Study of Localized Laser Post Weld Heat treatment on Microstructure and Mechanical Properties of ATSM A335 Gr. P91 welded Joints

Present by:

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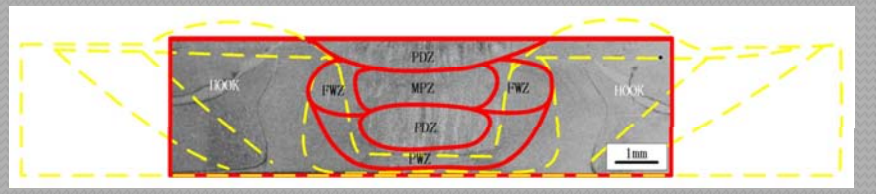
Part of Presentation :



Part I :

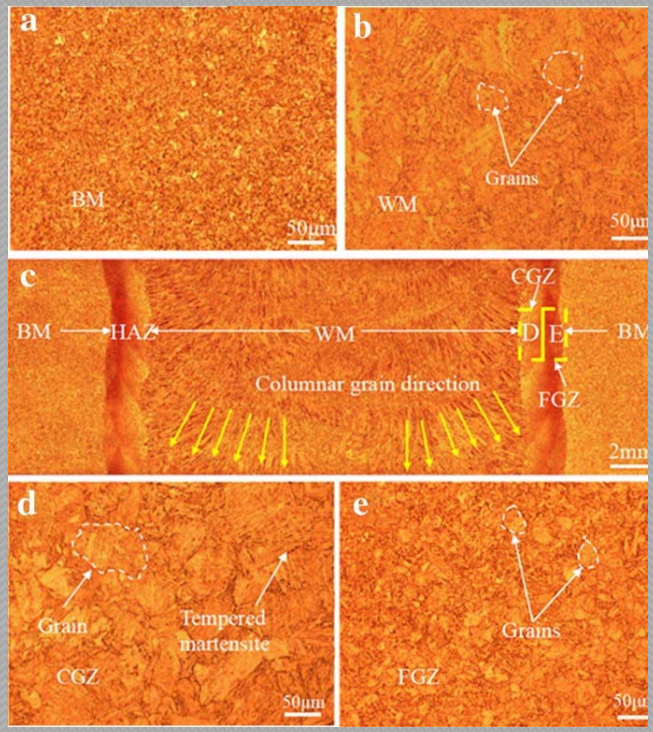
- *What and Why*

Part II :

- *The Problem and Interested*

Part III :

- *Research Progress*



Part I :

❖ What and Why

What and Why the PWHT on steel fabricated is required??????

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PWHT Post Weld Heat Treatment

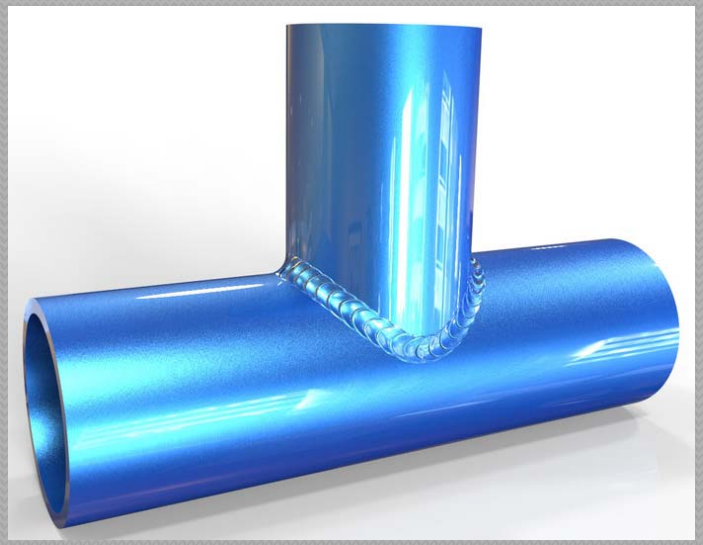
What is PWHT?

Post weld heat treatment (PWHT), defined as any heat treatment after welding, is often used to **improve the properties of a weldment**. In concept, PWHT can encompass many different potential treatments; however, in steel fabrication, the two most common procedures used are **post heating** and **stress relieving**.

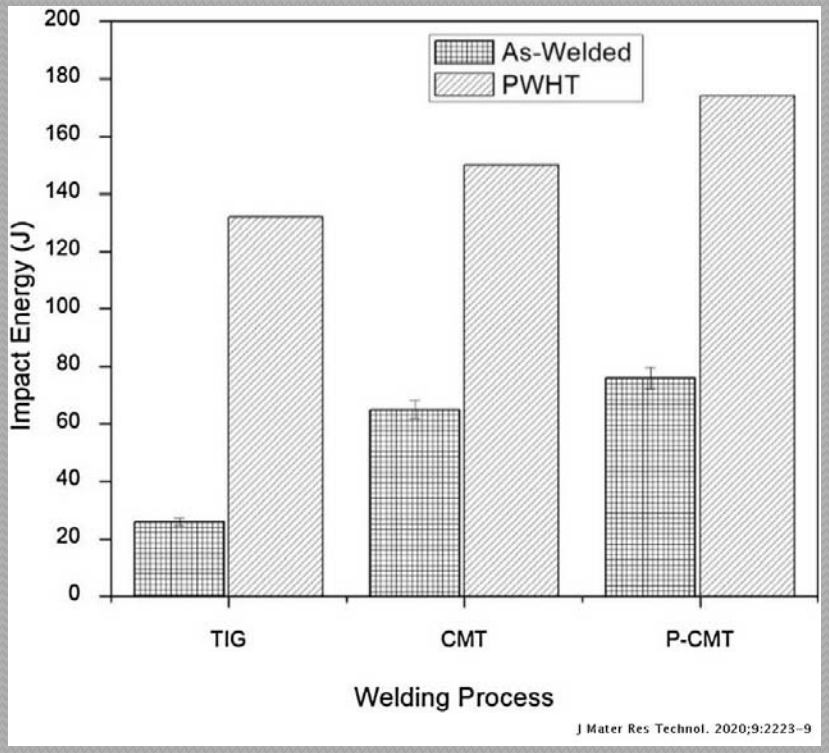
PWHT Post Weld Heat Treatment

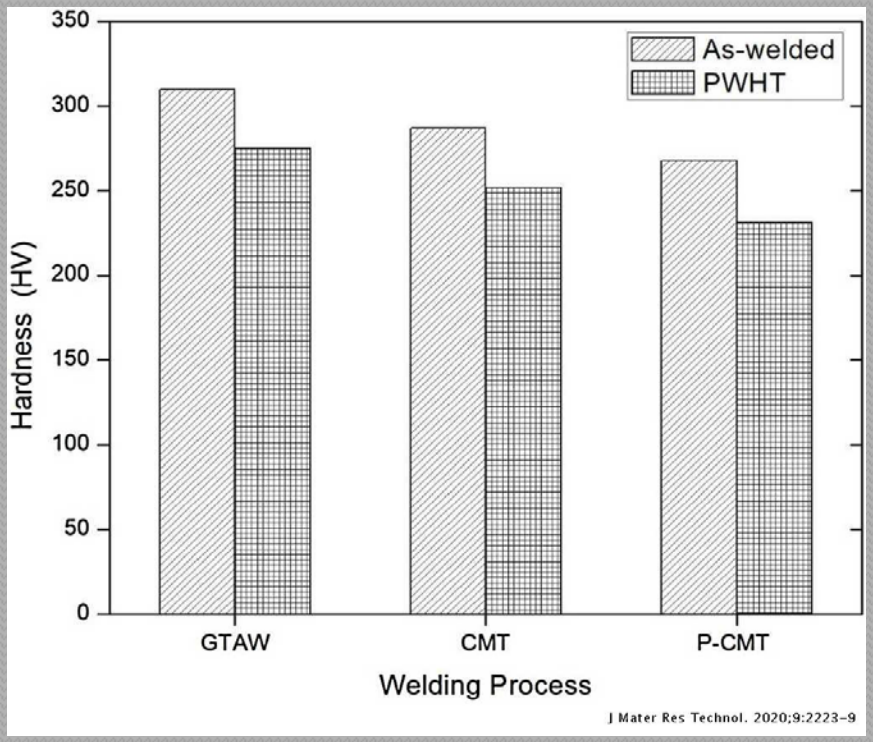
Why is it Required?

For steel fabrication, the needed for PWHT is driven by code and application requirements, as well as the service environment. In general, when PWHT is required, the goal is to ***increase the resistance to brittle fracture (Post heating) and relaxing residual stresses (Stress relieving).*** Other desired results from PWHT may include hardness reduction, and material strength enhancements.



Effect of thermal on welded joint



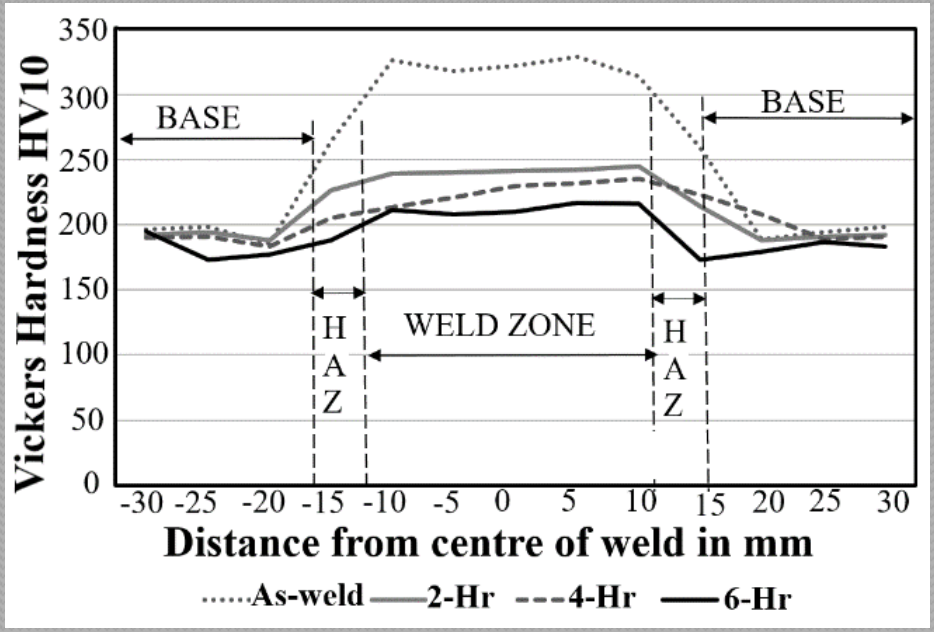


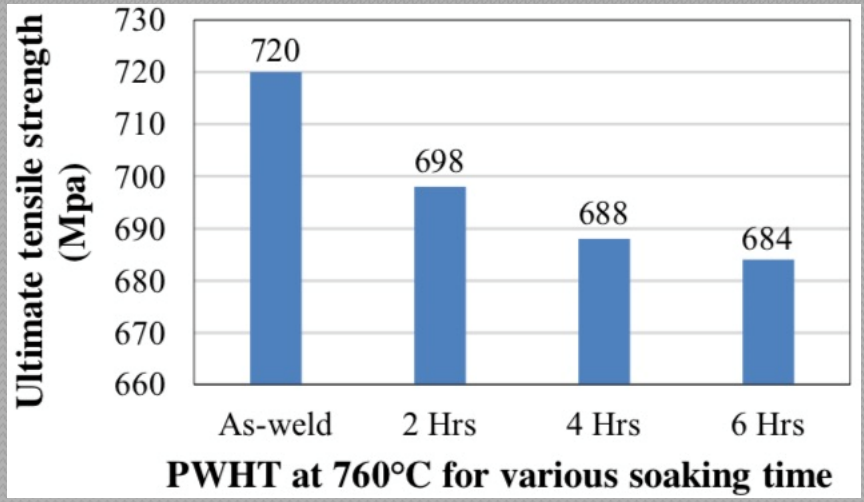
Variation of toughness in the as-welded and PWHT conditions for GTAW, CMT and P-CMT processes

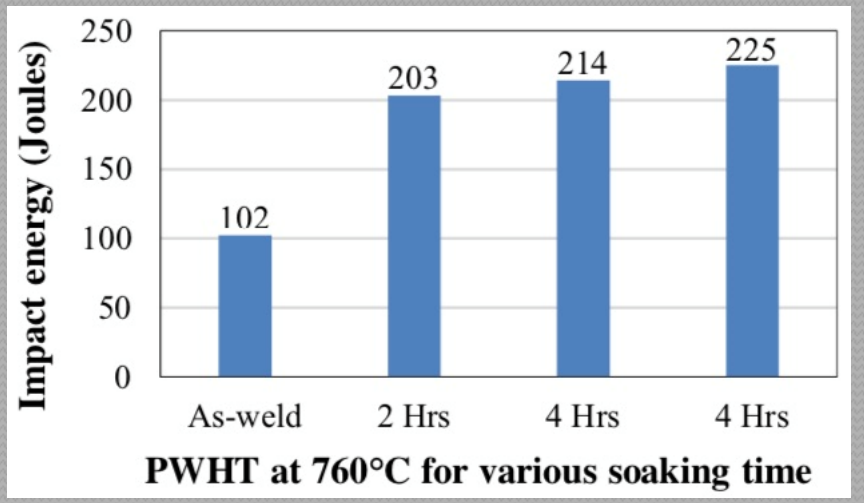
Variation of hardness in the as-welded and PWHT conditions for GTAW, CMT and P-CMT processes

https://www.jmrt.com.br/en-a-comparative-study-on-microstructure-articulo-S2238785419314127

Effect of thermal on welded joint







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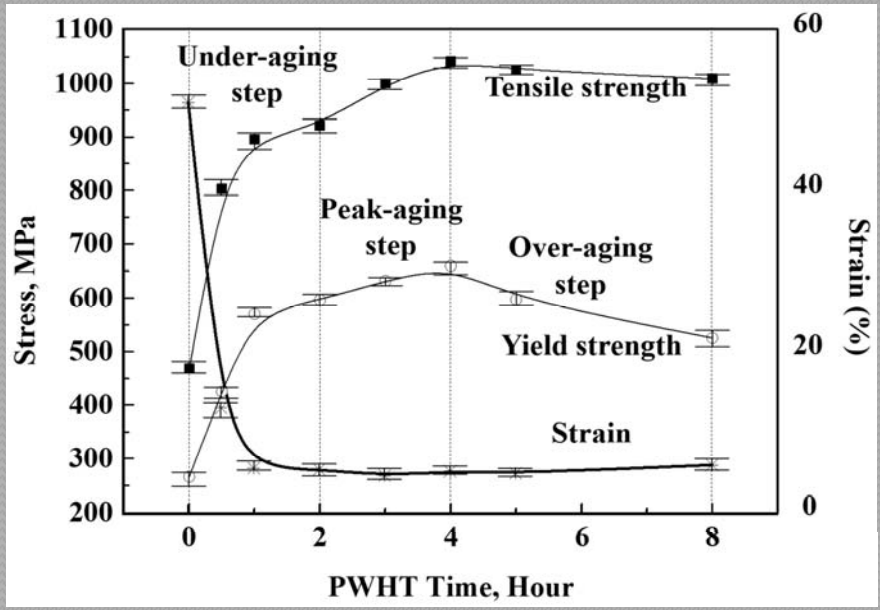
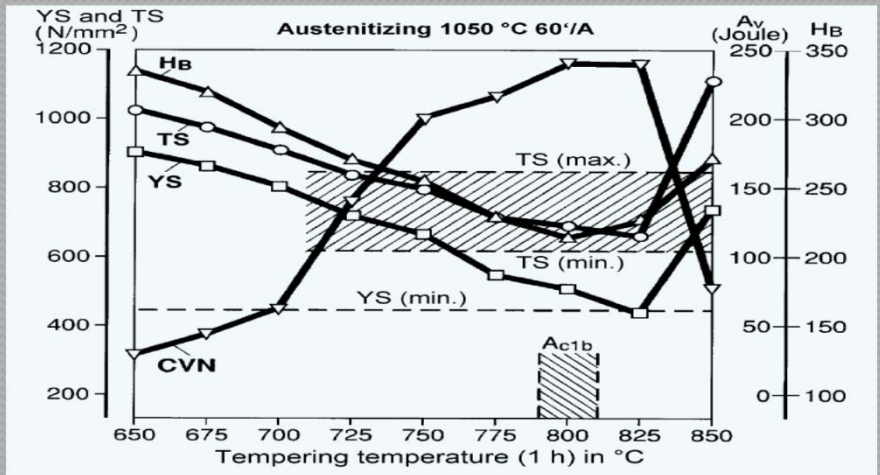
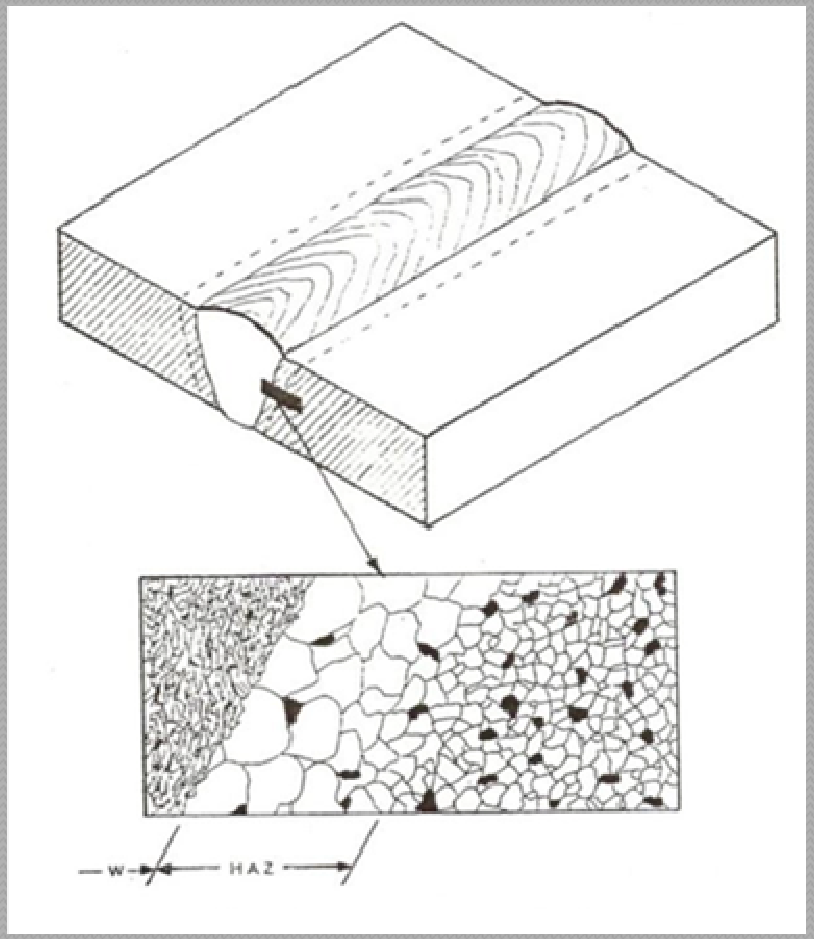
Effect of thermal on welded joint





> Fig. 5 - Tempering behaviour of steel T/P91 (X10CrMoVNb9-1)



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PWHT Post Weld Heat Treatment

Summary

Reasons for PWHT

- The three primary benefits of PWHT are recognized as:
  - Relaxation of Residual Stresses
  - Tempering
  - Hydrogen Removal
- Consequential benefits such as: avoidance of hydrogen induced cracking, dimensional stability, as well as improved ductility, toughness and corrosion resistance result from the primary benefits.

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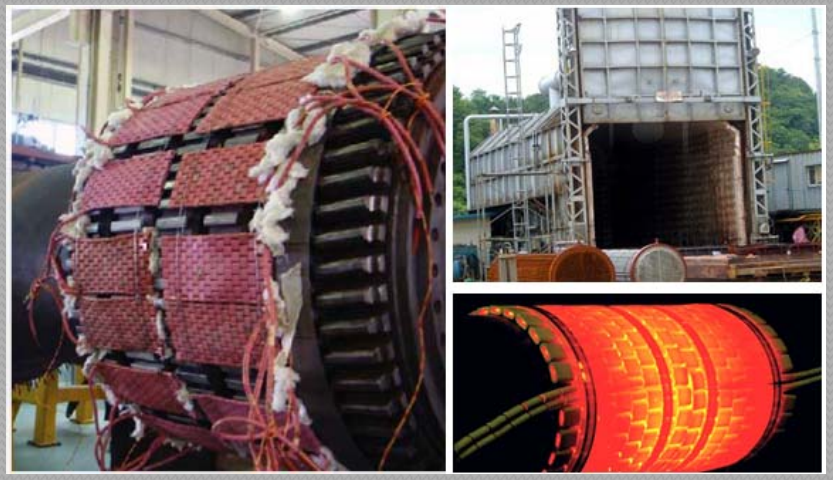
PWHT

Welding (Heating/Cooling)

Material and it's properties

- Harder
- Brittle
- Residual Stress
- Hydrogen Induce Cracking

Failure

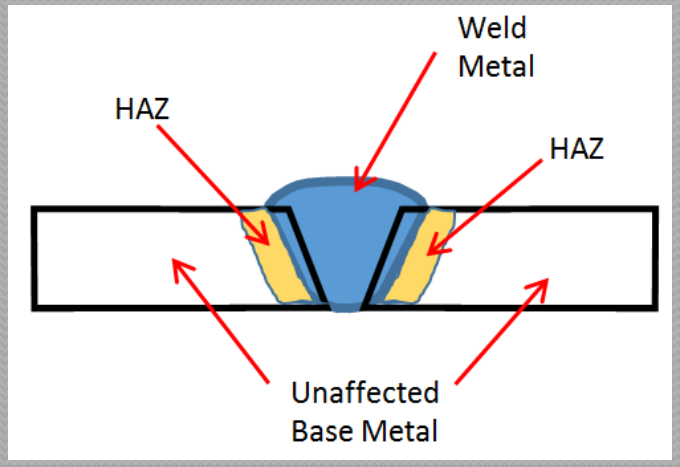


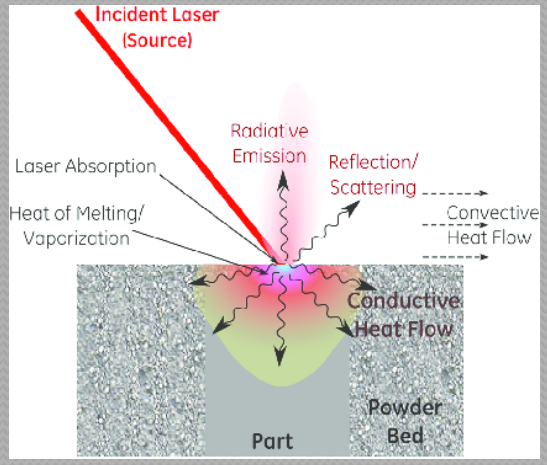
- **Reduces the risk of brittle fracture by reducing the residual stress**
- **Improving toughness**
- **Reduces the risk of stress corrosion cracking..**

Part II :

❖ The Problem and Interested

Advantage and Disadvantage of Conventional PWHT





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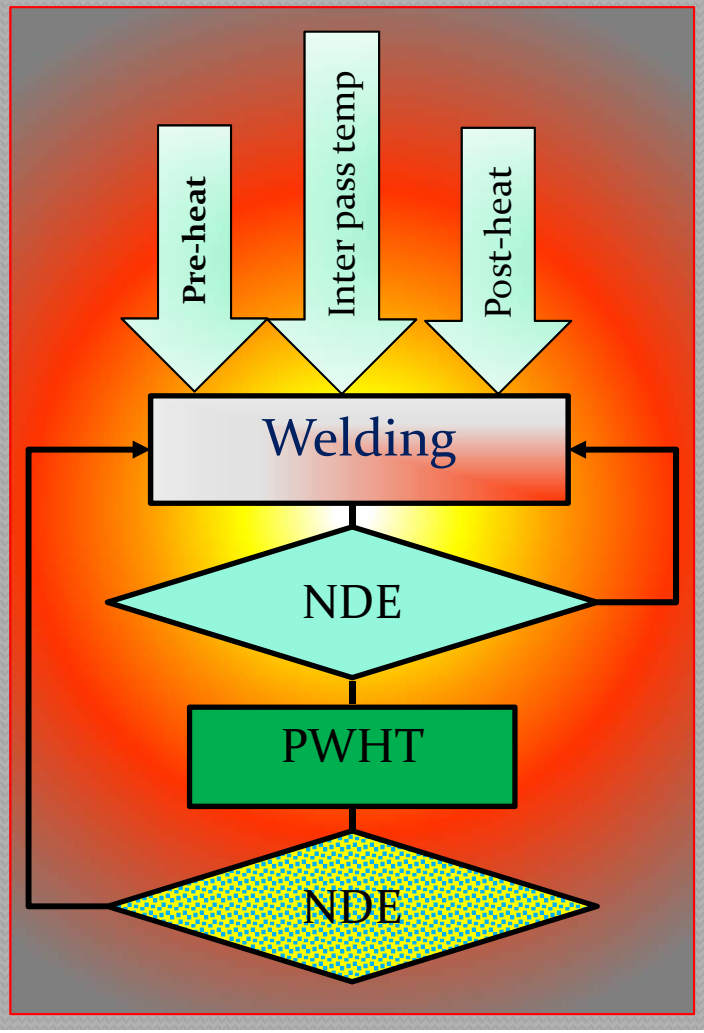
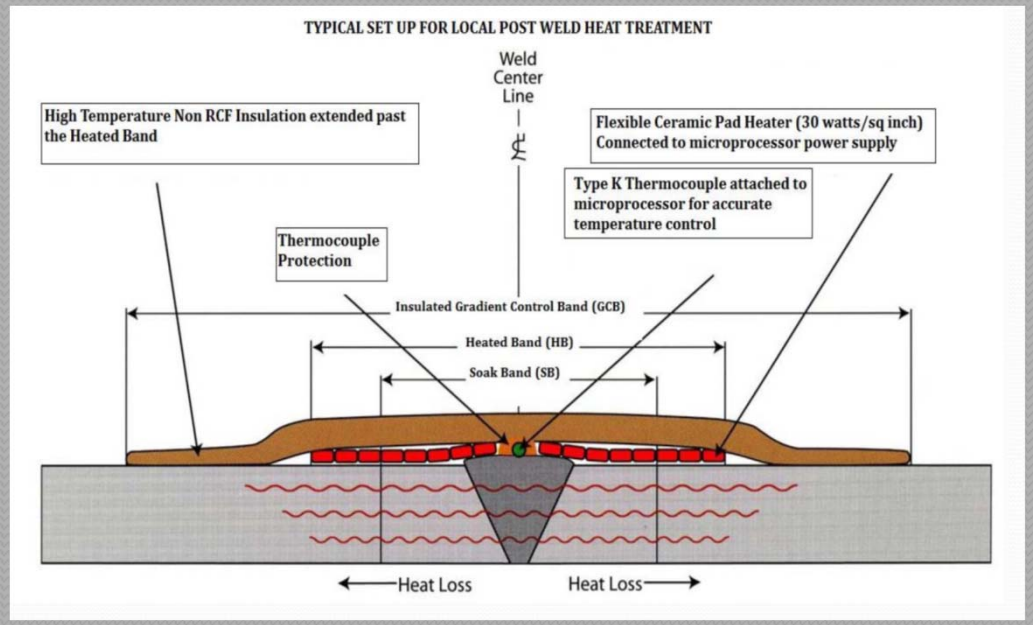
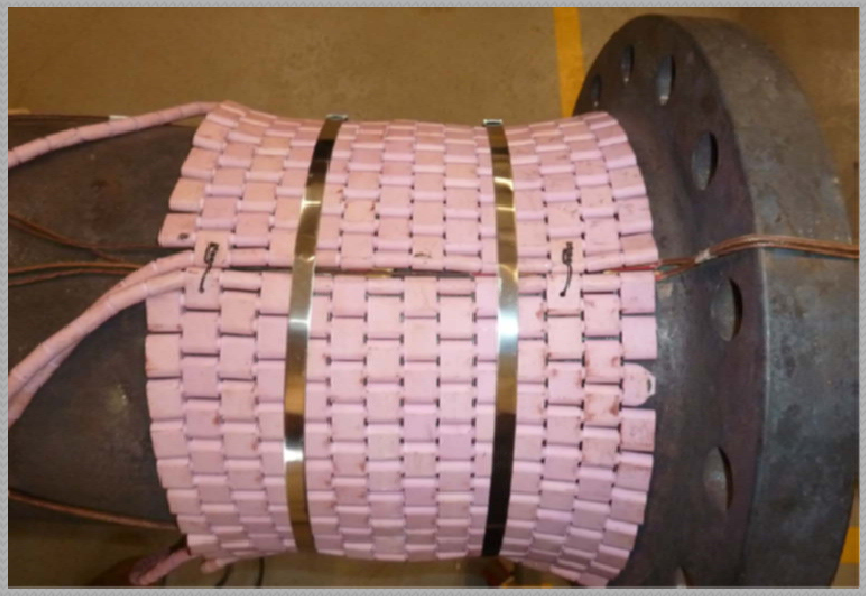
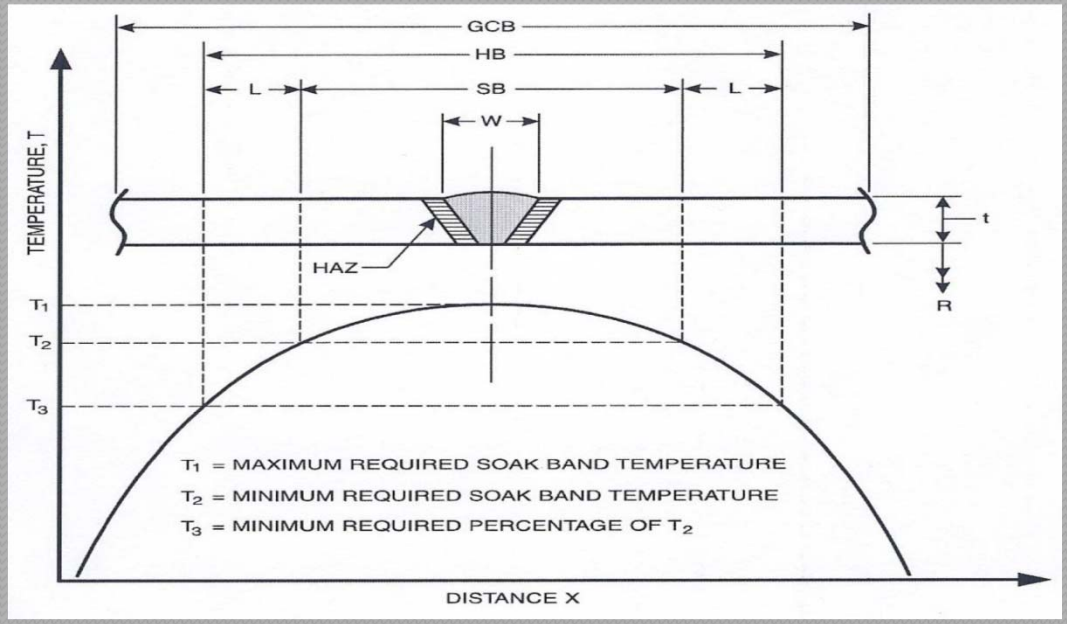
Welding of special steel for high temperature service (P91 steel pipe)

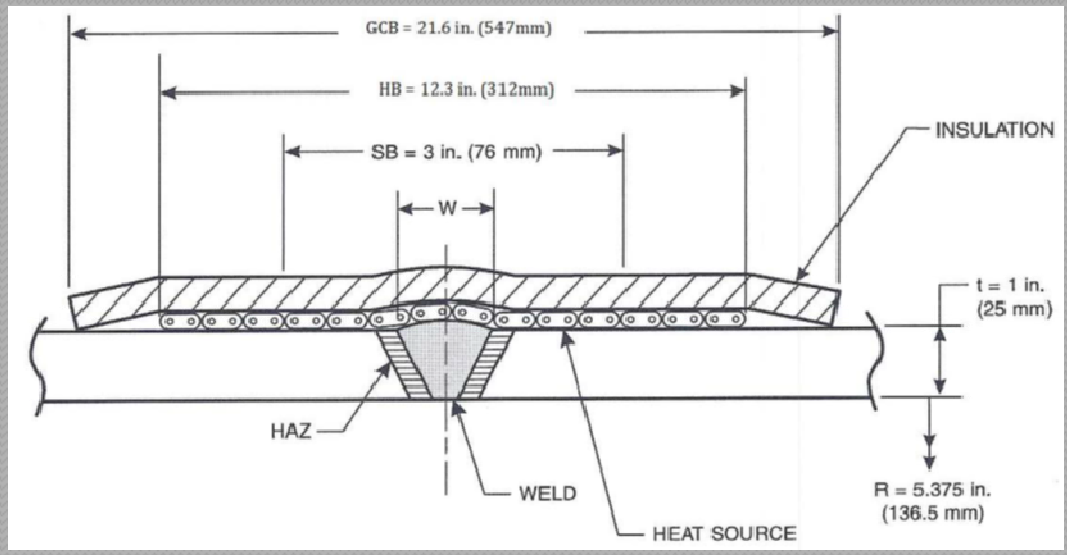



TYPICAL SET UP FOR LOCAL POST WELD HEAT TREATMENT
Weld Center Line
High Temperature Non RCF Insulation extended past the Heated Band
Flexible Ceramic Pad Heater (30 watts/sq inch) Connected to microprocessor power supply
Type K Thermocouple attached to microprocessor for accurate temperature control
Thermocouple Protection
Insulated Gradient Control Band (GCB)
Heated Band (HB)
Soak Band (SB)
Heat Loss
Heat Loss

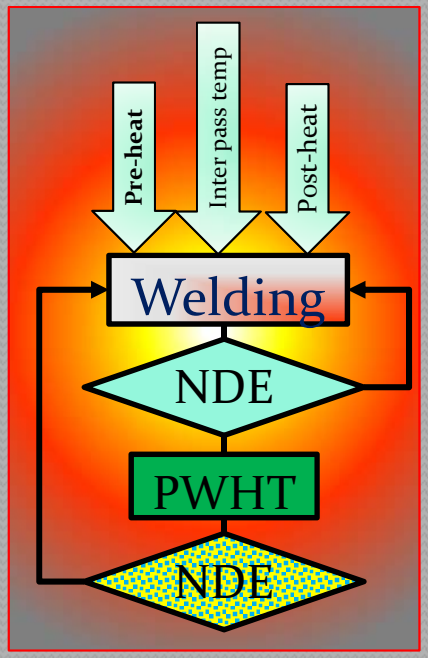


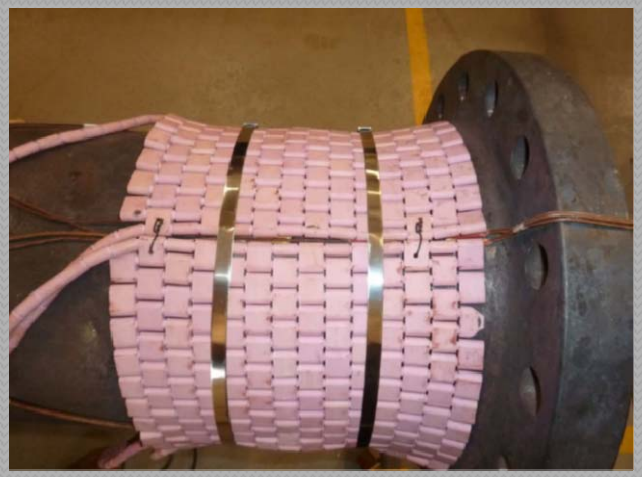
- **W** = Widest width of butt or attachment weld.
- **HAZ** = Heat-affected zone.
- **SB** = Soak band (width of the volume of the material where the holding temperature equals or exceeds the minimum and equals or is below the maximum required. The minimum width is typically specified as W plus a multiple of t on each side of the weld).
- **L** = Minimum distance over which the temperature may drop to a percentage of that at the edge of the soak band.
- **HB** = Heated band (width of heat source).
- **GCB**= Gradient control band (minimum width of insulation and/or gradient heat source).

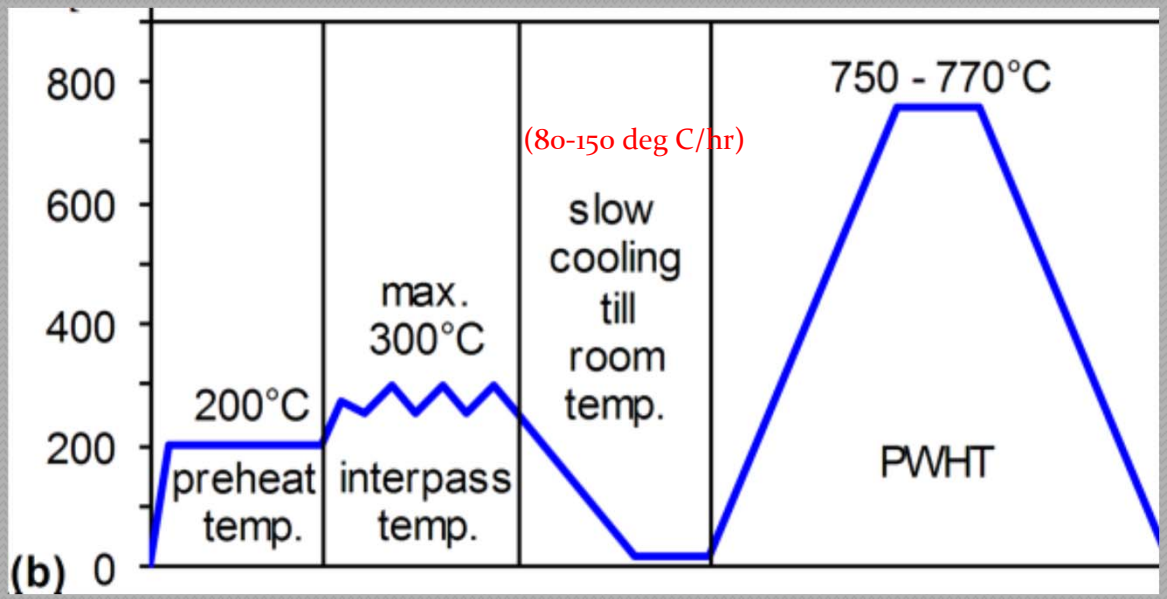


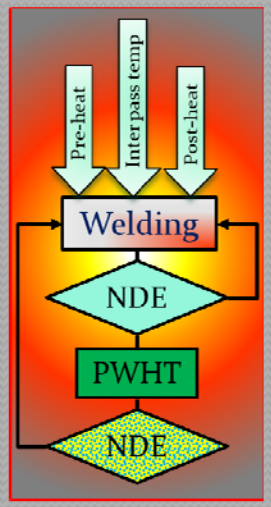


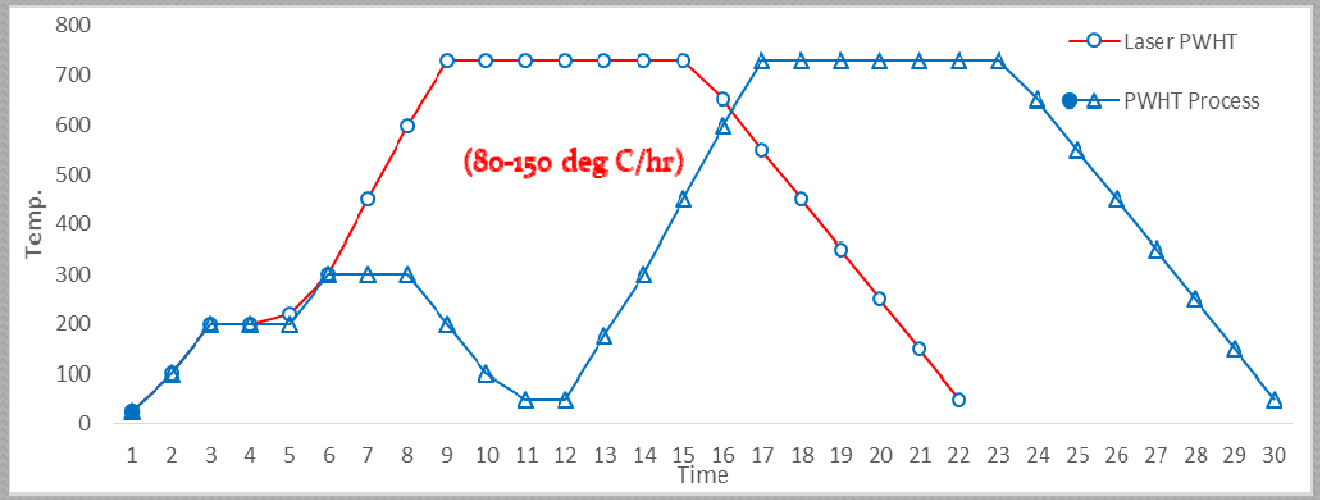
Post Weld Heat Treatment processes

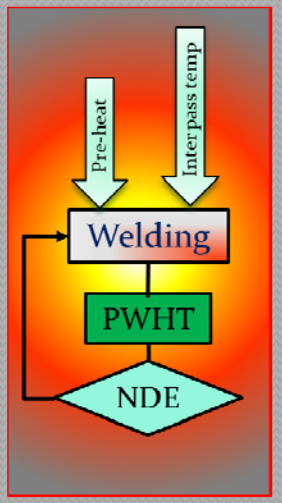












Proposed Process

- To minimize preparatory working time for attached PWHT equipment
- To shorten the timing of NDE process

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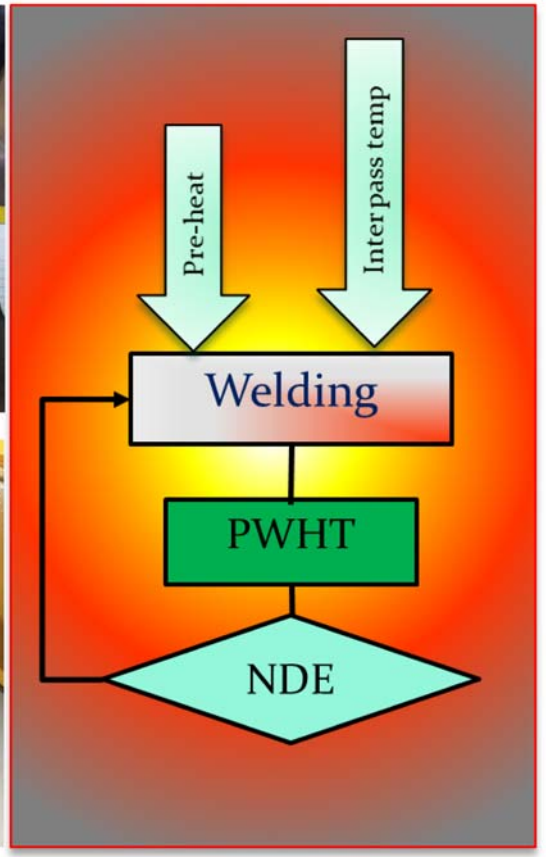

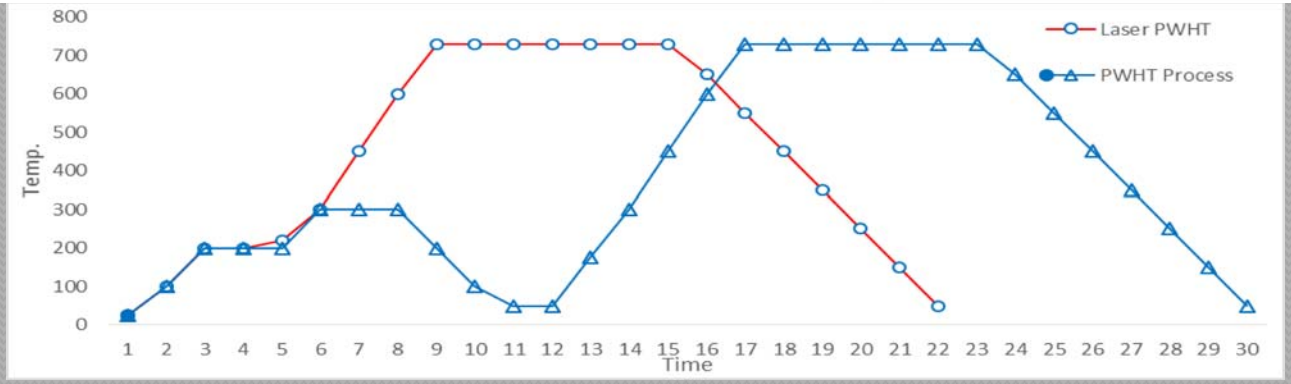

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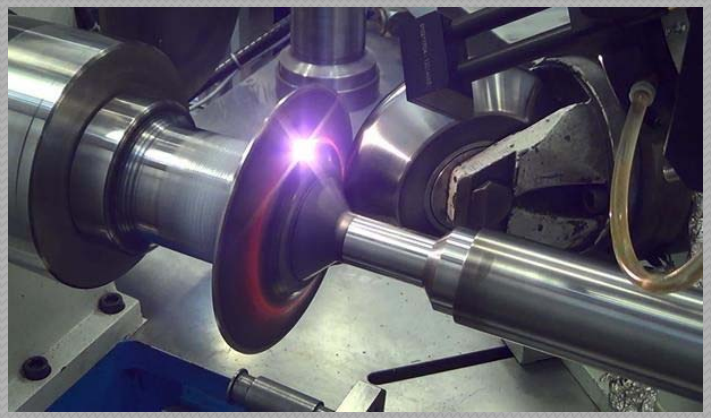
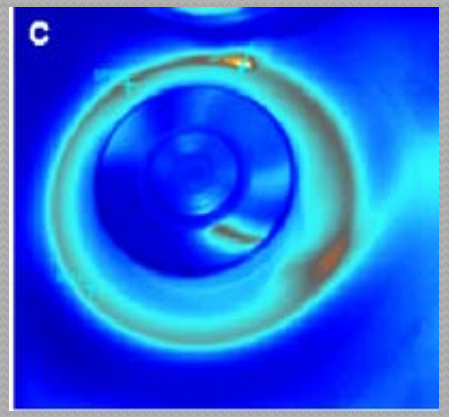
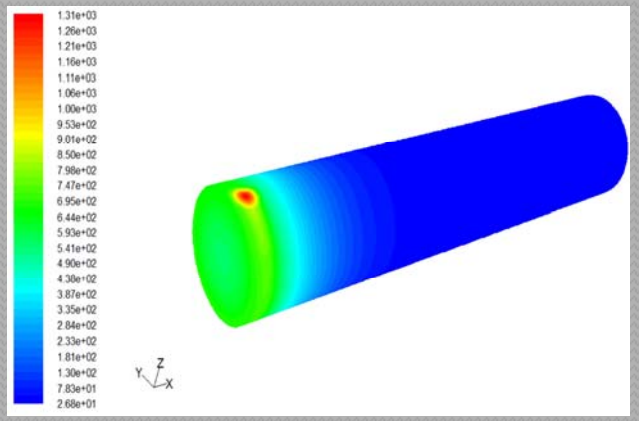
Question ??????

- How to maintain the temperature at;
  - During raising up period (80-150˚C/hr.)
  - Soaking period 15-30 Min at 730-775˚C
  - Cooling down period (80-150˚C/hr.)

(During heating the outer surface shall not be melted)







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Scope of the Study

- **To Study the relation between Laser Power, Focus Size, Focus Length and Travel Speed are effecting to the weldments.**
- **To Evaluate The Effect of Laser Heating PWHT on Mechanical and Metallurgical Properties of ASTM A335 P 91**
- **To Comparisons and describe the Effect between Laser heating and Electric Heat pad is applying the heat source for PWHT processes on Mechanical and Metallurgical Properties**
- **To Evaluate the Mechanical and Metallurgical Properties of ASTM A335 Grade P91 Welded Repair by Localized Laser PWHT**
- **To Assess the Cost of Laser PWHT**
- **To Establish the Guideline for PWHT Qualification of P 91 Welding Procedure.**

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Heating Processes

	Advantages	Disadvantages
Laser	❖Minimum part distortion ❖Selective hardening ❖No quenching required ❖Thin case capability ❖Case depth controllable ❖Eliminates post-processing ❖Improves fatigue	➢High equipment cost ➢Coverage area restricted ➢Absorbent coatings necessary ➢Multiple passes give local tempering.
Induction	❖Fast process rates ❖Deep case obtainable ❖Lower capital cost than laser ❖Coverage area	➢Downtime for coil change ➢Quenching required ➢Part distortion ➢Coil placement critical ➢Large thermal penetration ➢EM forces may spoil surface ➢Fabrication of complex coils for specific process
Flame	Cheap, flexible and mobile process	➢Poor re-producibility ➢Lacks rapid quench ➢Components distortion

William M.Steen, Laser Material Processing , Springer London

Experimental Procedures

Design of Experiment

- There will be 3 groups of testing coupon;
  - As welded 1 coupon.
  - Conventional PWHT. 3 coupons.
  - Proposed LASER PWHT 3 coupons.
- The welding process is done by GTAW
- Non destructive examination by radio graphic (X-Ray)

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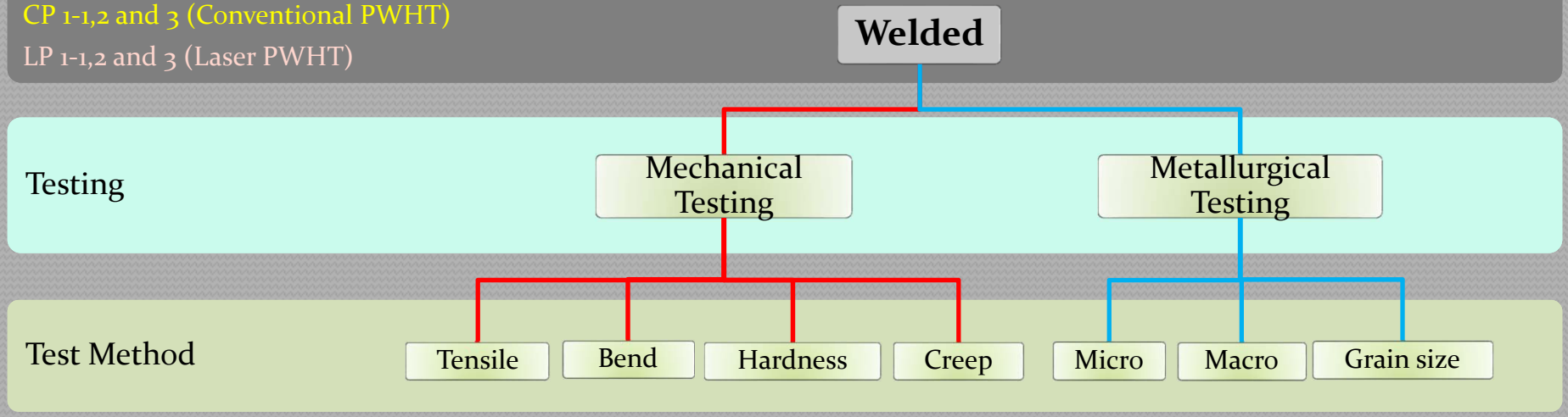
Experimental Procedures

NP-1-1,2 and 3 (As Welded)
CP 1-1,2 and 3 (Conventional PWHT)
LP 1-1,2 and 3 (Laser PWHT)



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Experimental Procedures

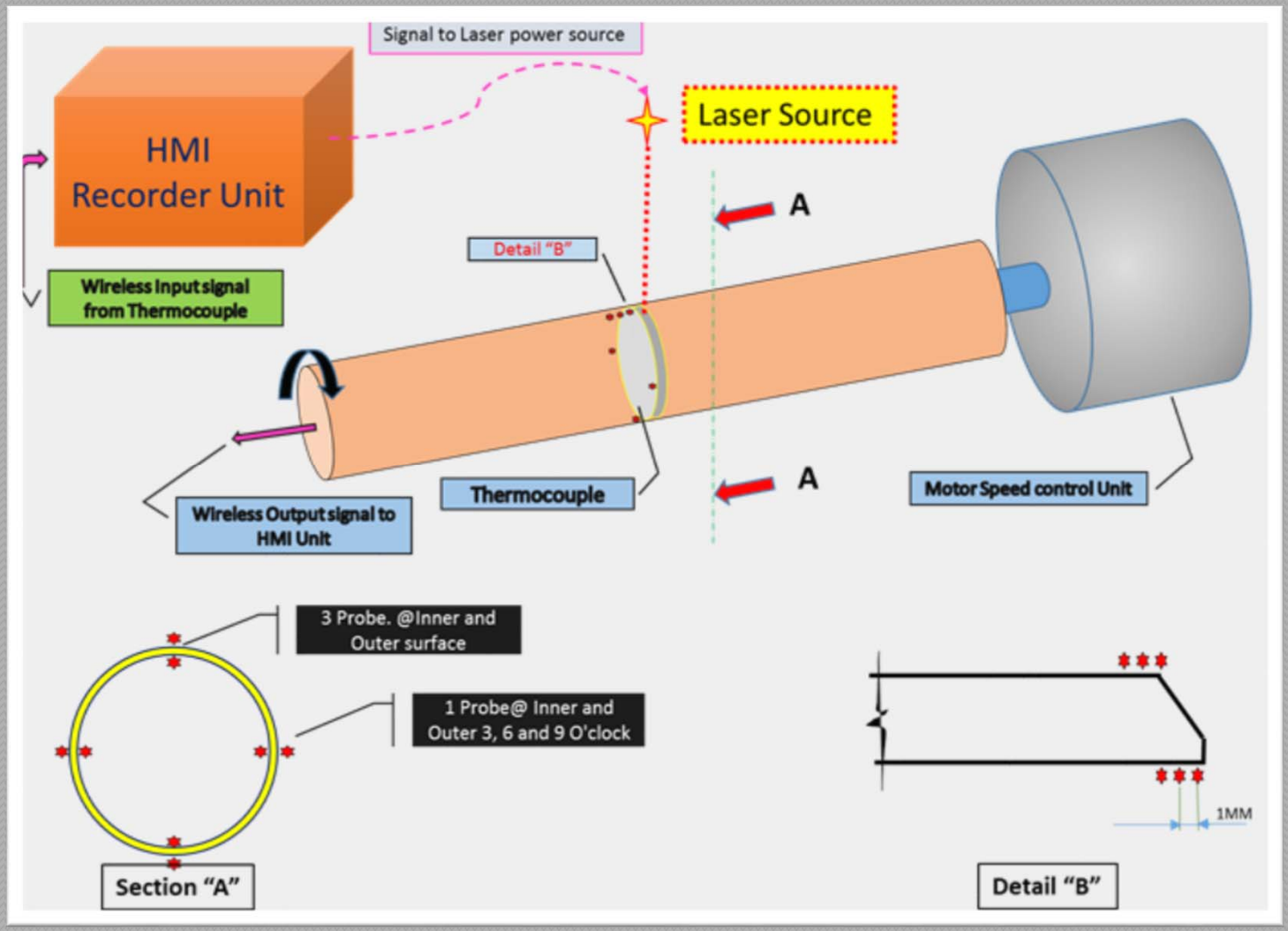
Laser Power (Watt.)	Focus Length (mm.)	Speed (Rpm.)	Heating Time (Min.)	Temp. °C	
				Outer	Inner

Mechanical testing	International Code	Qt'y
Tensile Test	ASTM A370	2
Micro Hardness Test	ASTM E384	1
Bend test	ASME IX	2
Creep test (Optional)	ASTM E139	1
Metallurgical testing		
Grain size measurements	ASTM E112	1
Macro structure Test	ASTM A340	1
Micro structure Test	ASTM E407	1

Expected result

- Relation between laser power per speed of travelling.
- Relation between the effected area and wide of laser heating band
- Describe the Softening zone is effect by the laser heating

Experimental schematics



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Part III :
❖ Research Progress

1st stage,

Preparatory

- ❖ Testing coupon welding.
- ❖ PWHT Data Logger and Driven Tool

2nd stage,

- ➢ Perform PWHT by Electric Heat Pad
- ➢ Perform PWHT by Laser.

Final stage,

- ➢ Labarotory test for Coventional PWHT Test Coupons
- ➢ Laser PWHT and Labaratory test.
- ➢ Summarize and Conclude the Result

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1st stage,

Preparatory

- Testing coupon welding.
- PWHT Data Logger and Driven Tool

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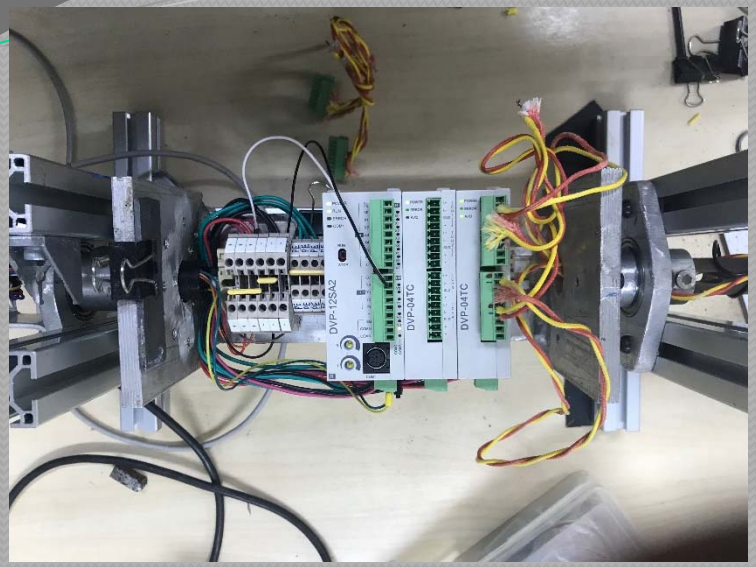
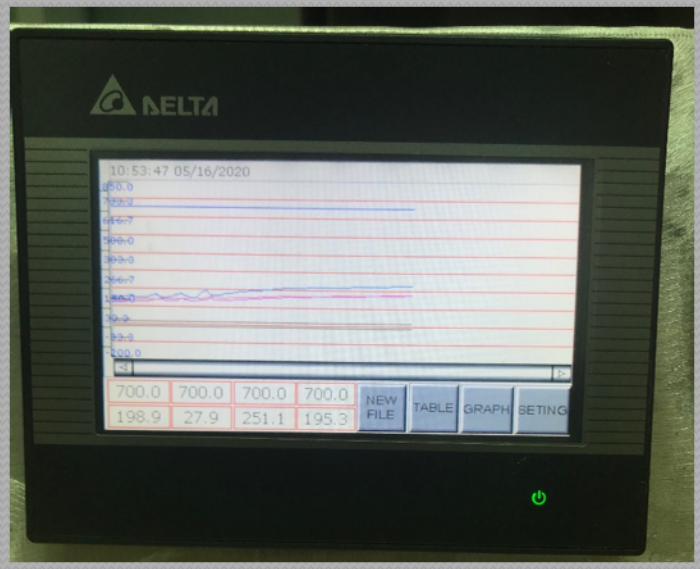


Data Logging Unit

Adjustable Driven Unit

Work pieces and Thermo Couple



HMI Unit

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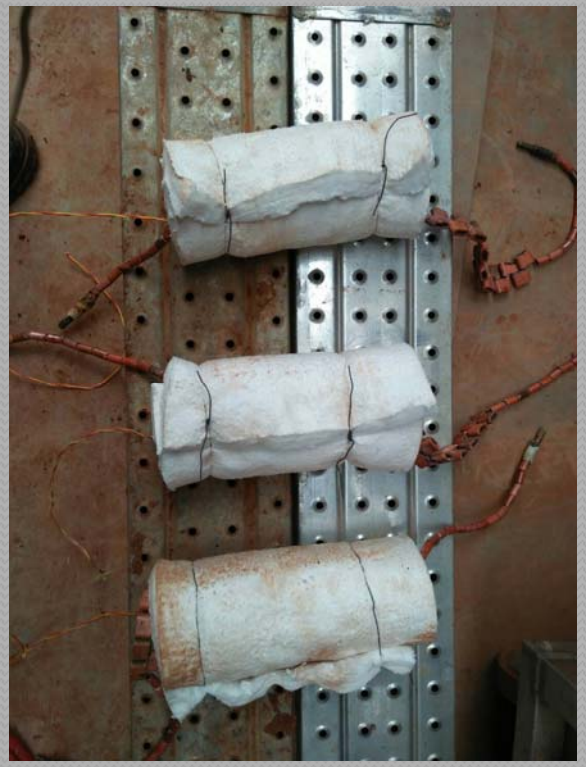
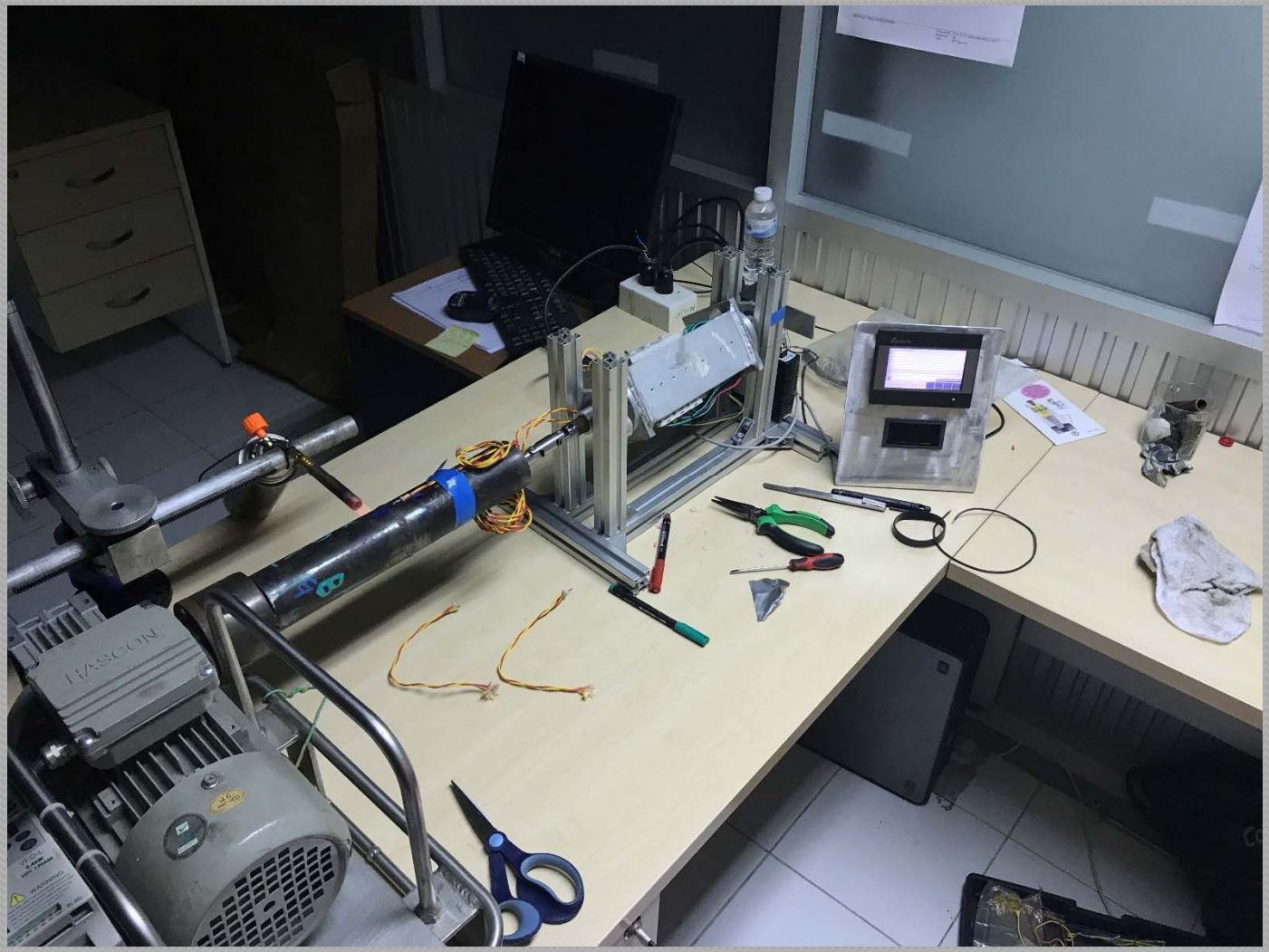
2nd stage,

- Perform PWHT by Electric Heat Pad
- *Perform PWHT by Laser.*





Assembled Unit

Unit Pre-Commissioning

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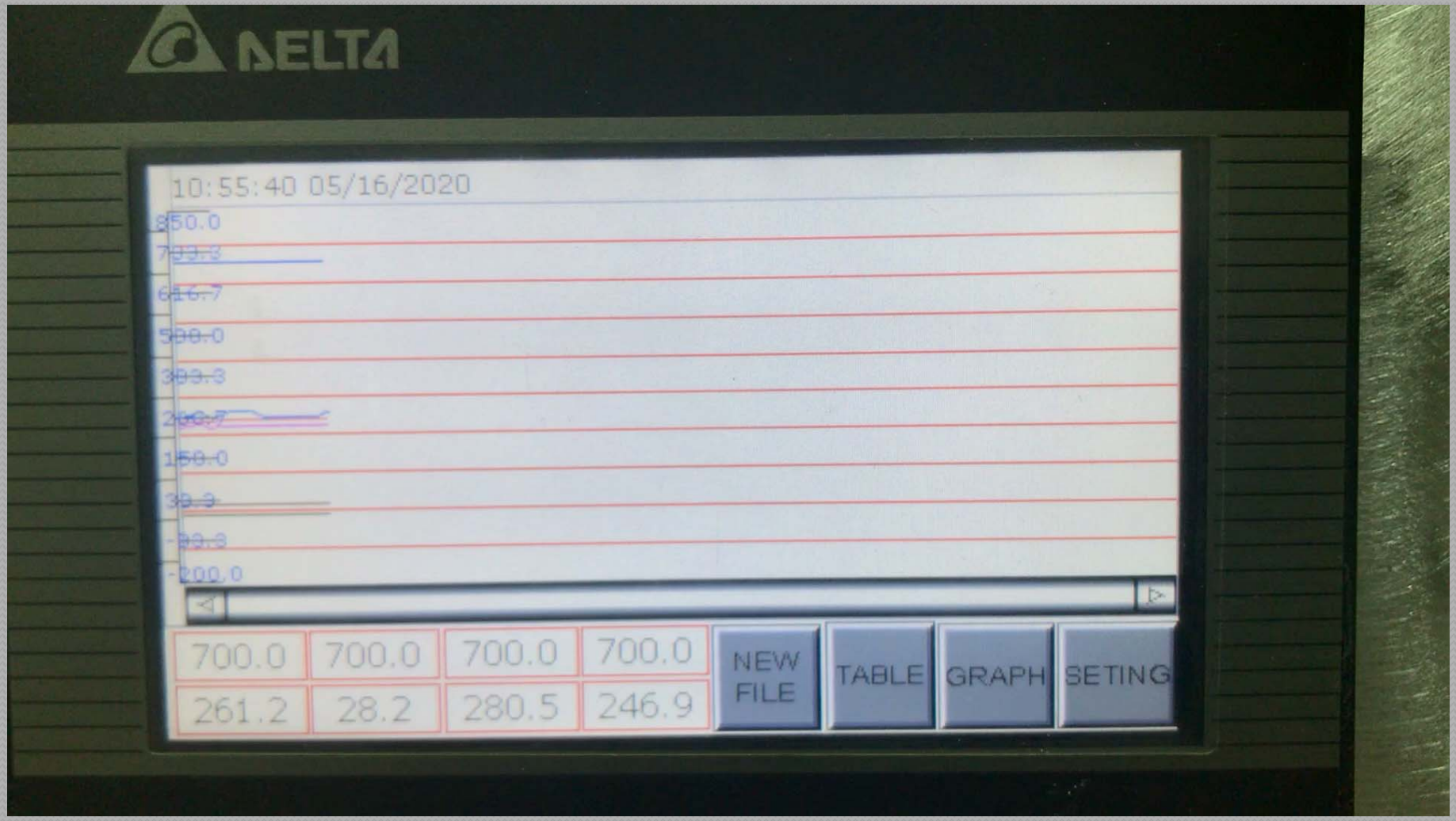
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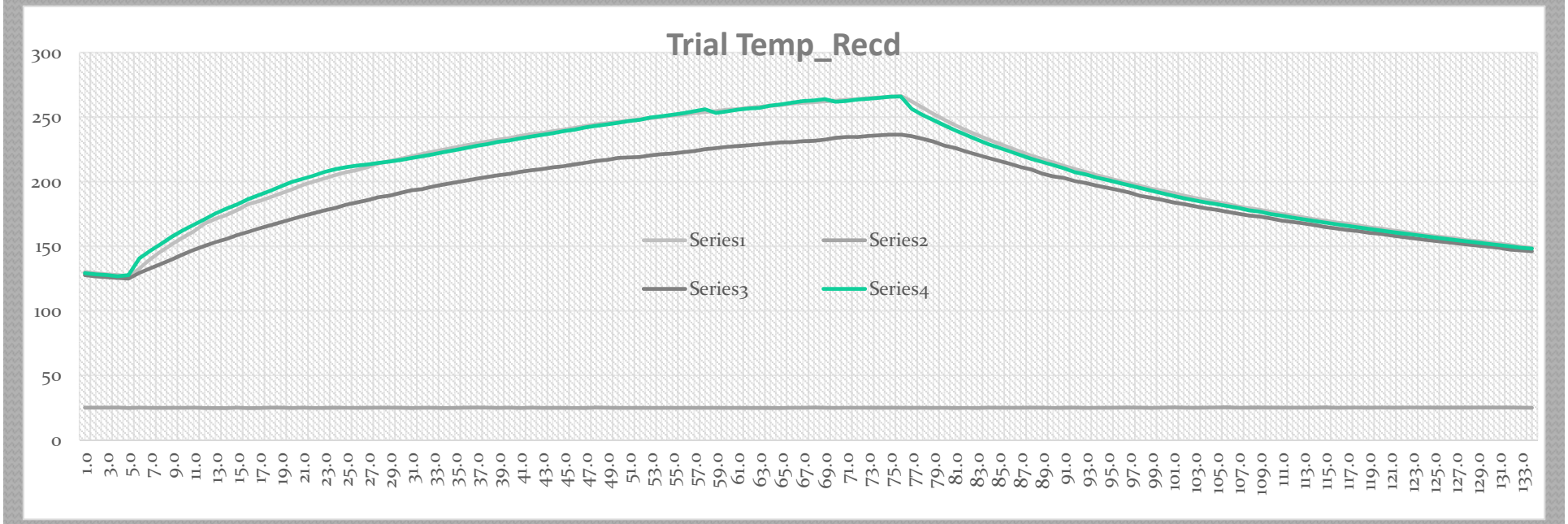

Data Logging during Heating Processes

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