and 430 - 620 ° C for tempered martensite. The temperature of maximum temper embrittlement appears to be approximately 530° C for both. It is suggested that the mechanism of temper brittleness is the same for both structures.

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Desulfurization of Cast Iron by Electrolyzing Slag

This paper presents a method for desulfurizing cast iron by electrolyzing slag. Experimental results obtained with this method warrant the following conclusions:

(1) Among the various methods used for desulfurization of cast iron, the method described in this paper is the most effective and less expensive, especially for cast iron with sulfur content higher than one percent.

(2) The percentage of sulfur reduction increases with the basicity (CaO/SiO_2) of the slag. For example, for slag with basicity of 0.5, the percentage of sulfur reduction is 72, while for slag with basicity of 1.4, the percentage of sulfur reduction is 97.5.

(3) The initial sulfur and carbon content of cast iron has an obvious effect on the process of desulfurization. As the sulfur and carbon content increases, the process of desulfurization proceeds more completely.

(4) There is a critical current density of the cathode (molten cast iron). At the critical point, the percentage of sulfur reduction is the highest. As the current density exceeds the critical value, the percentage of desulfurization decreases.

(5) If it is possible to prolong the process of electrolysis, the percentage of sulfur reduction increases with the time of electrolysis.

The paper also gives a brief discussion on the mechanism of desulfurization by electrolyzing slag.

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CHIN-SHU HSÜEH-PAO
金属学報

ACTA METALLURGICA SINICA

Vol. 4, No. 4, December 1959

CONTENTS

Research Notes

Experiments on Improving the Creep-resistant Strength of Nickel and 18Cr12Ni Stainless Steel

Lin Pao-chun (林保军)
Institute of Metal Research,
Academia Sinica

Temper Brittleness of 65 Mn Steel

Chen Shen (陳 森)

General Review

Continuous Casting of Steel

Chao Hwei-tian (趙惠田)
Chang Shun-nan (張順南)
Institute of Metal Research,
Academia Sinica

ABSTRACTS

Oxidation of Rimming Steel Ingot during Teeming and Solidification

Up till now, it is still controversial about the source of oxygen for the rimming action during solidification of rimmed steel ingots. The purpose of this paper is to carry out an investigation in order to observe the oxidizing action of different atmospheres, such as, oxygen, nitrogen, water, gas and air. Experiments are conducted on large rimmed steel ingots to control the rimming action by controlling the admission of air to the mold during solidification. Analyses of steel bath, and segregation and distribution of impurities in the ingots are also made. It is concluded that secondary oxidation during teeming and rimming is the main source of oxygen. Segregation of steel ingots may be reduced by the control of rimming action with the aid of regulation of air admission to the rimming bath in the mold.

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Continuous Casting of Steel

In this paper, various types of continuous casting machines employed in steel works are described. Design and operation of such machines are discussed and suggestions for proper measures to improve the quality of casting billets are reviewed.

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CHIN-SHU HSÜEH-PAO
金属学報

ACTA METALLURGICA SINICA

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CONTENTS

Acceleration of High-temperature Creep Test by Elevation of Temperature

Kung Ching-ping (孔慶平)
Lin Pao-chun (林保軍)
Ke T'ing-sui (葛庭燧)
Institute of Metal Research,
Academia Sinica

Powder Metallurgy

I. N. Frantsevich
Institute of Powder Metallurgy and Special Alloy Research,
Ukrainian Academy of Sciences

Production of Powdered and Sponge Iron from Iron Scale and Pseudohematite by Means of Natural Gas

I. N. Frantsevich
I. D. Radotysel'sky
Institute of Powder Metallurgy and Special Alloy Research,
Akrainian Academy of Sciences

Research Notes

Change of Internal Friction and Electrical Resistance of Metals and Alloys during Creep Tests

Chang Yi (張翼)
Kung Ching-ping (孔慶平)
Institute of Metal Research,
Academia Sinica

ABSTRACTS

Grain Boundary Migration in Recrystallized Armco Iron during Grain Growth

Grain boundary migration in recrystallized Armco iron during grain growth was studied by means of the vacuum etching method. It was found that grain growth in recrystallized α-ferrite is closely related to the substructures within the ferrite grains. Grains containing no substructures usually grow at the expense of those possessing substructures.

Through tracing and analyzing the grooves remaining after the migration of the grain boundaries and through other observations, we have confirmed the following theories suggested by previous researchers:

1. The main driving force for grain boundary migration is the interfacial energy of the grains.
2. The manner in which grains in metals disappear is basically the same as that of soap bubbles in a semi-vacuum container.
3. Burke's model for the disappearence of old grain boundaries and the formation of new grain boundaries .
4. Grain growth is a discontinuous process.

Isothermal Structural Decomposition in Certain Molybdenum-bearing Stainless Steels

This paper presents a description and discussion of structural changes in certain quenched ferritic, austenitic and duplex stainless steels during subsequent reheating.

In 16-6 Cr-Mo stainless steel, austenite formed at a certain solution treatment temperature is metastable and decomposes during subsequent reheating. New ferrite α' forms at the γ / α interphase boundaries. The rejected carbon atoms then diffuse into the matrix forming alloyed carbides surrounding the γ / α phase boundaries.

Fine carbides precipitated from ferrite in 16-6 Cr-Mo, 16-2.5-6 Cr-Ni-Mo and 16-5-6 Cr-Ni-Mo steels in the early stages of aging are metastable. They redissolve during prolonged heating and are gradually replaced by χ -phase. Some residual carbides serve as the nuclei of the growing χ -phase. The structure of quenched 16-15-6 Cr-Ni-Mo steel is austenitic. During subsequent heating, only M_6C and $M_{23}C_6$ mixed carbides are precipitated.

Both the alloyed carbides and χ -phase may noticeably affect the hardness of the steels studied. In duplex steels, χ-phase is a good strengthener, manifesting pronounced hardening effect at elevated temperature.

On the Method of Accelerating High-temperature Creep Test by an Elevation of Temperature

A series of creep tests was made on four types of heat-resistant steels under the same stress but different temperatures. The creep and rupture rate of five types of Nimonic alloys and four types of heat-resistant steels mentioned in the reference literature was also analyzed. The temperatures of the creep tests and those given in the literature are all above 0.45 T_m (absolute melting temperature) for each type of steel or alloy.

The results of the tests and analyses show that for the temperatures studied, the existence of the activation energy in the process of high-temperature creep is a general phenomenon for the above-mentioned different types of heat-resistant steels and alloys. The possibility of accelerating creep tests by an elevation of temperature through activation energy is pointed out, and the temperature range for the application of this interpolation method and the errors involved are also discussed.

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