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The research of improving the smelting quality of D2 steel

[**Abstract**] The effect of forging ratio and ingot size on the eutectic carbide inhomogeneity of D2 forged bars and the effect of refining process and the surface state of electrode on the oxygen content have been studied. Results show that the forging ratio and ingot size have significant influence on eutectic carbide inhomogeneity of D2, namely the grade of eutectic carbide inhomogeneity of D2 forged bars made by Ø 1100mm ESR ingot decreases with increase of forging ratio at the range of 2 to 8, while the grade of eutectic carbide inhomogeneity of D2 forged bars increases with the increase of the ingot size at the same forging ratio. And the Oxygen Content of D2 can be controlled under 16ppm By the refining process LF+VD. The surface state of electrode also has some great effection on the oxygen of D2 ESR steel, the oxygen content of D2 ESR steel made by casting skin electrode increased 25% than by surface-conditioned electrode.

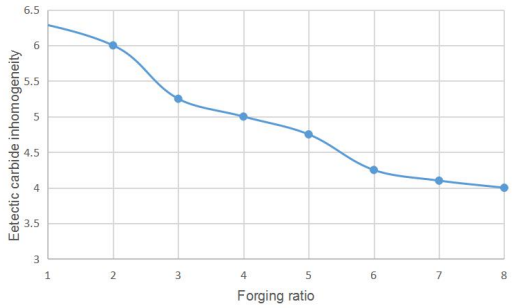
With the use of mold in machinery manufacturing industry growing day by day, the mold performance and service life become an important mark to measure the mold manufacturing level. Among the many factors that affect the quality of mold, the smelting quality and heat treatment level play the most important role. The development direction of high quality mold steel is improving the purity and eutectic carbide inhomogeneity. As the Most popular type of Cold Mould TOOL STEEL, D2/1.2379 tool steel come with the following character : good hardenability and hardening capacity, high wear resistance and small heat treatment deformation. The eutectic carbide inhomogeneity and oxygen content (include oxide inclusions) are the main influence factors to reduce the mold service life after study the molds failure.

1.1 - The process factors that effect eutectic carbide inhomogeneity

The alloy elements of D2 steel e.g., Cr, Mo, V will form a large number of carbides during the solidification and eutectoid transition. Tough the fishbone eutectic carbide can be broken during rolling or forging etc thermal deformation process, but under the influence of rolling or forging direction, the distribution of carbides in steel is still uneven. It will down the steel mechanical property and lead to die deformation and broken etc problems during the heat treatment process when there exist conglomeration carbides and uneven distributed carbides. So the eutectic carbide inhomogeneity is one of the most important technical indicators to measure the quality of D2 steel.

1.1 - 1. Forging ratio

Take Ø 1100mm ESR ingot to study the influence of forging ratio on the eutectic carbide inhomogeneity, forging ratio range between 2 to 8. Refer to the curve variation, we can see that the class of eutectic carbide inhomogeneity downed from 6.0 to 4.0 with the increase of forging ration 2 to 8. When the forging ratio is 4, the eutectic carbide inhomogeneity is Class 5.0. General speaking, the forging ratio can only be a brief description of forging effect, it can not accurately reflect the changes of microstructure and steel performance. So in actual production, on the premise of a certain forging ratio, it need to increase the times of upsetting during the stretching process, to ensure that the carbide is fully broken.



1.1 - 2. Ingots size

With the rapid industry development, the need and use of large size ingots is increasingly widespread. But as everyone knows, The Large Size ingots certainly will lead to a decrease in the cooling rate, thus intensify the chemical composition segregation. For the ledeburite steel D2, the increased segregation will further promote the aggregation and growth of eutectic carbide particles. Refer to the production experience of HSS (high speed steel), the slab ingot can greatly improved the cast micro-structure, but in the metallurgical industry the general used large size ingots shapes is polygonal ingot for forging hammer. In this paper, the eutectic carbide unevenness at R / 2 of round steel forged with dodecagonal ingot and octagonal ingot was studied. Refer to the data and metallography film in the table 2 and photo 2, it can be founded that at a same forging ratio,

A photo - forging ratio 3.1 - the carbide in the steel arranged in a thick and complete net.

But for the B photo, the distribution of carbide get greatly improved even the forging ratio is 2.9, although the carbides also form a continuously elongated and relatively complete net, but the net wall is thin, thick cumulate reticulate carbide only be found in part. The test results show that the class of eutectic carbide of large size dodecagonal ingot is higher than octagonal ingot, means the cast micro-structure have greatly influence on the distribution of carbide particle size of finished material. So during the real production, we need to select a suitable ingot size which based on the size of finished steel bar, to avoid such kind of problem that obtain a poor eutectic carbide inhomogeneity while a bigger forging ratio was in taken.

Table 2 - the influence of ingot sizes on the eutectic carbide inhomogeneity

Ingots shape	Ingot average diameter (mm)	Forging ratio	Eetuctic carbide (Class)
Dodecagonal ingot	970	3.1	6
Octagonal ingot	820	2.9	5

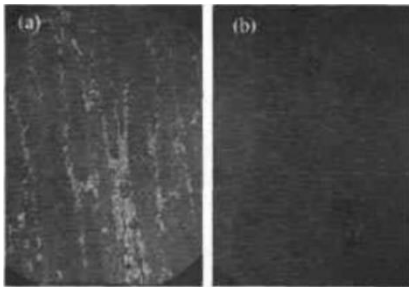


Photo 2 - structure of eutectic carbide inhomogeneity (100X)

2.2 The process factors that affect oxygen content

For the mold materials, the oxide particles and numbers are increasing with the grow of oxygen content, that lead to the decrease of steel fatigue properties. So It's easily produce Hot crack in the process of heat treatment and and using. To reduce the content of oxygen is become a trend of developing high quality mold steels. In this paper, the

influence of take LF+VD & ESR process on oxygen content were studied.

2.2.1 The influence of LF+VD

For LF+VD refining process, the main measures to reduce oxygen content is by strengthen LF furnace deoxidation in reducing stage and ensure the behavior of VD furnace vacuum degassing. In the experiment, combined deoxidation was used in the LF furnace to control the basicity of white slag ⩾4 and the vacuum degree of VD furnace ⩾67Pa. The results in the Table 3 showed that the content of oxygen is only 16ppm after LF+VD which Compared With normal production process [O] 32.57ppm, reduction rate up to 50.88%.

Table 3 - the oxygen content during diferent process in LF+VD

Sampling time	The end of LF refining	Without Vacuum in VD
[O] ppm	33	16

2.2.2 The influence of ESR

General speaking, a slight positive pressure in the ESR crystallizer can avoid the increase of oxygen content in a certain degree. In this paper, we studied the influence of different surface state of electrode (surface-conditioned & casting skin) on oxygen content when the Ø330mm electrode re-melted into Ø610mm electroslag ingot. The test results in Table 4 showed that produced by different surface state of electrode, the oxygen content increased 12.5% and 37.5% respectively which compared with electrodes. It means that the surface state of electrode have greatly influence on the content of oxygen, there are 25% increased by casting skin electrode than surface-conditioned electrode.

Table 3 - the influence of different surface state of electrode on oxygen content

Location test	Electrode	ESR ingot (surface-condition electrode)	ESR ingot (casting skin electrode)
[O] ppm	16	18	22

3.3 HUANGSHI ALTA SPECIAL STEEL CO.,LTD

For SKD11, 1.2379, D2 cold work tool steel, our supply ability is as the following

Diameter : Ø 8mm - 450mm (0.3” to 17.7”)

Thickness : 6mm - 350mm (0.24” to 13.77”

Width : up to 810mm (max 32”)

Quality available in EAF, LF, VD, ESR process, with minimum Ultrasonic testing level SEP1921-84, Class D/d.

Any requires on the steel materials, please contact ALTA, we are professional and timely deal your issues.

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