Process Table I – Dry Contact Press Hardening

Requirement to Comply:

This Process Table is made available as of May, 2014. Users of these parts may request suppliers be compliant to these requirements 90 days after notifying supplier.

Introduction:

Process Table I is being added to incorporate the growth of die quenching in the industry. The most common type of die quenching is known as hot stamping, which is a process that first austenitizes and then simultaneously quenches and forms the part. **Quenching is achieved by direct contact with a die that is water cooled.** Hot stamping is sometimes referred to as press hardening or hot forming.

The addition of a new table was warranted due to the unique nature of the process which includes furnace design, relatively short cycle times, materials, and quench method.

The most common furnace design is a continuous furnace, but other designs include single chamber and multi-chamber box type furnaces. Regardless of the furnace design, there is frequent part loading and unloading typically performed by robots with cycle times on the order of minutes. The material is typically an ultra-high strength steel sheet contain boron to improve hardenability. The quench rate (mechanical properties) is determined by die design and subsequent maintenance. The use of thermal imaging cameras during die development and the preventative maintenance program are also critical.

Another unique feature with this process is the use of coatings and their development during heat treatment. Some post treatments include sand blasting or similar cleaning process, trim operations including laser trimming, welding, and painting.

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All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

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Item #	Related HTSA Question #	Category/Process Steps	
1.0		PROCESS AND TEST EQUIPMENT REQUIREMENTS	OK / NOK / NA
I1.1	3.1 3.7	All furnaces and quench (tool cooling) systems shall have temperature indicating instruments.	
I1.2	3.1 3.7	Continuous strip charts and/or data loggers are required for temperature controlling devices.	
I1.3	3.1 3.7	Continuous strip charts and/or data loggers are required for protective atmosphere monitoring unit, e.g., dew point, oxygen probe or other atmosphere controlling devices.	
I1.4	3.2	Furnace loading device and control elements used to avoid double layer loading shall be verified and maintained per maintenance plan.	
I1.5	3.2	Dew pointers, 3-gas analyzers, spectrometers, and carbon IR combustion analyzers (shim stock analysis) used to verify protective atmosphere in furnaces shall be calibrated annually at a minimum.	
I1.6	3.2	Oxygen probe controllers shall be calibrated quarterly (single-point or multi-point calibration) or semi-annual (multi-point calibration only; single-point calibration not allowed).	
I1.7	3.2	Verification of calibration of spectrometers and carbon combustion analyzers shall be checked daily or prior to use.	
I1.8	3.2	Verification of calibration of 3-gas analyzers with zero gas and span gas shall be performed weekly at a minimum.	
I1.9	2.16	All hardness test equipment (for each scale used) shall be calibrated annually minimum and verified daily or prior to use per the applicable ASTM standard, ISO standard, JIS standard, or approved standard.	
I1.10	2.16	Tensile Test Equipment shall be calibrated annually.	

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2.0		**PYROMETRY**					**OK / NOK / NA**
I2.1	3.2 3.3	Thermocouples and calibration of thermocouples shall conform to Section 3.1					
I2.2	3.2 3.3	Pyrometry Instrumentation and Calibration of instrumentation shall conform to Section 3.2					
I2.3	3.2 3.3	CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in each Zone per Section 3.3					
I2.4	3.4	TUS shall be performed annually and after major rebuild per Section 3.4 Temperature uniformity tolerance for hardening furnaces shall be +/- 15°C (or +/- 25°F) in the Qualified Work Zone.					
I2.5	3.5	Recorded temperature(s) for austentizing processes shall be controlled within +/- 10 C (or +/- 15F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above). **For Continuous Furnaces, this requirement applies to the Qualified Work Zone.**					
I2.6	3.2	Infrared pyrometers or thermo cameras shall be calibrated annually using proper calibration methods or an approved manufacturer's procedure.					
3.0		**PROCESS MONITOR FREQUENCIES**	**Single Chamber BOX Type Furnace**	**Multi Chamber BOX Type Furnace**	**Continuous Furnace**	**Atmosphere Generation**	**OK / NOK / NA**
I3.1	1.4 2.14	Monitor primary temperature control instrument(s).	Continuous recording with sign-off every 2 hours. Alarm systems (if set per limits in I2.5) satisfy the sign-off requirement	Continuous recording with sign-off every 2 hours for each chamber. Alarm systems (if set per limits in I2.5) satisfy the sign-off requirement	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement	Sign-off required for each shift for generators.	
I3.2	1.4 2.14 3.7	Monitor atmosphere generation as applicable.				Dried air or nitrogen-systems, may either be continuously monitored and alarmed, or sign-off every 2 hours.	

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I3.3	1.4 2.14 3.7	Monitor primary furnace atmosphere control(s), as applicable	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement	Continuous recording with sign-off every 2 hours for each chamber. Alarm systems satisfy the sign-off requirement	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement		
I3.4	1.4 2.14	Monitor time in furnace.	System monitoring of time in furnace (ex. Robot, PLC, etc). Alarm for times outside of process window	System monitoring of time in furnace for each chamber(ex. Robot, PLC, etc). Alarm for times outside of process window	System monitoring of time in furnace (ex. Roller speed). Alarm for times outside of process window		
		Quench Process Parameters					
I3.5	1.4	Monitor part temperature in die.	System to monitor part temperature in the die and immediately prior to quenching (infrared, thermo camera, or other suitable non-contact pyrometer method)				
I3.6	1.4 2.14	Temperature of die cooling system	Continuous recording. Alarm for Temperature control systems is required.				
I3.7		Cooling System flow control	Monitoring of die cooling system flow. Alarm for flow control systems is required.				
I3.8		Press cycle parameter (e.g., dwell time, tonnage)	System monitoring of applicable press cycle parameters. There shall be an alarm for conditions outside of process window.				

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4.0		IN-PROCESS/FINAL TEST FREQUENCIES	Single Chamber BOX Type Furnace	Multi Chamber BOX Type Furnace	Continuous Furnace		OK / NOK / NA
I4.1	1.4 2.15	Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available.	Daily per furnace	Daily per furnace (chamber). May rotate chambers but minimum each chamber per week	Daily per furnace		
I4.2	1.4 2.15	Decarburization (for bare steel only)	Daily per furnace	Daily per furnace (chamber). May rotate chambers but minimum each chamber per week	Daily per furnace		
I4.3	1.4 2.15	Coating Thickness, Layer Evaluation (for coated material)	Daily per furnace	Daily per furnace (chamber). May rotate chambers but minimum each chamber per week	Daily per furnace		
I4.4	1.4 2.15	Surface hardness	At start up (per cavity) and every 4 hours minimum (per cavity)	At start up (per cavity) and every 4 hours minimum (per cavity). May rotate chambers but minimum each chamber every 48 hrs.	At start up (per cavity) and every 4 hours minimum (per cavity)		
I4.5	1.4 2.15	Mechanical (Tensile, Yield, % Elongation) - When specified	As required by customer	As required by customer	As required by customer		
I4.6	1.4 2.15	Core Hardness (when specified)	Daily per furnace	Daily per furnace (chamber). May rotate chambers but minimum each chamber per week	Daily per furnace		

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5.0		PRESS & QUENCH TEST FREQUENCIES	Single Chamber BOX Type Furnace	Multi Chamber BOX Type Furnace	Continuous Furnace		OK / NOK / NA
		Press & Quenching					
I5.1	2.15 3.14	Die - Segment Wear managed to maintain desired properties	Per maintenance and equipment plan.				
I5.2		Cooling System check. Cooling media contamination. Cleaning/maintenance of cooling system and cooling channels in the die	Per maintenance and equipment plan (tubes, channels, filters etc.)				

Glossary of Terms for Use with Process Table I

Dry Contact Press Hardening – A process where a work piece (blank) that has been heated to an elevated temperature is quenched and formed at the same time. The blank is typically a thin section material with excellent formability. Quenching is achieved by direct contact with a die that is internally cooled with a suitable medium. The die is used in conjunction with a high tonnage press and relatively short heat treat cycles are used.

Hot Stamping –A common form of dry contact press hardening also referred to as hot forming or press hardening. A blank is austenitized for a given time, and then transferred to a die. The blank is stamped and cooled in the die for a predetermined length of time before removal. Once removed, the part is then allowed to continue cooling to room temperature. Subsequent process steps might include tempering, shot blasting, laser trimming, welding, or E coating. Typical components are automotive structures such as B-Pillars, door beams, and bumpers. The process allows for high accuracy tolerances, complex shapes, and minimal spring back. It is most common to hot stamp a blank (direct method), but it is also possible to pre form (roll form or other cold forming) before hot stamping (indirect method).

Ultra High Strength Steel – A low alloy steel containing boron, example 22MnB5, commonly used with hot stamping. Often referred to as press hardened steel (PHS), and capable of meeting applicable OEM post hardened strength requirements.

Aluminized Coatings – A corrosion resistance coating sometimes used with ultra-high strength steels. The use of such precoatings eliminates some post heat treat processing steps and allows for an air atmosphere during heating. Uncoated steels are susceptible to decarburization and scale, and require post heat treat processing. The process is hot dip aluminum (with silicon) with AlSiFe intermetallics formed during heat treatment.

Furnace Design/Type- The type of furnace used for hot stamping is slightly different than the conventional batch or continuous furnace. The process table has the following distinctions: Single chamber BOX, multi chamber BOX, and continuous. Regardless of furnace design, robotic loading and unloading are typical.

Continuous Furnace – The traditional long, narrow furnace with large footprint where parts are loaded at one end and removed at the other. Has the ability to modify roller speed (furnace time) and temperature (heat up rates) over various zones/lengths to achieve desired result.

Single Chamber Box – A batch furnace with multiple doors allowing the loading of multiple blanks. A typical furnace may have 4 or 6 doors (or more) that are situated one on top of the other (sometimes referred to as pizza ovens). The furnace may have multiple zones of control but is one furnace. A common loading convention is to sequentially load each door such that by the time the last door is loaded the blanks in the first door have completed their cycle. They are removed and the next set of blanks reloaded. This continues on with each door. This style of furnace allows for a small footprint and flexibility with loading.

Multi-Chamber Box- batch furnace similar to single chamber but each door is a unique chamber (furnace) by itself. Separate temperature controls per chamber and typically stacked on each other. Uses a similar loading methodology, has a small foot print and flexibility. Often can remove entire chamber for maintenance and continue running other chambers.