INDUCTION HEATING FOR THE FASTENERS INDUSTRY

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INTRODUCTION

Fasteners are hardware devices providing non-permanent joints used to mechanically join or affix two or more objects together. They may come in different shapes and sizes and may be produced form different materials.

The most common industrial fastener materials include three major groups of steels – carbon steel, stainless steel and alloy steel. Aluminium, titanium and various (nickel, brass, etc.) alloys are also used for manufacturing of metal fasteners. Different types of coatings (including chrome, zinc, hot dip galvanizing, etc.) are often applied as well.

A variety of metalworking operations can be used for shaping, sizing or production of finishes on metals but only heat treating can provide a significant change in the physical, mechanical and metallurgical properties of these shapes.

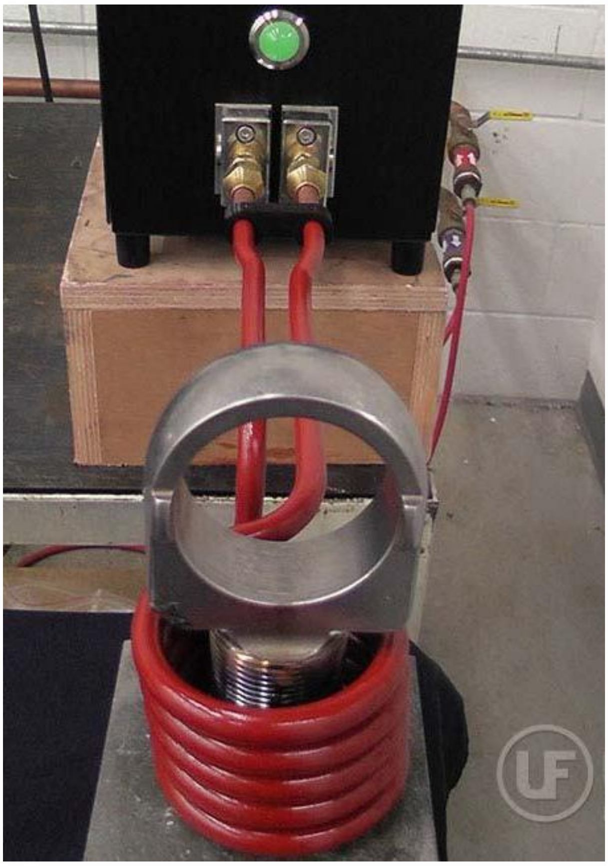
Heat treatments consider the controlled application of temperature for a predetermined time period in order to obtain a predictable change in the treated material internal structure.

To achieve high quality of the workpieces, strict control of important process parameters (temperature range, time, heating and cooling rates) should be provided.

Induction heating is a fast and efficient contactless method for heating of conductive materials applying a fluctuating magnetic field. It is particularly useful for performing of highly repetitive operations. It provides high efficiency and improved control of the heating process.

HEAT TREATMENT PROCESSES

Being a critical step in the manufacturing process, heat treatment is a group of industrial and metalworking techniques providing enhanced material properties. It involves the use of heating or chilling, normally to extreme temperatures, which results in softening or hardening of the treated material.



Most of the heat treatment processes can be divided into two main groups.

Annealing

These treatments are necessary to keep the material in workable condition. They may provide removal of stresses, material softening by alteration of its mechanical properties, refinement of its grain structure and/or production of specific microstructure. The most common annealing heat treatment processes in the manufacturing of steel fasteners are Annealing, Recrystallization, Stress-Relieving and Tempering.

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💡 ***Annealing*** – used to soften the material structure before manufacturing processes such as hold heading to make the workpiece processing easier, as well as, to prevent from cracks and other types of mechanical damage. annealing, fasteners are heated up to about 720°C for several hours and then cooled slowly.

💡 ***Recrystallization*** – also known as ***Normalizing***, this method brings the coarse and brittle grain structure (as result from processes such as hot forging or hot rolling) back to its original fine shape. For this purpose, the workpiece is heated up to 800-920°C for some time and is then slowly cooled. Thus, the yield point and the impact strength of the fasteners are increased without significant reduction of the tensile strength.

💡 ***Stress-Relieving*** – when cold deformation is done to the workpiece, internal stresses are induced in the material resulting in decreased elongation. By heating up to 500-600°C for a long time followed by slow cooling, most of the hardening effects due to cold deformation are eliminated. Therefore, this heat treatment is often applied to cold headed bolts and screws.

💡 ***Tempering*** – the harder the material, the more brittle its structure becomes. Therefore, a second treatment called tempering must follow the quenching as quickly as possible. Depending on the applied temperature, either only the brittleness will decrease (for treating temperature below 200°C), or the hardness will be reduced (for treating temperature above 200°C) providing improved toughness and decreased stresses.

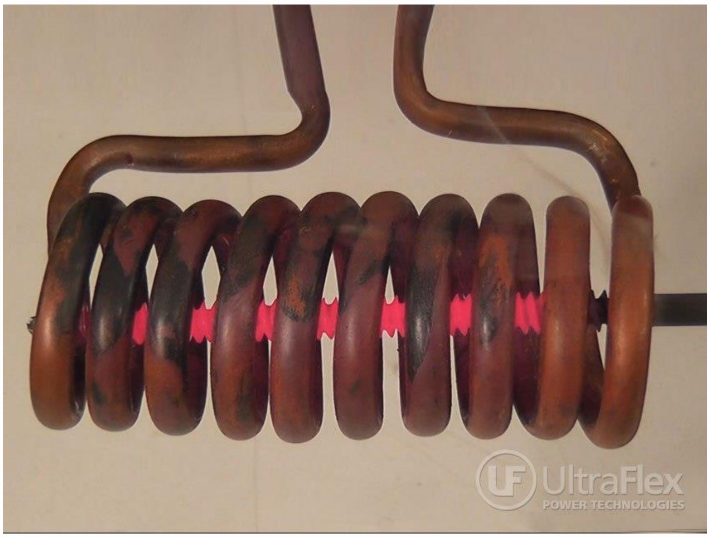
HARDENING

This type of treatment involves heating followed by rapid cooling, which results in change of the material microstructure. Hardening processes are used to improve the surface hardness, the wear and impact resistance of the material and to increase its toughness.
Very hard martensite structure of the treated material can be obtained by heating the workpiece up to above 800°C (depending on the specific type of steel) followed by quenching in water, oil, air or in a salt bath. The achieved hardness depends on the content of carbon and the percentage of the martensite part in the whole structure.

The most important and, therefore, the most commonly practiced heat treatment of fasteners considers combination of quenching immediately followed by high-temperature tempering (at between 340°C and 650°C). Thus, an optimal compromise between high tensile strength, high yield/tensile strength ratio and sufficient toughness can be obtained, which is mandatory for the effective functionality of a fastener carrying all kinds of external forces.

UltraFlex POWER TECHNOLOGIES

BENEFITS OF INDUCTION HEATING FOR THE FASTENERS PRODUCTION AND TESTING



Compared to some of the classic heating techniques (resistance heating, flame heating, furnaces, etc.), induction heating has the following advantages:

Reduced time – via induction heating, the target is heated directly resulting in reduction of both heating time and wasted heat. This method provides high power density and low to none thermal inertia, which allows to easily obtain fixed heating rates and temperature maintenance within a narrow range of variation.

High efficiency – efficiency values higher than 90% are obtained due to proper design of the power converter and the coil. Thus, loss optimization of long-term annealing processes can be made. In addition, high temperatures can be reached quicker and easier as the ambient heat loss is significantly reduced.

Improved control – precise regulation of the heating power can be achieved via appropriate coil design and control of the power converter. As a result, additional features such as local heating, pre-heating, predefined temperature profiles, etc. may be implemented. Thus, high repeatability of the manufacturing process can be guaranteed.

Industrial automation option – induction heating allows improvement of both the productivity and the quality of the processes. Quality is additionally guaranteed as the heating is contactless (no interference by the heating tool).

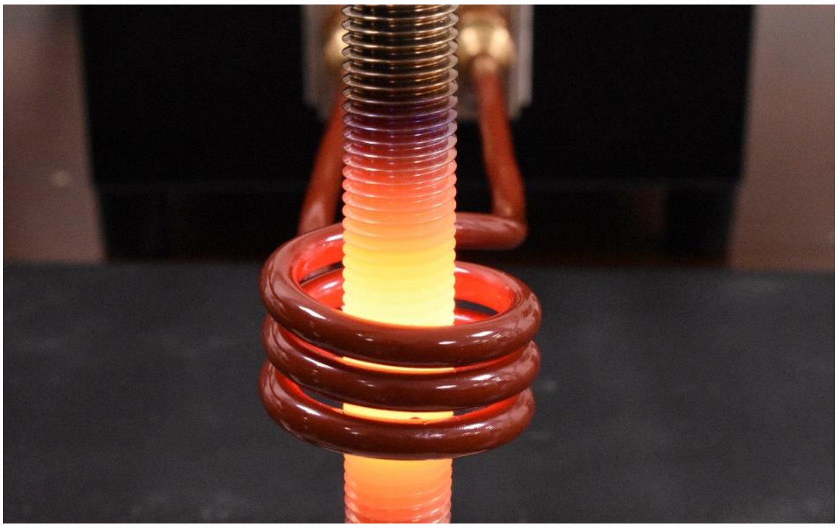
Surface/Local Hardening

Induction heating also allows surface hardening of the workpiece to be performed. Thus, a hard wear resistant layer can be formed at the fasteners surface. In addition, local hardening can be executed for extra protection of weak spots without interfering adjacent workpiece areas. The hardening depth can be precisely controlled by the process time and the frequency of the applied electromagnetic field.

Non-Destructive Testing

Apart from the heat treatment operations throughout the manufacturing process, induction heating can also be used for non-destructive testing of the produced fasteners. When a workpiece is placed inside the induction coil, the applied electromagnetic field generates eddy currents into the conductive material. These eddy currents can be used for detection of surface cracks or revealing of defects, which allows rejection of the damaged fastener right at the manufacturing conveyer line output.

Moreover, different grades of fasteners can be segregated using the eddy current testing methods. By analysis of the eddy currents parameters, specific properties of the fasteners materials such as Rockwell hardness can be determined.



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Our compact 5kW induction heating system operates with either water-cooled or air-cooled remote heat station. It utilizes the latest switching power technology. The adaptive digital phase control provides efficient operation in a wide frequency range.

The system is very easy to maintain and service. Flexible load impedance matching is possible by utilizing multiple ratios matching transformer and configurable tank capacitors.

The machine can be easily tuned to a wide range of loads and coils. The LCD touch display provides safety and diagnostic information.

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This is an advanced, cost-effective 5-15 kW Induction Heating system which can be configured to with an external Heat Station that can be easily positioned to a desired side.

The system has a very durable design and an adaptive digital phase control provides efficient operation in a wide frequency range.

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