CON MECH ENGINEERS

WORLD CLASS heat treatment

HEAT TREATMENT WATER QUENCH

The thermal cycle, including normalising, hardening and tempering of any component is critical to successful heat treatment.

However the ultimate success is wholly dependent on the quench process, rapidly and consistently cooling the steel to a depth within the components to meet test requirements. This is not a simple task and requires more engineering and process challenges than the relatively simple heating process.

Detailed below is the range of factors that have been addressed at Con Mech. When they are combined successfully it becomes possible to achieve the perfect quench. Failure of just one of the factors can significantly reduce the full quench effect. It is important to monitor, maintain and document these factors to ensure complete and continuous compliance.

Con Mech Heat Treatment regards the quench process as the most important part of the heat treatment cycle.

TRANSFER TIME

Transfer time is 60 seconds maximum from furnace to full immersion. To ensure this, we have remote control operation of furnace doors and quench cradle from the charger cab making it quick, repeatable and safe. The building is enclosed with no external draughts that might accelerate the cooling rate during transfer or cause uneven cooling from one side only.

IMMERSION RATE

Once the load is on the cradle it is immersed quickly to minimise quench differential from top to bottom of component. The descent rate of the cradle is 1 foot per second. This is also the start of the quench process, the vapour blanket is immediately dislodged as the water passes quickly over the steel surface entering the water. To further assist the process, the load sits on 4 perforated vertical supports so that there is no interference of water flow below the load.

AGITATION

Agitation is critical and must be vigorous in order to remove the vapour blanket as it forms on the surface. The vapour blanket is a layer of steam approximately 10mm thick that forms on the surface as the water reacts to the very high temperature of the steel and immediately boils at this interface. Agitation must also be consistent over the full component surface so that there are no variations in hardening response. To achieve this when the cradle is fully immersed, there are 5 mixers down both sides and 3 mixers at the rear of the quench tank. These 2 foot diameter mixers vortex out and produce a continuous wall of high velocity water impacting on every point of the load.

As the component cools, the formation of the vapour blanket slows down and at this stage the vigorous agitation promotes rapid heat transfer into the presenting water, thereby cooling the steel very quickly.

WATER TEMPERATURE

The temperature of the water significantly affects the cooling rate. Above 25°c the cooling effect dramatically drops off. We operate with a maximum water temp of 35°c at the end of the quench and ensure that the start temperature is below 20°c. To meet these requirements we operate an outside evaporative cooling tower which is thermostatically controlled. It draws water from the top of the tank at the rear and returns the cooler water downwards at the front of the tank.

WATER VOLUME

As the heat transfers from component to water it is essential that the water doesn't heat up otherwise the cooling effect will rapidly fall as the quench progresses and an inconsistent quench will result. To ensure this cannot happen, a large volume of water is required in order to instantly dissipate the heat. The recommended quenchant to weight ratio is 10m³ water / tonne of steel quenched at 900°c. The size of the Con Mech tank is 8m long x 5m wide x 4.5m deep equating to a volume of 170m³. With a maximum load of 15 tonne, depending on the size and configuration of the load, this is almost double the recommendation and equates to 0.5° rise in water temp for every tonne quenched. This volume also allows for scale to settle in the bottom of the tank to avoid reducing the tank's efficiency.

WATER HEAD

At the design stage, the tank was created to guarantee a good height of water above the quenched load, ensuring that there was no possibility of locally heating the water close to the surface. The Con Mech tank has 2m above so there will always be at least 1m above the biggest load. Additionally there is 2m of water below the cradle to minimise the heating of water. There is a 1m corridor all around the sides of the cradle so the load is effectively suspended in the core of the volume.

OSCILLATION OF CRADLE

Once immersed, there is an automatic oscillation operation of 8 inches of the cradle and this has 3 advantages. Firstly it ensures that from point of initial immersion the component is constantly moving relative to the water and this is in the vertical plane as opposed to the horizontal plane of the mixers. Secondly it ensures that there is no localised impingement from the side mixers. Thirdly, the continuous jolting effect of the cradle further displaces steam pockets as they build up on the surface.

IMMERSION TIME AND REMOVAL TEMPERATURE

From the moment the cradle is lowered, an automatic time clock starts to monitor the immersion time and the product is always completely quenched out to fully equalize temperature. The formula used is 5 mins / inch ruling section for carbon steels and 10 mins / inch for stainless. If there is any visual evidence of the surface drying out on removal from the tank then it is immediately re-immersed for extra time. Surface temperature is checked using an optical pyrometer.

COOLING SYSTEM ASSOCIATED WITH WATER QUENCH

The purpose of the cooling system is to cool the water quenchant down to the desired temperature ready for the next quench. The cooling rate of the towers is affected by outside temperature and humidity (dew point) and will only cool to ambient temperature. The cooling system does not play any part in the actual water quenching process as no cooling system can cool rapidly enough to meet quench speed requirements. To be able to keep the water cool during the quench process, a large volume of water is chosen instead (i.e. 170,000 ltrs). This gives almost instant cooling effect as the reservoir of cold water under the cradle immediately mixes with the working volume of water surrounding the load. The cooling towers are of the evaporative type and are located outside the building for the maximum cooling effect .They are thermostatically controlled to cool down to 10°c or ambient whichever is the greatest. Running of the cooling towers may or may not happen during the quench cycle depending only on the temperature of the water. The warmer water in the tank is taken from the top at the rear of the tank, passed through the cooling tower and gravity fed back to the front of the tank where it is directed downwards with some momentum to the bottom.

WATER TREATMENT

The quality of the water plays an important role in the quench rate as the purer the water, the faster the quench rate. Water quality is monitored on a monthly basis by a sub-contractor, who checks chloride levels, dissolved solids, conductivity, bacterial activity and PH. They also chlorinate every 6 months to meet government guidelines and in addition, as part of the PPM routine, there are dip slide weekly checks for bacteria and conductivity checks.
The tank is fitted with an automatic dosing system that uses non chloride based biocides twice a week.

FURNACE TRAY DESIGN

The design of the furnace tray is an important factor in the quench process. The Heat Treatment department uses specially designed open trays which give support to the product but at the same time allow free movement of water to access the underside of the component and promote all round quench circulation.

FURNACE LOADING

The layout and configuration of the components must be such that no component adversely affects the quench rate. There is no contact between components and they are never stacked in the tank.

SURFACE FINISH OF COMPONENT

A clean, machined surface promotes a faster heat transfer rate. As the vapour blanket builds up on the surface, steam is more easily dislodged from a smooth surface than a rough surface where adhesion can take place. The worst possible surface is an 'as forged' surface for two reasons.

Firstly the surface layer is denatured and oxidized from the high temperature forging process and conductivity of this layer is significantly lower than the parent metal, leading to a reduced quench rate throughout the full temperature range of the quench. Secondly a very rough forged surface allows a very high adhesion of steam to the surface - particularly in forging laps etc.

VIDEO RECORDING OF ALL QUENCHES

As the quench is the most important part of the heat treatment process, it is essential that there is a reliable and accurate record of the process. The operators time the quench from a time clock in the charger cab and this is documented. Additionally there is a web camera which is motion activated and automatically records all quenches. By arrangement, this can also be securely accessed from the internet for witness purposes.

PLANNED PREVENTATIVE MAINTENANCE

As with all plant in the heat treatment department, the water quench is inspected weekly and serviced.