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1 SCOPE

This procedure shall be applied to the stress relief for valves which will be manufactured at AMP.

2 APPLICATION CODE AND SPECIFICATION

2.1. ASME B31.8 (Chapter IX)

2.2. ASME boiler and pressure vessel code
2.2.1. Sec. II Part A : Material specification
2.2.2. Sec. XI : Welding and brazing

2.3. Project technical specifications.

3 GENERAL DISCRIPTION

Heat treatment is one of the important processes in the production process of steel valves. It plays an important role in exploring potential of metal materials, improving the service life of steel valve and making performance of steel valve better. The service life as well as performance can be affected by various factors such as the internal micro structure of metal materials including a variety of defects, the size of internal stress, the morphology, size and boundary structure of grains and the form and distribution of the strengthening phase and inclusions. Using different heat treatment processes means that the heating temperature, holding time and cooling rate are different. Through these methods, the steel valve can have different internal micro structures so as to meet various standards of steel valve, performance requirements of users and operation requirements of specific conditions.
According to the steel valve' standards which have diverse requirements on the micro structure, performance and hardness of steel valve, the heat treatment process can be summarized into the following five categories.

Table 1
TYPES OF HEAT TREATMENT AND SURFACE HARDENING USED FOR PRODUCTION OF AUTOMOTIVE COMPONENTS.

Types of heat treatment	Purpose	Typical components
Annealing	Softening, and removing residual stress for post processes	Forged blanks for gearing and misc. parts
Isothermal annealing	Transformation control hardness and micro-structure for machining.	Machinability control
Normalizing	Control microstructure and hardness for machining	Reduce hardness for machining
Spheroidizing	Control microstructure and hardness for cold forming	Reduce hardness and microstructure for cold forming
Control roll and control cooling	Control rolling and control cool for bake hardening and high strength steel sheets.	Body panels and frame [2,3] Joint yorks, Crank shafts, con' rods,
Forge and direct cooling	Forge and directly quench or control cool.	Steel sheet panels. [4]
Quench and temper	Optimize hardness for strength and toughness	Fasteners, Rods and Arms
Austemper	Optimize microstructure and hardness via isothermal transformation	Cast iron brackets, High carbon springs
Solution treatment and aging	Optimize hardness and strength of Al and age hardening metallic materials.	Aluminum casting: (T/M & Dif. casings In. & Ex. Valves
Case hardening: (Pack, Salt bath, Gas, Vacuum, Plasma) Carburizing Carbonitriding	For fatigue strength and wear resistance through diffusion of Carbon and or Nitrogen at the surface of components and quench for case hardening	For fatigue and wear resistanceGears and shafts, Same to above carbon steels
Oxidizing Nitrocarb-oxidizing	Oxidize surface to improve corrosion, wear and scuff resistance. Steel Titanium	Corrosion and wear resistant of steel and Ti alloys
Induction hardening	Heat up by inductive power and quench to get hard case locally.	Cam shafts, Drive shafts, steering knuckles
Induction tempering	Heat up by inductive power and slow cool to soften heated area	Thread area of shafts
Nitriding: (Salt, Gas, Vacuum, Plasma) Nitro-carburizing Oxy-nitro-carburizing	Diffuse Nitrogen, C and or O depending to impart wear and corrosion resistant nitride layer at surface and to get a deeper diffusion layer to improve fatigue strength	Cam shafts, oil pump gears, valves, Brake pad liner plates, A/T gears
Diffusion coating (Salt bath, Gas)	Diffuse Cr to form chromium film, carbide and etc.	Chain pin, stove pipes, Forming Dies
Remelt refining (Laser, TIG etc)	Heat and melt surface and solidify quick to get fine crystal structure	Cam nose and valve seat wall
Alloying (TIG, MIG, Laser, EB)	Melt and mix with added powder materials to improve surface properties	Cam profile, Valve seat of cylinder head and valves
Powder metallurgy	Compact and sinter metallic powders to get desired composition and shape	Engine sprockets, gears, T/M sliding hubs
Thermal spray coating (Plasma, TIG, MIG)	Spray molten particle to get desired composition for wear resistance, etc	Piston ring, Lifter periphery, Synchronizer ring
Post treatment processes: Coat forming quench	Improve surface properties Form protective film during quenching	Fasteners, V.S. retainer
Cryogenic treatment	Deep cooling to end transformation	Dies, Gears
Shot peening (0.8 ~ 1.4 C steel or cast iron shot)	Spray particles to clean or increase residual stress and fatigue strength	Leaf and coil Springs
Hard, double peening	Spray hard large and small particles to increase residual stress for higher fatigue strength.	T/M and differential gears
Fine particle peening (Fine particles)	Spray fine particles to clean, remove thin surface layer and to form shot dimples	Piston skirts, Continuously Variable Transmission drums

3.1 Heating

The steel material could be heated below the critical point or above critical point. The former heating way can stabilize structure and eliminated the residual stress. The latter way can make material austenitizing.

Austenitizing is to heat steel metal over its critical temperature long time enough, so it could be transformed. If a quenching followed after Austeniting, then the material will be harden. Quenching will take fast enough to transform austenite into martensite. Once reached austenitizing temperature, suitable microstructure and full hardness, the steel pipe material will be attained in further heat treatment processes.

3.2 Heat preservation

the purpose of heat preservation is to uniform the heating temperature of steel material, then it will get a reasonable heating organization.

3.3 Cooling

The cooling process is the key process in heat treatment, it determines mechanical properties of steel pipe after cooling process.

FOUR MAIN HEAT TREATMENT METHODS IN CARBON AND ALLOY STEEL VALVE AND PIPE INDUSTRY.

3.4 NORMALIZING

Heating the steel pipe above the critical temperature, and cooled in the air.

Through normalizing, the steel material stress could be relieved, improves ductility and toughness for the cold working process. Normalizing usually applied for the carbon and low alloy steel valve material. It will produce different metal structure, pearlite, bainite, some martensite. Which brings harder and stronger steel material, and less ductility than full annealing material.

3.5 ANNEALING

Heating the material to above its critical temperature long enough until microstructure transform to austenite. Then slow cooled in the furnace, get maximum transformation of ferrite and pearlite.

Annealing will eliminate defects, uniform the chemical composition and fine grains. This process usually applied for the high carbon, low alloy and alloy steel valve need to reduce their hardness and strength, refine the crystal structure, improve the plasticity, ductility, toughness and machinablity.

3.6 QUENCHING

Heating the steel valve material to critical temperature until microstructure transformation is done, cooling it in a rapid rate.

Quenching purpose is to produce the thermal stress and tissue stress. It can eliminate and improve through the tempering. The combination of quenching and tempering can make the comprehensive performance improved.

3.7 TEMPERING

Heating the steel material to a precise temperature below the critical point, and often done in the air, vacuum or the inert atmospheres. There are low temperature tempering 205 to 595°F (400 to 1105°F), medium temperature and high temperature tempering (to 700°C 1300°F).

The purpose of tempering is to increase the toughness of steel and alloy steel pipe. Before tempering, these steel is very hard but too brittle for the most application. After process can improve the plasticity and toughness of steel pipe, reduce or eliminate the residual stress and stabilize the steel pipe's size. Brings good comprehensive mechanical properties, so that it does not change in service.

The tempering treatment of stainless steel valve

In order to solve the work hardening caused by cold processing of the stainless-steel valve, it is necessary to process the tempering in the subsequent forming process. Therefore, whether the tempering process has a very direct impact on the molding process and costs.

As we all know, when stainless steel is close to or less than room temperature, it will harden and increase the strength and hardness of stainless steel. In essence, not all stainless steel valves can be expected to be shaped. For example, ferritic 400 stainless steel valves, when they are cold processing, will only produce a small amount of deformation, or it will produce sudden damage or even cracking. For example, 430 and 446 stainless steel valve themselves have notch sensitivity, so their supply status needs to be marked as annealed. When it is necessary to shape it, it must be processed by tempering.

The hardened martensitic stainless steel is also supplied by annealing, otherwise the stainless steel is cured by normalizing or by quenching and solidifying. Austenitic stainless steel valves, however, can be supplied within a wide range of cold working hardness. The mechanical properties of the austenitic 300 series stainless steel valves under various tempering conditions are listed. Not all austenitic and stainless steel valves of all sizes and grades can be machined and formed after tempering.

The content of alloy elements is lower 201, 202, 301, 302 and 304 stainless steel are very suitable for cold drawing; alloy element content is high and the cold hardening rate of low stainless steel, tempering products production is greater than 1/2 cold work hardening state is not widely used. 305, 316, 317 and 310 stainless steels belong to the latter category. With the continuous increase of nickel content, the tendency of hardening of stainless steel will be reduced.

It should be noted that some non-standard chromium manganese austenitic stainless steel valve, but also greatly increased the processing range of cold drawn steel valve. The tempering dimension relation of the large size stainless steel valve processed by cold drawing can be seen that the regularity of the small size stainless steel valve may be changed during processing. When small stainless steel pipes are higher than the hardness of the annealed ones, especially when they are expected to have 1/2 chilling properties, it is necessary to consider the use of specialized equipment for the production of small-size stainless steel valves.

Because of the utilization ratio of raw material, the rate of success is the condition that must be taken into consideration, and the above basic knowledge is beneficial to improve the yield of stainless steel valve. In the processing of cold drawn stainless steel valve, the processing dimension must be considered to limit the production of the stainless steel valve. Because of the price limit, the lubricant performance and the above analysis inherent factors, only certain sizes of stainless steel valves in a variety of tempering state can be cold drawn processing.

4 PREPARATION AND SET-UP

4.1. PWHT shall be done before the hydrostatic test and after any welding and welded repairs, except as permitted by ASME Sec. VIII Div.1 and purchaser's technical specification when approved by purchaser's.

4.2. Before PWHT, final visual and dimensional inspection shall be done and related report to be signed and stamp by vendor.

4.3. Prior to any heat treatment, inspection shall be done on welded or formed assembly for cleanliness, and oil, grease, paint & other foreign material shall be removed . A light layer rust or mill scale is acceptable prior to PWHT or heat treatment, provided it is clean.

4.4. All machined surface shall be protection from scaling during PWHT using a suitable protective coating.

5 CHECK OF STRESS RELIEF HEAT TREATMENT

The Inspector shall satisfy himself that all postweld heat treatment has been correctly performed and that the temperature readings conform to the requirements.

6 AFTER HEAT TREATMENT

6.1. All thermocouples and temporary attachments shall be removed and the attachment areas ground to clean, smooth contour.

6.2. If specified by the inspector, the areas shall be examined by MT or PT after grinding.

6.3. Hardness test shall be carried out after final heat treatment. When post weld heat treatment is required, one Brinell hardness reading shall be taken on the inside of each shell section, head, longitudinal weld, nozzle, and each longitudinal, girth and nozzle weld after final post weld heat treatment, and no reading shall exceed 234.

7 RECORDS AND DOCUMENTATION

7.1. Furnace operator shall have approved P.W.H.T. Procedure and position load (location thermocouples and supporting items) by owner & Q.C. Leader prior to starting furnace operating.
7.2. Heat treatment record/chart shall include the following
- Heat treatment type
- Thermocouples identification, number and location.
- Time of heat treatment (Figure 1)
- Start of heat cycle : Time
- End of soak period : Time & date
- End of cooling time : Time & date
- Chart speed
- Sign or stamp of operator

7.3. After completion of the PWHT written the actual PWHT conditions and other necessary data shall be submitted to QA team together with the time-temperature charts. All charts shall be marked with the the date and sufficient information to identify the item PWHT. All PWHT chart records shall be submitted to owner inspector for review and approval, and shall be submitted as a part of the equipment for permanent record.

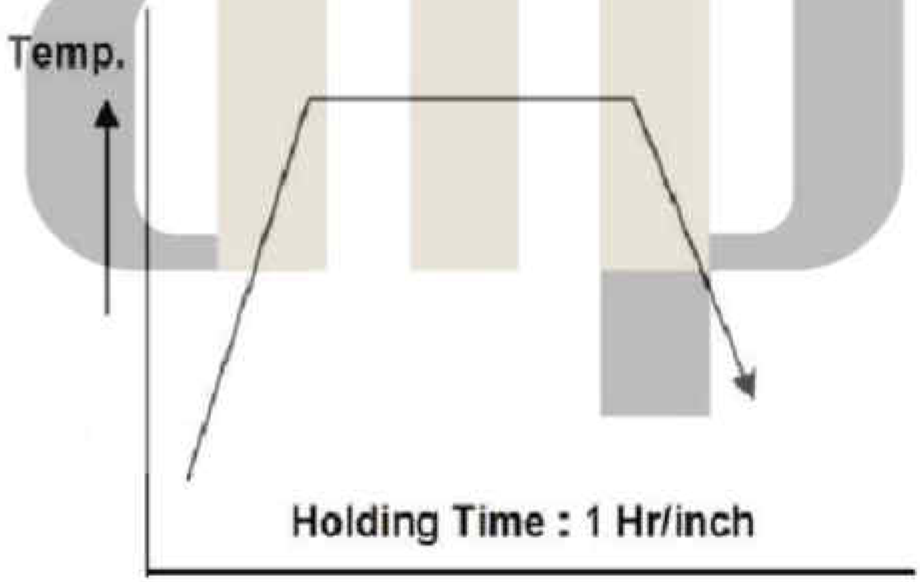

Figure 2