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The harmful effects of non metallic inclusions and its influence on Metal Properties

Due to the existence of non-metallic inclusion in steel, the metallic continuity will be damaged : mechanical character, physical properties, chemical properties and process performance will be decreased. For example, the non-metallic inclusion could lead to stress raisers, as a result of fatigue-induced fracture. The large number and uneven distribution of inclusions will significantly reduce the plasticity of steel, toughness, weldability and corrosion resistance. Mesh-like sulfides can cause hot brittleness, corroded media can cause pitting corrosion.

Sulfide hazards

Because MnS is easily soluble in Cl-containing water, it will reduce the corrosion resistance of steel (especially to reduce pitting and crevice corrosion resistance) and the plasticity, toughness and fatigue resistance of steel. If the sulfide content in steel exceeds a certain standard, it will cause slab crack in the smelting and rolling process.

Oxides and silicates hazards

Oxides and silicates can damage the continuity of the steel matrix and lead to stress concentration, on the one hand to the deterioration of the transverse mechanical properties of steel, on the other hand to reduce the cutting performance of steel, thereby reducing the plasticity of steel, toughness and fatigue Performance, such as FIgure 1 : oxide damage the steel substrate uniformity, continuity. The surface flaking, scarring, ruggedness, and cracking of the steel material are related to the oxides and nitrideS of the metals in the steel, SiO2, FeO, Al2O3, and titanium.

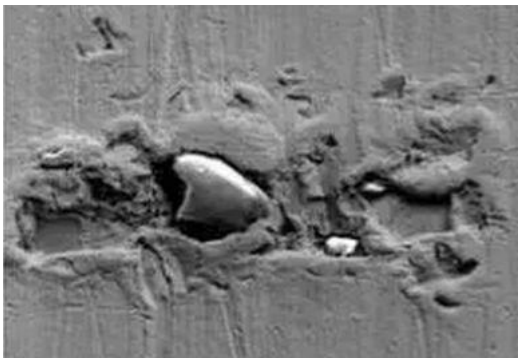

Figure1 : The oxide in scanning electron microscopy

Nitrides hazards

The nitride inclusions are characterized by high hardness, not easily deformed and clumped distribution. As the increase Of the nitrides, the brittleness of the steel will increased obviously. The geometric shape of nitrides will form a crack source of transcrystalline rupture in the steel.

Influence on steel properties

The composition, quantity, shape, distribution of the non-metallic inclusions and the spatial distribution in the matrix have different degrees Affect on the strength, plasticity, toughness,

fatigue, cutting and corrosion resistance of steel.

Influence on steel strength

When a metal breaks, cracks are not only formed in the matrix but also often in the inclusions. This is because the inclusion can not produce the corresponding deformation when metal is deformed, it will produce more and more stress which surrounding inclusions, so that it will lead to micro-cracks in the interface between the inclusions and the matrix micro-cracks. Once under the action of tensile stress or shear stress, It would produce fracture along the direction of Inclusions,which can cause rupture.

The results show that the influence of inclusions on the strength of steel is closely related to the grain size. When the inclusions are relatively large (> 10μm), the yield strength of the steel get significantly decreased and the tensile strength of the steel is reduced. When the inclusions are small to a certain Size (<0.3μm), the yield strength and tensile strength of steel will get significantly improved.

Influence on the plasticity

In general, inclusions have little effect on the longitudinal ductility of steel, but the effect on transverse ductility is significant. The transverse section shrinkage will decreased along with the total amount of inclusions and the number of banded inclusions growth. The influence of inclusions on the ductility of Low carbon austenitic steels is greatly affected by the fine secondary phase precipitates (such as AlN, TiN, etc.) which can effectively pin the austenite grain boundaries.

Influence on the toughness

In the process of deformation of metal, inclusions with the metal elasticity, plastic have quite a big difference, can not be deformed with the matrix, and then it will produce more and more stress surrounding it, so that lead to its own fracture, or produce micro-cracks as it take apart from the interface of matrix. With the deformation process on going, micro-cracks will continuously produced and develop into holes, endlessly expanding of hole size, it would lead a result of breakage by connecting adjacent holes. The growth of the quantities and length of S and sulfide will significantly reduce the toughness index. The results Show that the inclusion content is inversely proportional to the fracture toughness.

Influence on the fatigue properties

There are two ways for inclusions induced the fatigue crack in steel : First, under the condition of service the inclusion can not Deliver the stress which existing in the steel matrix, while would produce stress surrounding the inclusion, formed crack and nuclear. Second, during the processing of steel, the inclusion own a degree of deformation, and micro-cracks are formed into a fatigue source at the interface. It found that there are thick brittle or point-like non-deformation of inclusions existed at the most serious fatigue failure place, during

researching the fatigue fracture of failure parts.

The study found that the fatigue limit be decreased along with the inclusion growth, the bigger the inclusions are, the bigger the unfavorable effect is, and the brittle inclusion is more influential than the plastic inclusion. the larger foreign oxide inclusions are more obvious. The change of the inclusions size affects more on the fatigue performance than the changes in inclusions content.

Influence on the cutting performance

Al2O3, Cr2O3, MnO, Al2O3 and calcium aluminate oxide inclusions greatly reduce the machinability of the steel, but a certain content of MnO-SiO2-Al2O3 and CaO-SiO2-Al2O3 inclusion Material can improve the cutting of steel. Spherical sulfide inclusions can significantly improve the cutting performance of steel, and the greater the sulfide particles, the better the steel cutting.

Influence on the corrosion resistance

Sulfide and sulphide complexes are the root causes of corrosion of steel, and there are greater effect by composite inclusions, while the single oxide inclusions does not cause pitting.

Review and summarize, the effect of non-metallic inclusions in steel on the properties of the steel is multifaceted, which require us to pay necessitates attention to the production process to minimize the errors that can be avoided in order to ensure the quality of the steel.

It could reduce the content of inclusion by the process of LF, ESR to some extent. In here, we sincerely recommend you our top sold grades 1.2344/H13/SKD11 ESR tool steel, H11/1.2343 ESR tool steel, 1.2367 ESR tool steel, 1.2714 tool steel, 1.2379/D2/SKD11 tool steel, 1.2363/A2 tool steel, S7 ESR tool steel, 1.2083/420 stainless steel, 1.2767 ESR tool steel..Etc.

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