The basic principle of induction heating and the mechanical properties of steel pipes after heat treatment

Introduction

Medium frequency induction heating furnace is widely used to heat steel and non-ferrous metal materials in advanced industrial countries and countries with abundant electric power resources. Since the 1970s, induction heating furnace has been used and developed in the quenching and tempering of steel pipes, especially petroleum pipes. Longsta Iron and Steel Co., Ltd. and Kawasaki Iron and Steel Co., Ltd. all have medium frequency induction heat treatment furnaces to heat the oil casing. The TA Gan Luo Ge metallurgical plant has an intermediate frequency induction hardening and tempering heat treatment line for oil casing and thickening drill pipe. Many factories in France and Japan use intermediate frequency induction heating furnace to heat the welded pipe. Medium frequency induction heating furnace is widely used in heating and heat treatment of domestic automobiles and mechanical parts. In recent years, in order to improve product quality, reduce cost, reduce investment and improve working conditions, intermediate frequency induction heating furnace has been widely used in steel heating and heat treatment, such as billet heating of some forging press, steel tube extruder and cross wedge rolling mill, tempering and heat treatment of PC bars, pipe end heating of petroleum drill pipe, and petroleum drilling. Heat treatment of welding seam of rod and tool joint, weld heat treatment of welded pipe, etc.

The basic principle of induction heating

If alternating current is applied to the induction coil, the alternating magnetic field with the same frequency as the current will be generated around the coil. If the steel pipe is put into the alternating magnetic field, the inductive current (i.e. eddy current) with the same frequency and opposite direction will be generated in the steel pipe. Due to skin effect, the current density on the surface of the steel tube is high, and the surface temperature rises rapidly. The temperature reaches 800-1000 C in seconds, while the current density inside the steel tube is almost zero. When the surface reaches the quenching temperature, the pipe is cooled immediately to harden the surface. The depth of the induction current penetrating into the surface of the steel tube is related to the current frequency. The higher the frequency is, the lower the depth is, the thinner the heating layer is. Therefore, as long as the frequency of alternating current is changed, the hardened layer with different thickness can be obtained. In production, the frequency of induction heating is usually selected according to the size of steel pipe and the depth of hardened layer needed.

Because the induction heating speed is very fast, only a few seconds to a dozen seconds time it can make the steel pipe to reach quenching temperature. Rapid heating has a greater impact on the microstructure transformation, so the phase transformation of intermediate frequency induction heating has the following characteristics compared with conventional heating:

(1) Austenite transformation critical temperature increased. The critical temperature of austenite transformation increases with the rapid heating rate, and the higher the heating speed, the higher the critical temperature. Therefore, the induction quenching temperature is higher than the general quenching temperature.

(2) The austenite grain is finer. The speed of induction heating is very fast, and the grain of austenite becomes fine. This is because the heating temperature increases, the nucleation rate and growth rate increase, but the nucleation rate increases faster, and because the heating time is short, the grain can not grow up, so the grain

becomes very small.

(3) The austenite composition is not uniform. When the heating temperature is increased, the austenite transformation temperature increases. From the iron-carbon phase diagram, it can be seen that the difference of carbon content in austenite increases at this time, and the diffusion process can not be fully carried out during rapid heating, so the austenite composition (mainly carbon) is not easy to achieve homogenization, so the carbon distribution in martensite after quenching is also uneven.

Mechanical properties of steel pipes after medium frequency induction heat treatment

(1) The surface hardness and wear resistance are improved. After medium frequency induction hardening, the surface hardness of steel tube is 2-5 HRC higher than that after ordinary quenching, and the wear resistance is also higher than that after ordinary quenching. The reasons can be attributed to the following points: fast heating speed, fine austenite grains, cryptocrystalline martensite after quenching; When medium frequency induction quenching, in the surface of the steel pipe produced greater compressive stress.

(2) Fatigue strength is improved. The main reason is that the specific volume of martensite in the surface hardened layer is larger than that of the original structure, which results in the formation of a large residual compressive stress in the surface layer.

(3) Impact toughness and strength increase. Medium frequency induction heating can refine the microstructure and improve the impact energy absorption of parts, which is mainly achieved by reducing the brittle transition temperature of materials. At a certain temperature, the impact brittle fracture occurs in coarse grained materials, while the refined grains may turn to ductile fracture and increase the impact energy absorption.

(4) Flexural strength and torsional strength increase. The bending strength and torsional strength of the steel tube are both increased with the increase of the depth of hardened layer after intermediate frequency induction heat treatment.

More details for induction heat treatment furnace, pleas contact with us.