THE INVESTIGATION OF THE EFFECT OF PUNCH VELOCITY INCREMENT ON THE THICKNESS REDUCTION OF PHE PLATES

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16TH LS-DYNA FORUM
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Metal Forming Process in Plate Heat Exchanger(PHE)
Outline

- Plate Heat Exchanger (PHE) definition and sub-components
- Production processes of PHE
- Metal forming processes and process parameters.
- Material characterization tests & material card
- Numerical Results

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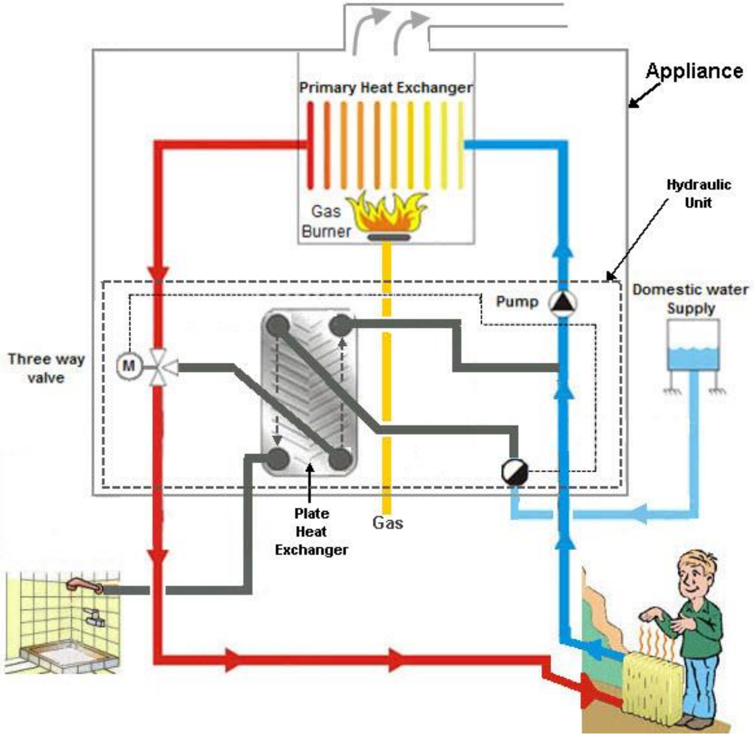
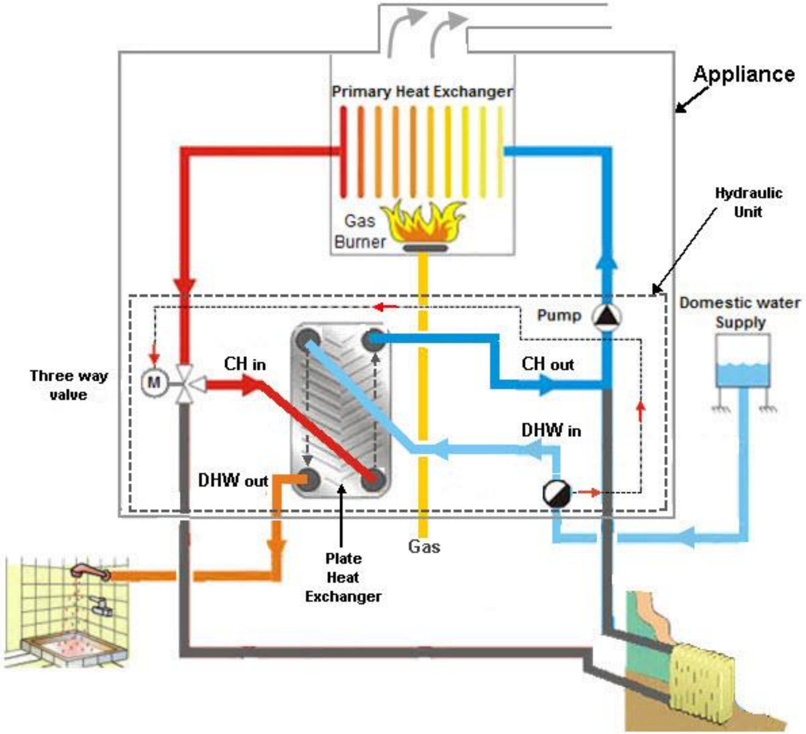
Metal Forming Process in Plate Heat Exchanger(PHE)
Introduction

Functioning of Combi Boiler

Central Heating (CH) Mode



Domestic Hot Water (DHW) Mode



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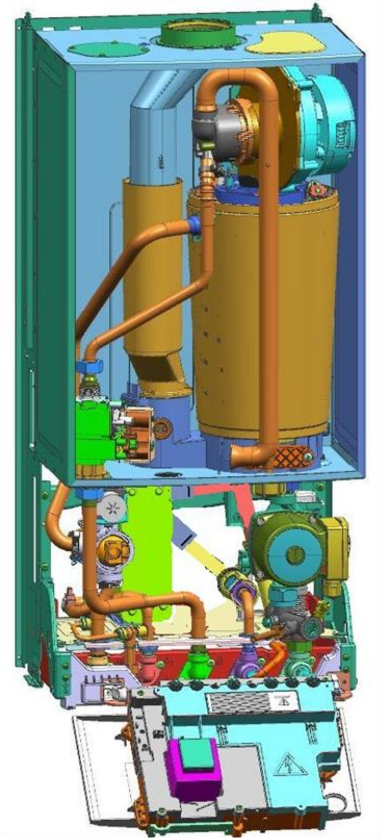
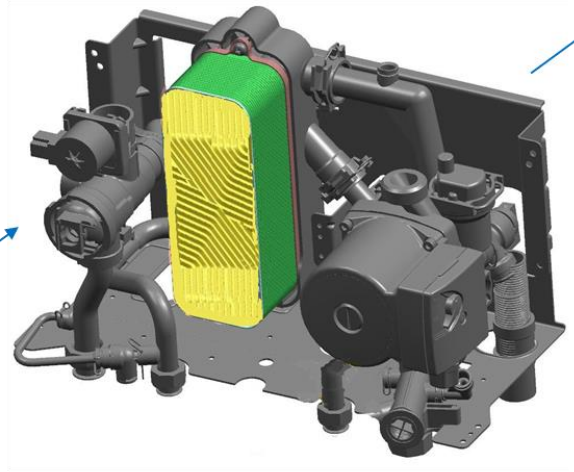
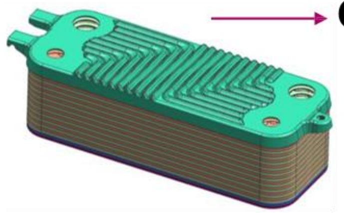
Metal Forming Process in Plate Heat Exchanger(PHE)
Introduction



Condensing Combi Boiler

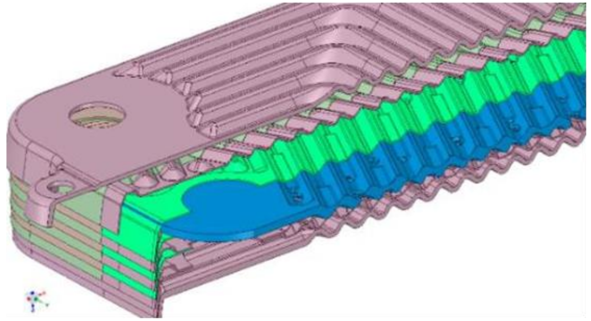


Hydraulics module of boiler



Compact PHE

Section view of PHE



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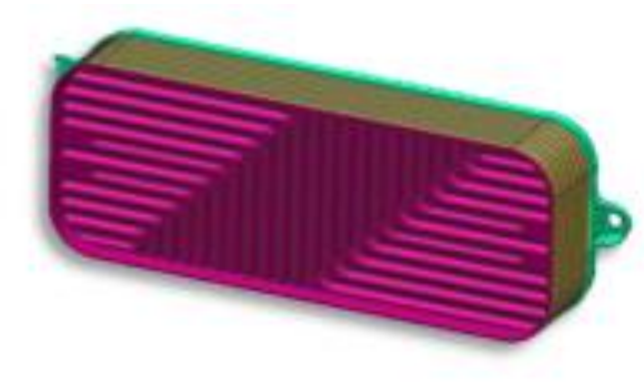
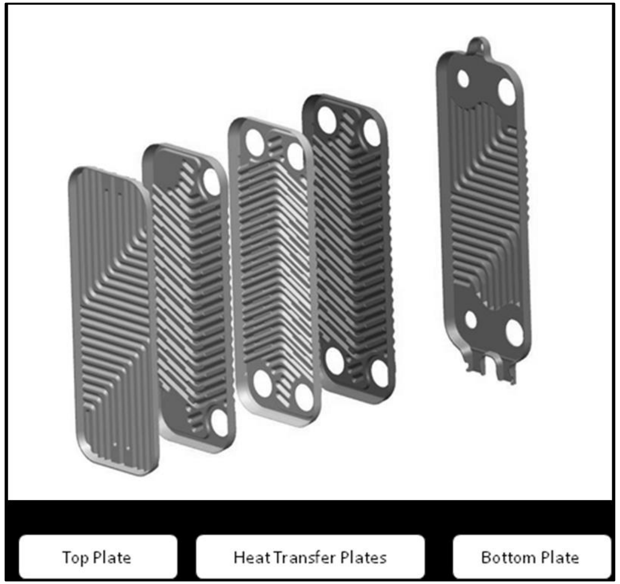
Metal Forming Process in Plate Heat Exchanger(PHE)
Introduction

- The plate heat exchangers have crucial importance due to compact size and thermally efficient behavior. Plate heat exchangers have unique patterns and produced with step-wise operations which forming, stacking, vacuum brazing, water-hammer respectively. Main intension of this study understanding the importance of process speed in PHE production and applicable ratio activities.





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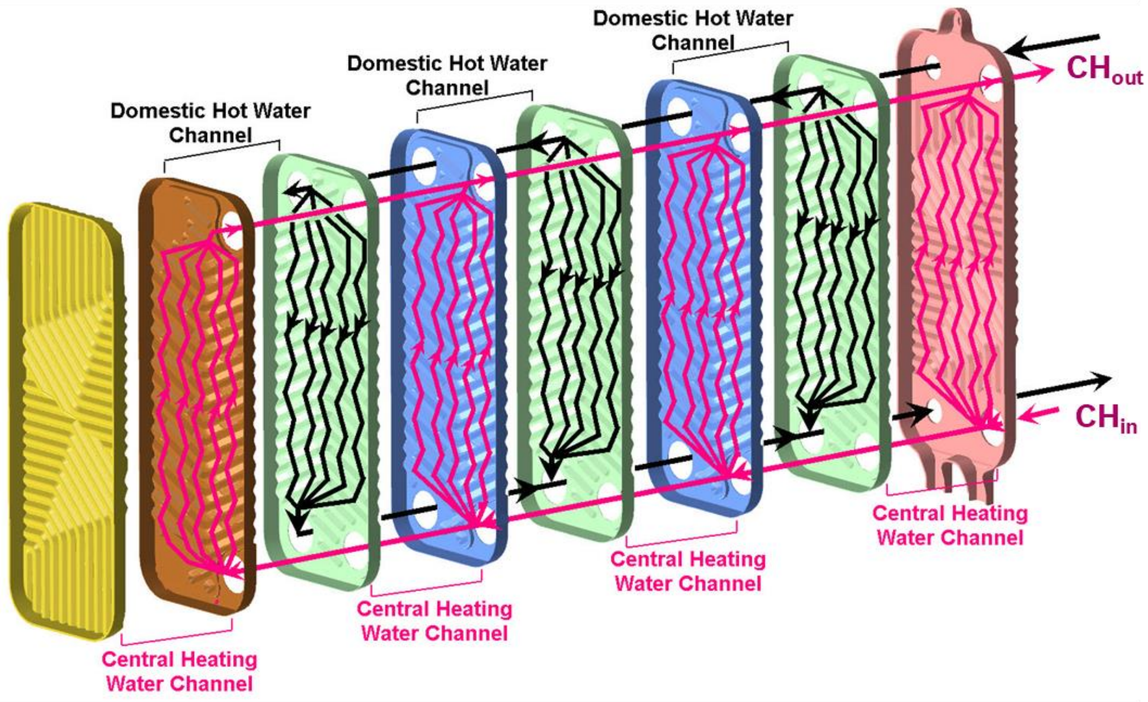
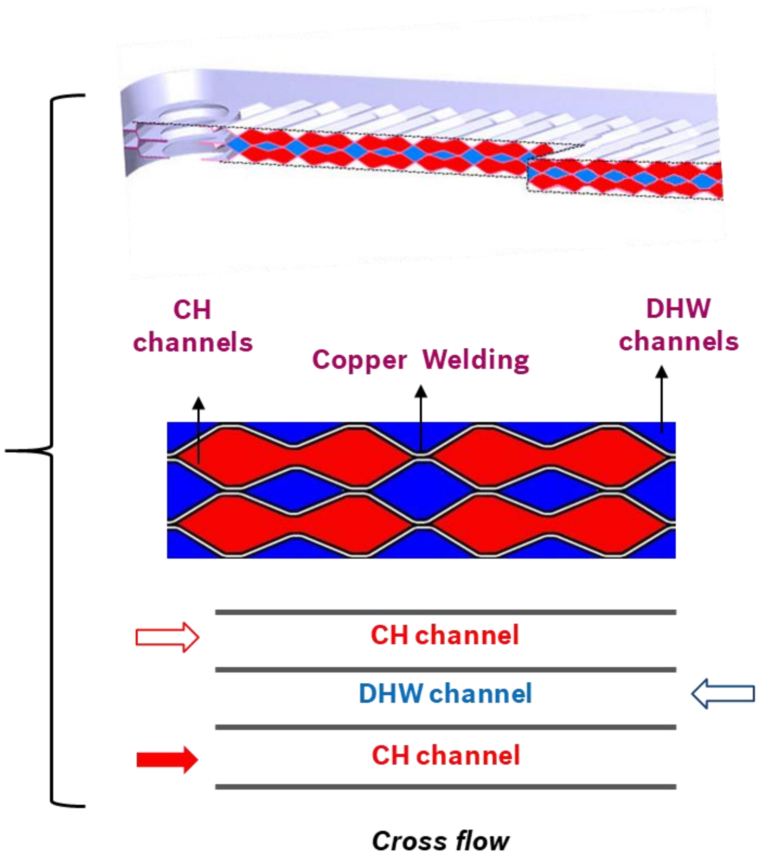
Metal Forming Process in Plate Heat Exchanger(PHE)
Introduction





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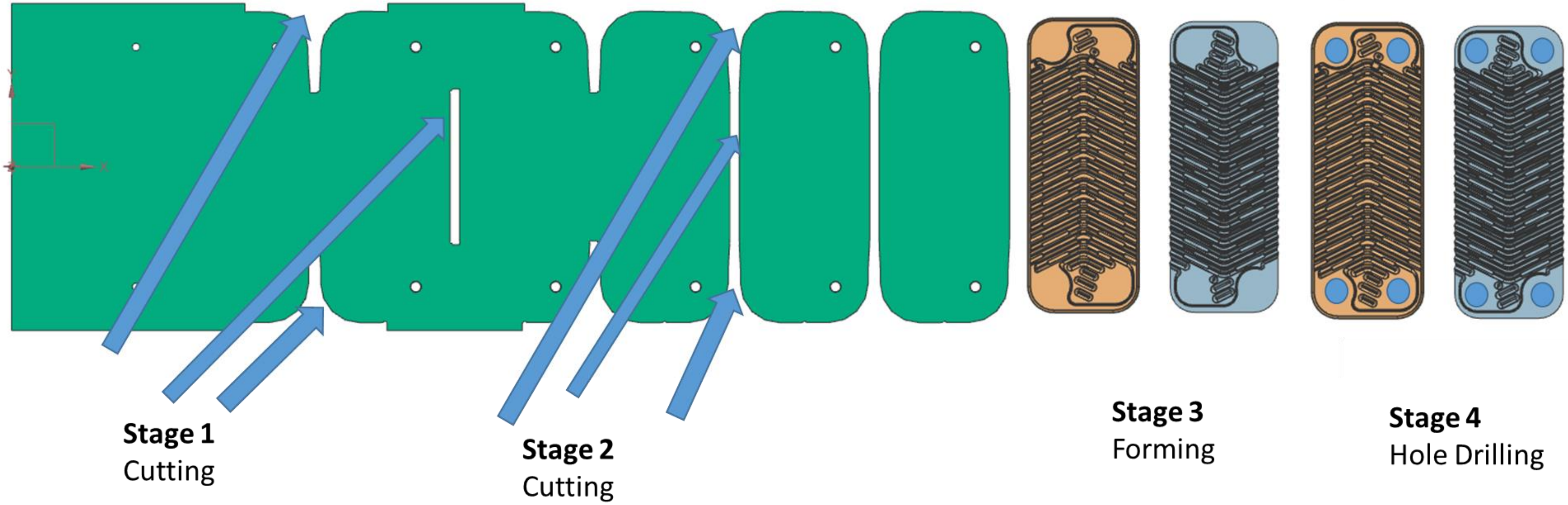
Metal Forming Process in Plate Heat Exchanger(PHE)

Production Steps



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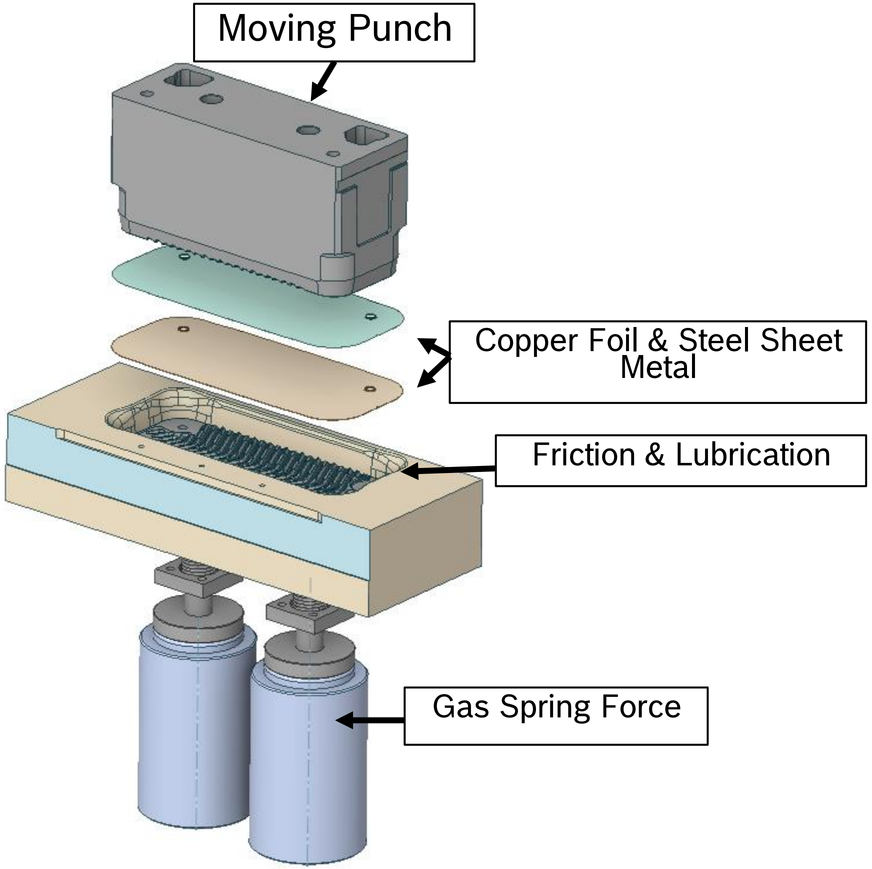
Metal Forming Process in Plate Heat Exchanger(PHE)
Metal forming processes and process parameters.



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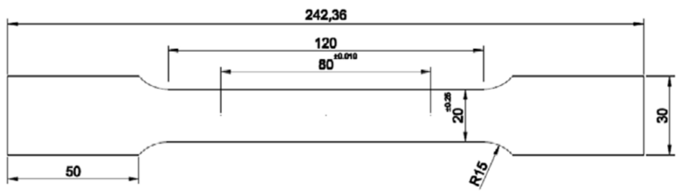
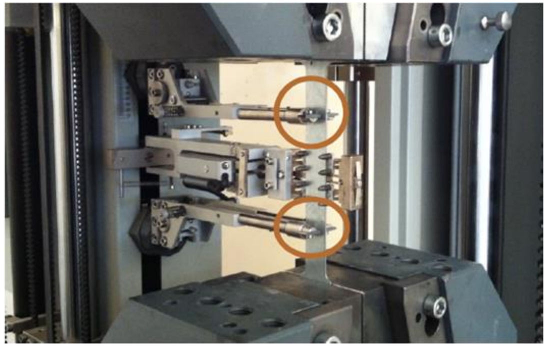
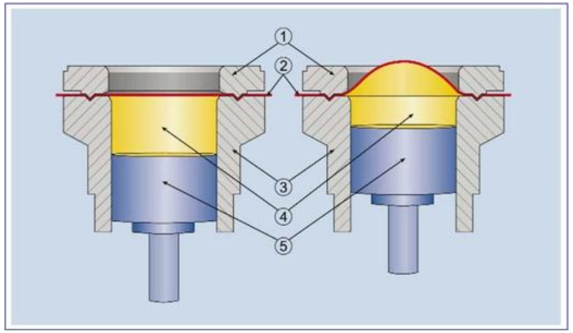
Metal Forming Process in Plate Heat Exchanger(PHE)
Material characterization tests

- The tensile and hydraulic bulge tests were carried out to obtain tensile properties and flow curve of stainless steel.
- The tensile tests were performed for 3 different rolling directions such as 0°, 45° and 90 ° within the elastic region of material.
- Each group of tests are repeated for statistical robustness of tests. Quasi-Static Tensile Test and Bulge tests are conducted to obtain the required input parameters for the MAT_133_BARLAT_YLD2000 material model in Ls-Dyna.



Standart Tensile Specimen (Flat)


Macro Extensometer



Bulge Test Illustration [1]

*Note that, static tests related to 316L were performed in **Center of Excellence for Metal Forming** at Atılım University, Ankara.

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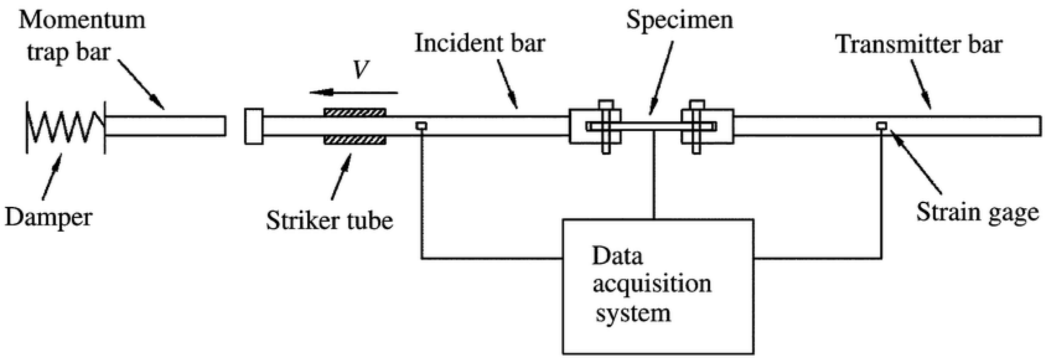
Metal Forming Process in Plate Heat Exchanger(PHE)
Split Hopkinson Tension Bar (SHTB) Test

- The mechanical behavior of 316L stainless steel were studied during tensile loading at high strain rates, using a Split Hopkinson Tension Bar (SHTB).



*Note that, dynamic tests related to 316L were performed in **Dynamic Testing and Modeling Laboratory and Department of Mechanical Engineering**, Izmir Institute of Technology, Gulbahce, Urla, Izmir, Turkey.

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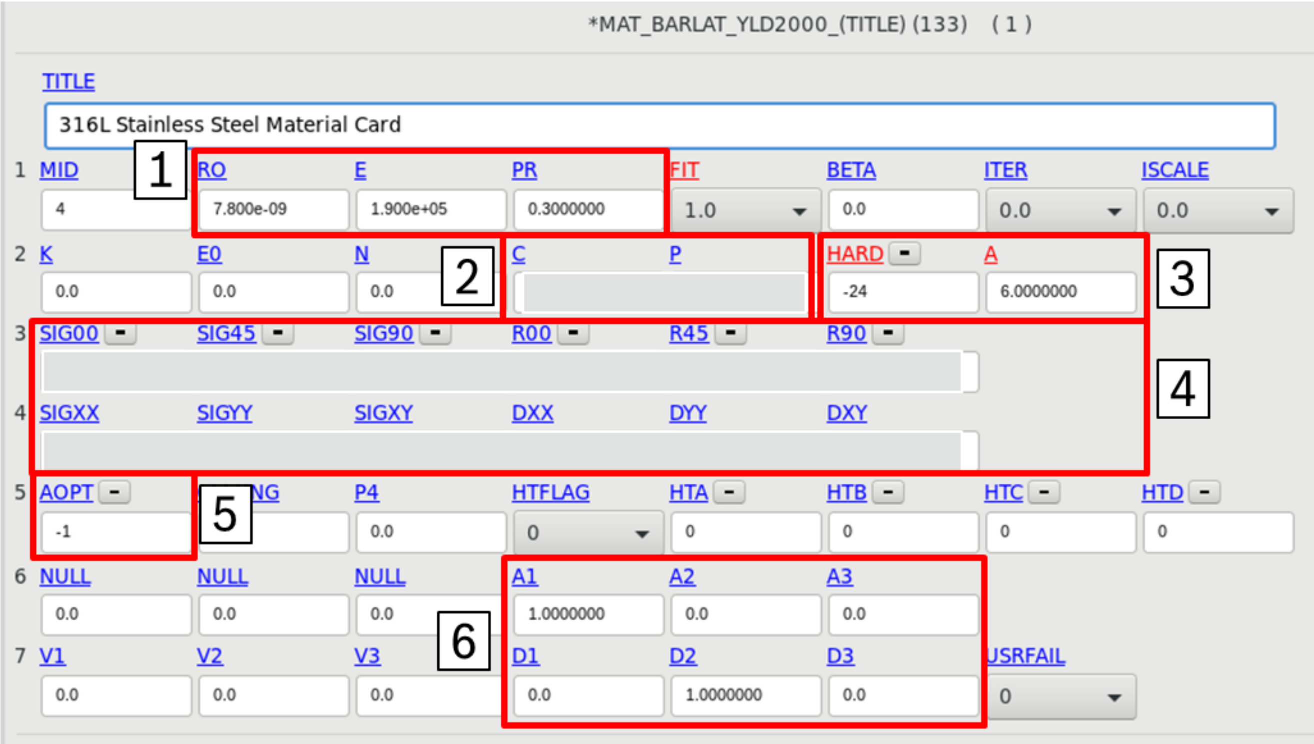
Metal Forming Process in Plate Heat Exchanger(PHE)

Material Card



Barlat's 2000 Yield Criteria

1. Mechanical Properties (Density, Elastic Modulus, Poissons Ratio)
2. Strain Rate Parameters (Cowper-Symonds Constitutive Equation) from Dynamic Tests
3. Hardening Type Selection & Hardening Curve
4. Yield Stresses, Lankford Parameters from Static Tests
5. Material Coordinate System
6. Components of vectors

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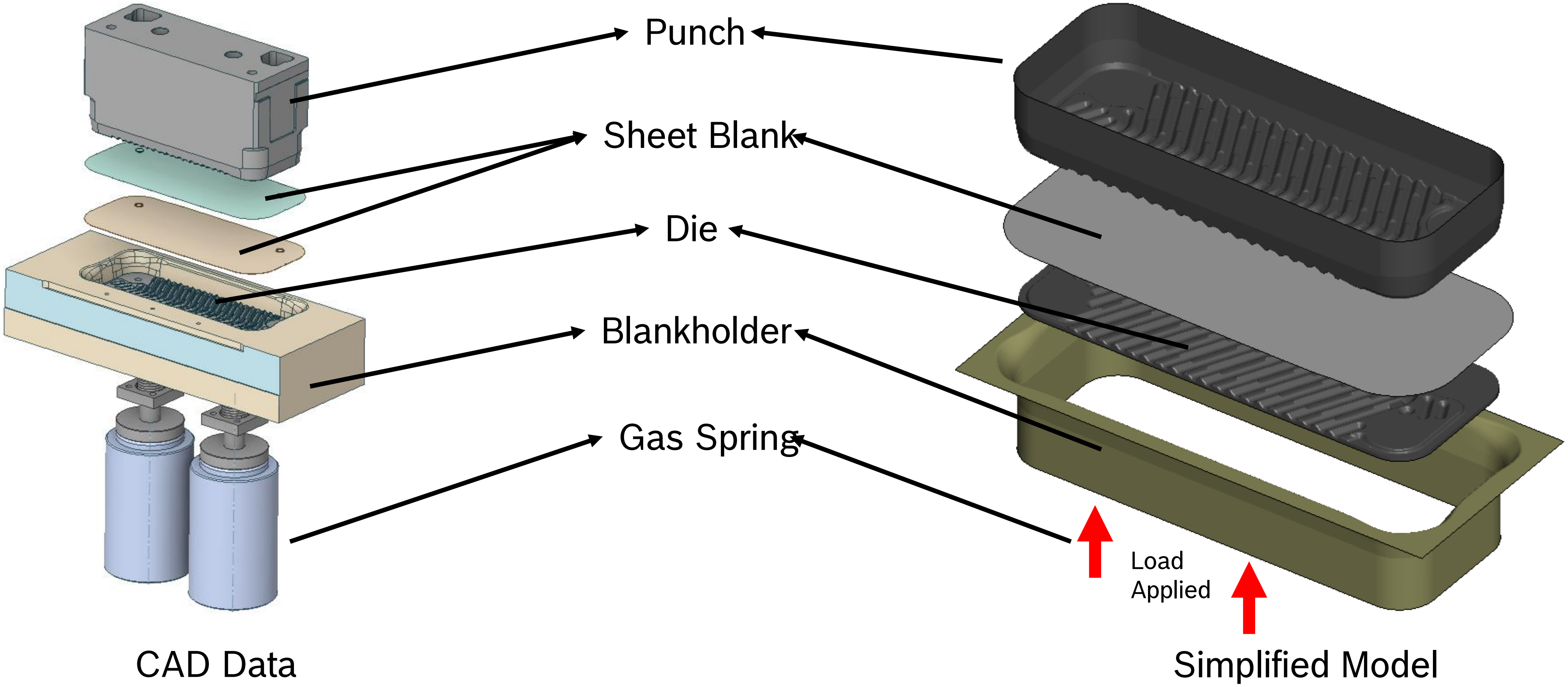
Metal Forming Process in Plate Heat Exchanger(PHE)
Numerical Modelling



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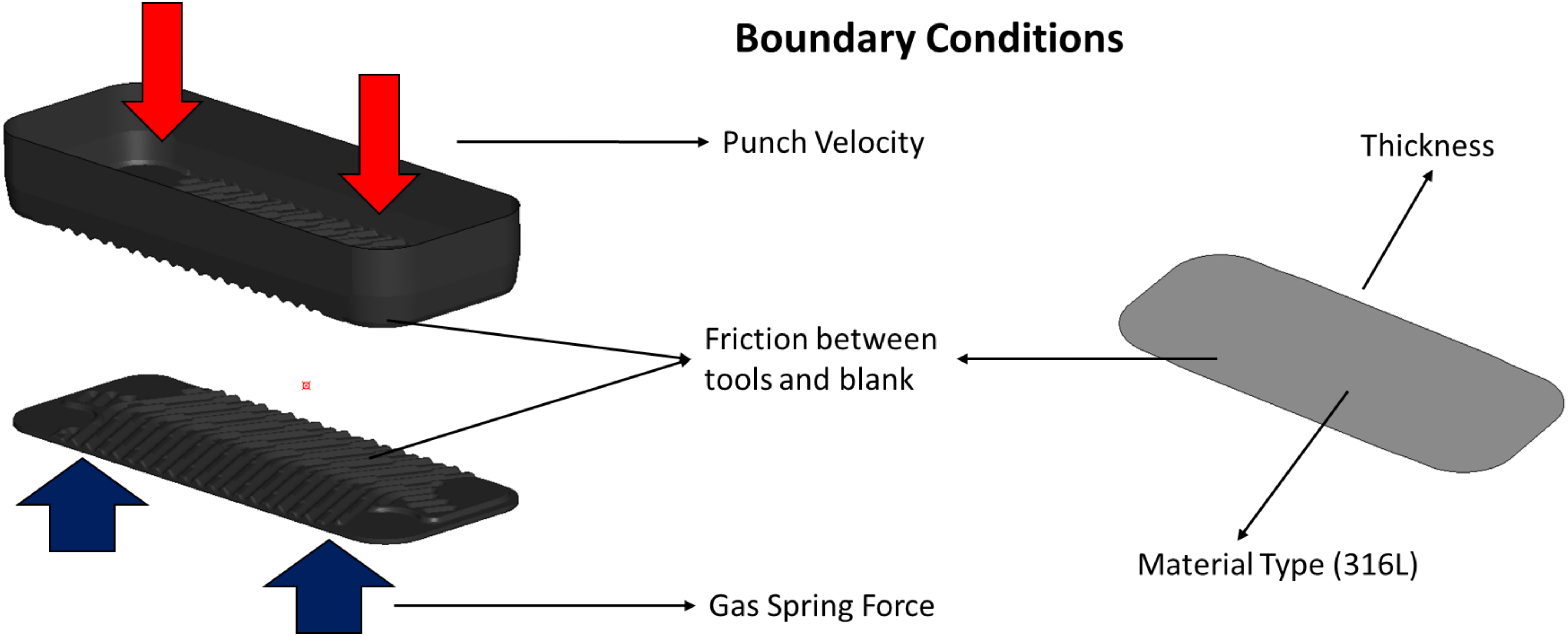
Metal Forming Process in Plate Heat Exchanger(PHE)
Numerical Modelling



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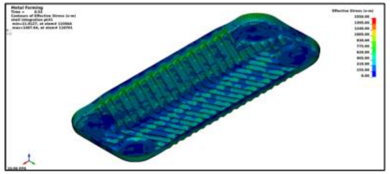
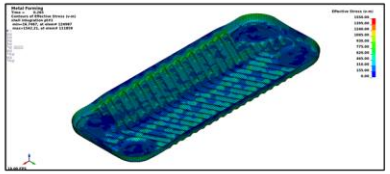
Metal Forming Process in Plate Heat Exchanger(PHE)
Numerical Modelling - Results
Effective Stress (MPa)

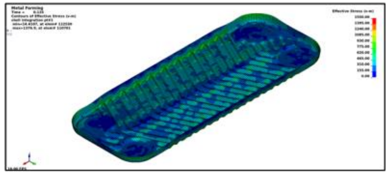
1x Velocity



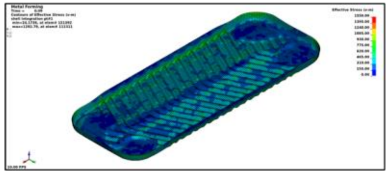
2x Velocity



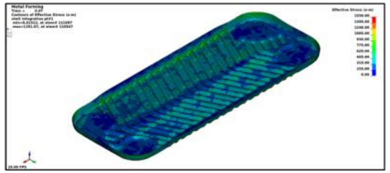
4x Velocity



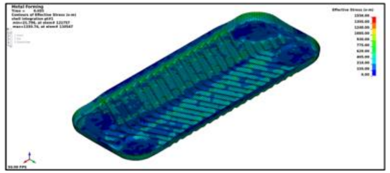
6x Velocity



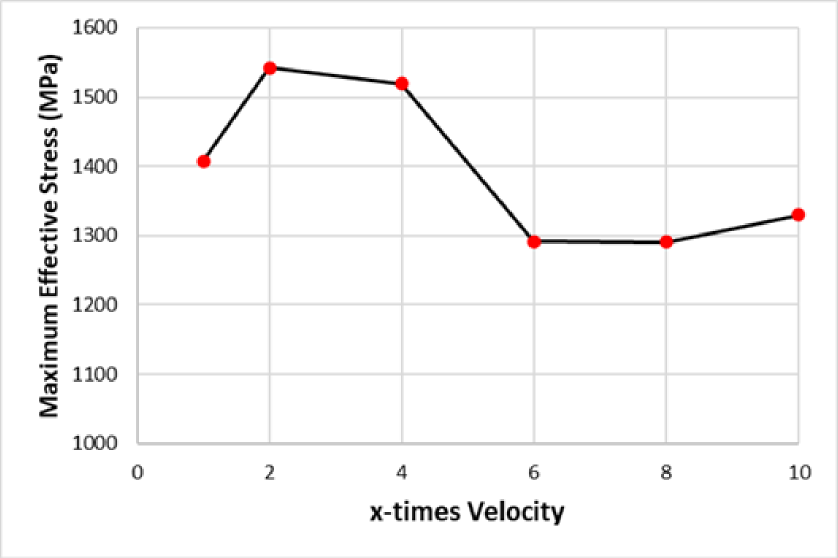
8x Velocity



10x Velocity



x-times Velocity	Maximum Effective Stress (MPa)
1	1408
2	1542
4	1519
6	1292
8	1291
10	1330



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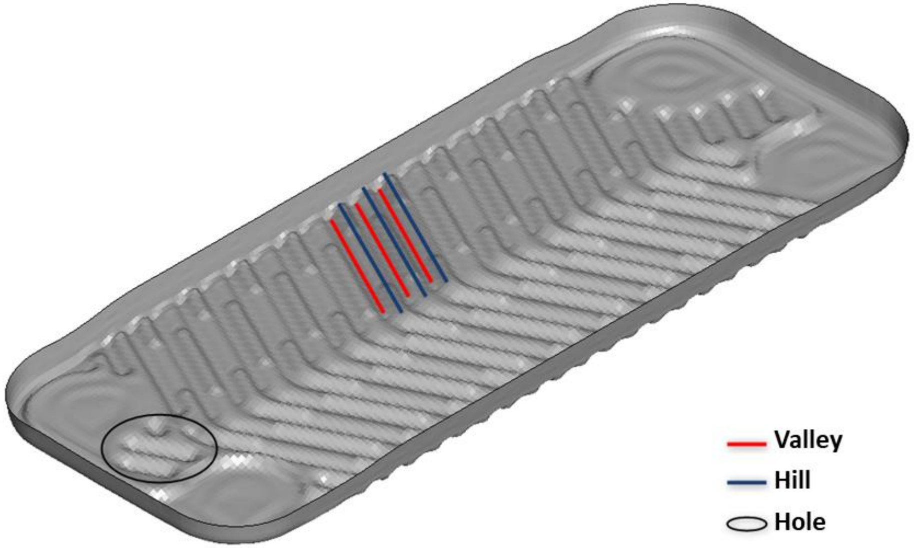
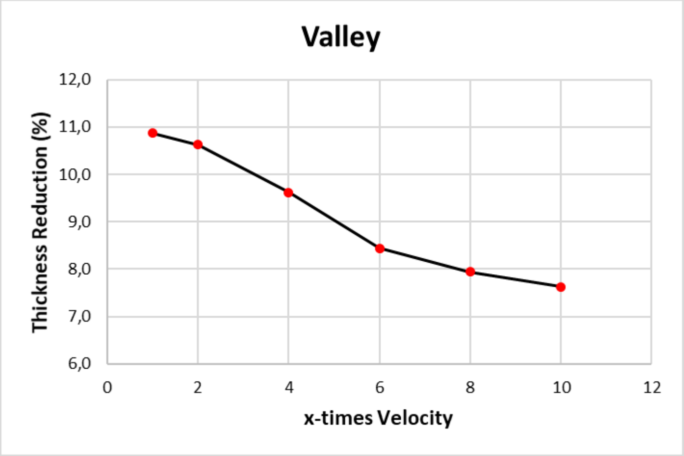
Metal Forming Process in Plate Heat Exchanger(PHE)

Numerical Modelling - Results

Thickness Reduction (%)



Valley	
x-times Velocity	Thickness Reduction (%)
1	10,87
2	10,63
4	9,62
6	8,44
8	7,94
10	7,63



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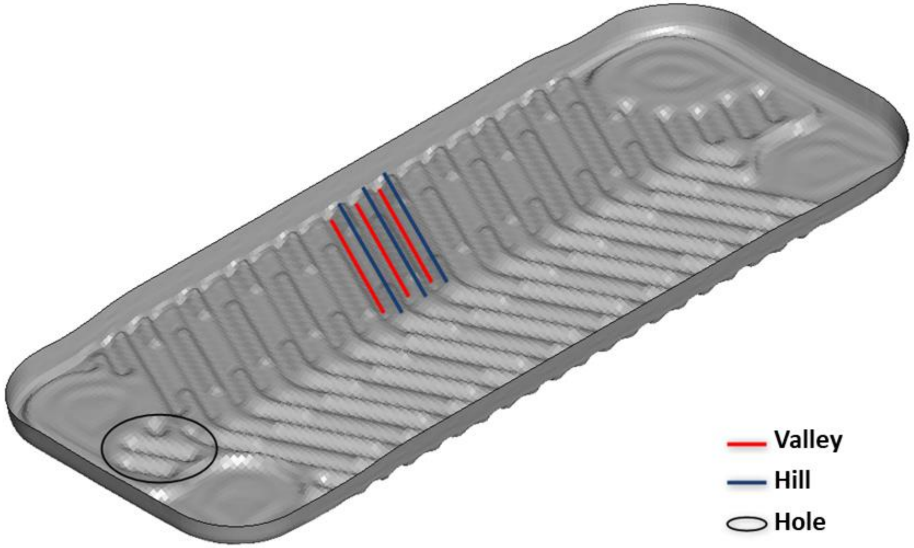
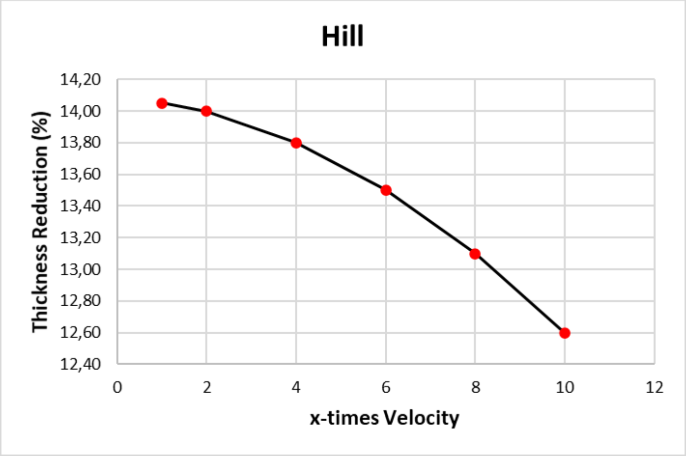
Metal Forming Process in Plate Heat Exchanger(PHE)

Numerical Modelling - Results

Thickness Reduction (%)



Hill	
x-times Velocity	Thickness Reduction (%)
1	14,05
2	14,00
4	13,80
6	13,50
8	13,10
10	12,60



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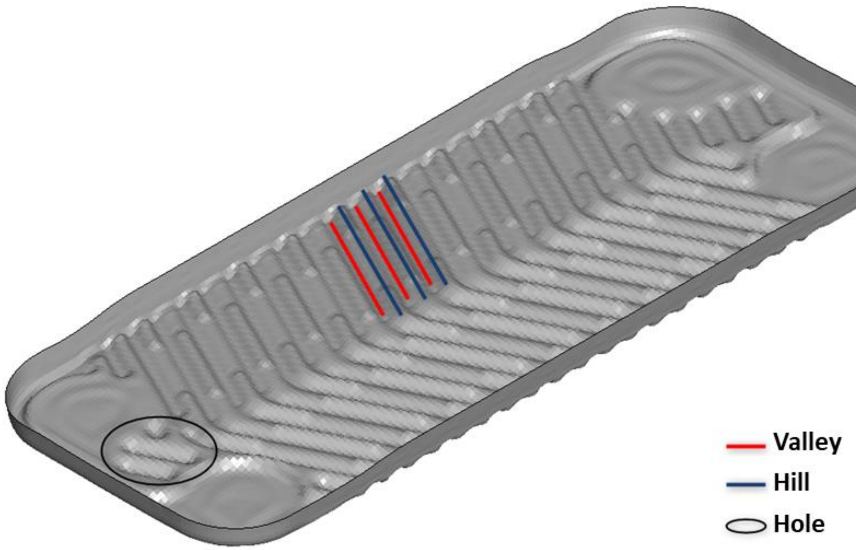
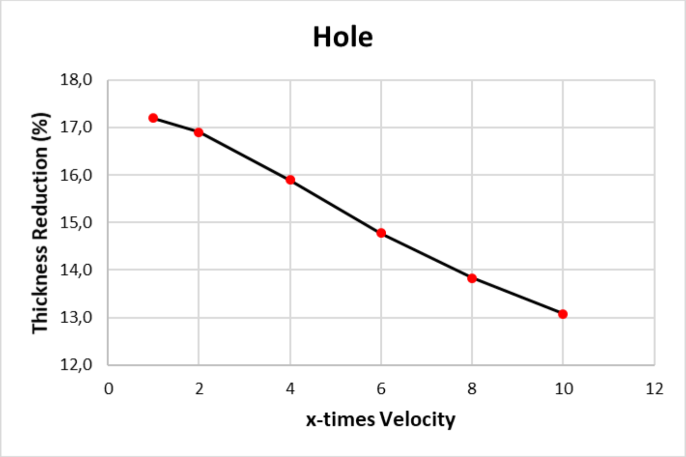
Metal Forming Process in Plate Heat Exchanger(PHE)

Numerical Modelling - Results

Thickness Reduction (%)



Hole	
x-times Velocity	Thickness Reduction (%)
1	17,19
2	16,90
4	15,89
6	14,77
8	13,83
10	13,08



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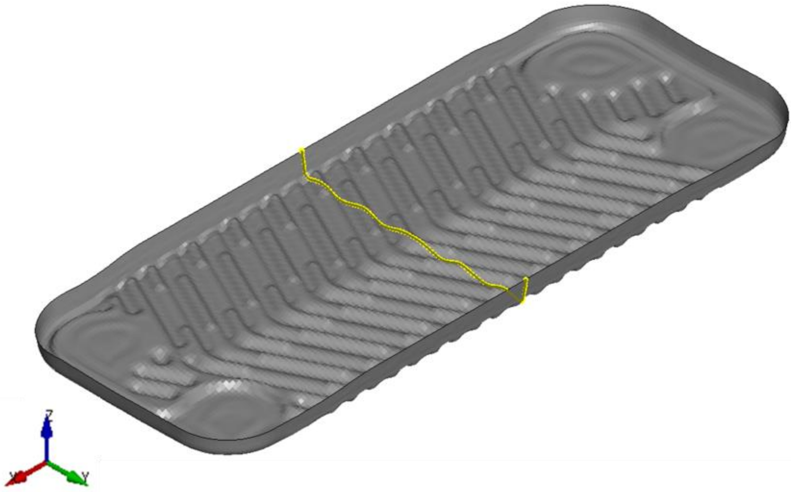
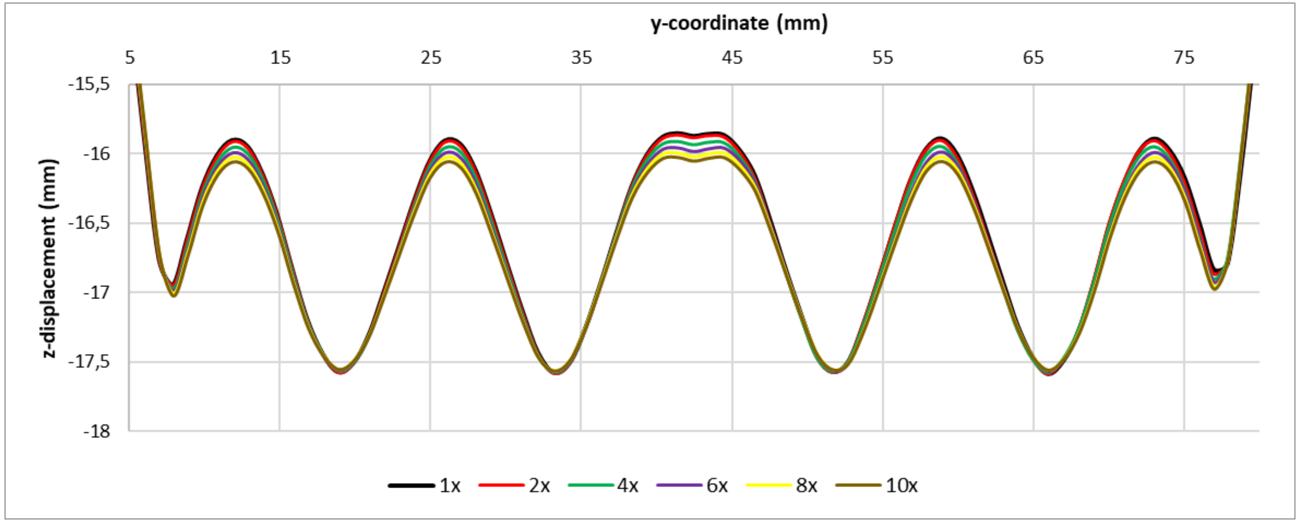
Metal Forming Process in Plate Heat Exchanger(PHE)

Numerical Modelling - Results

z-displacement along the path





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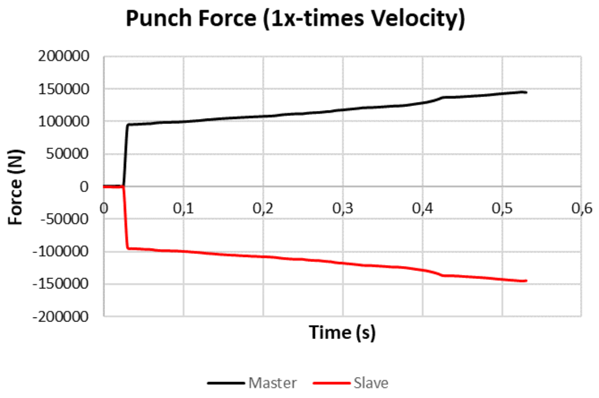
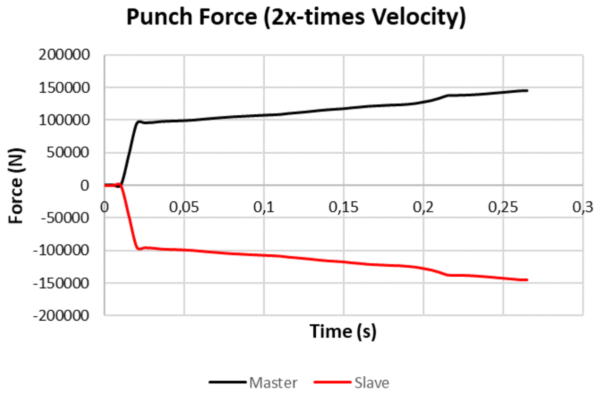
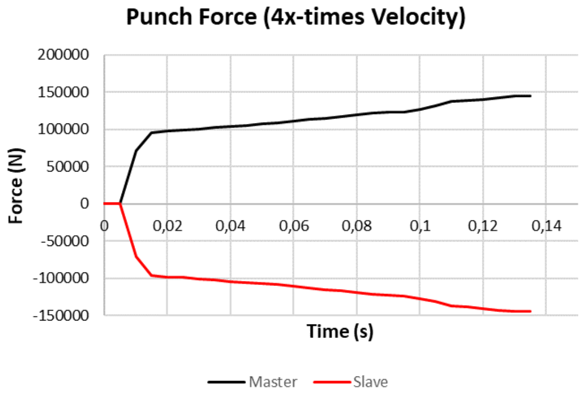
Metal Forming Process in Plate Heat Exchanger(PHE)

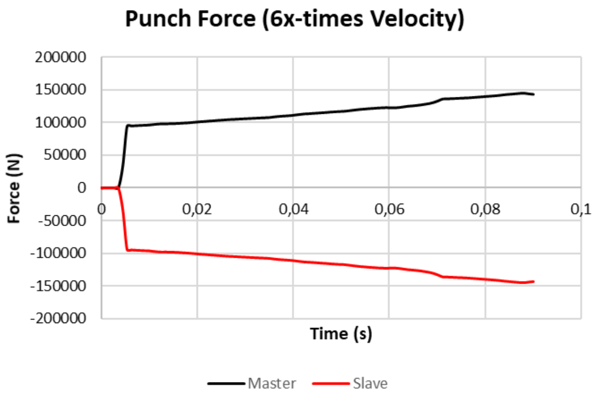
Numerical Modelling - Results

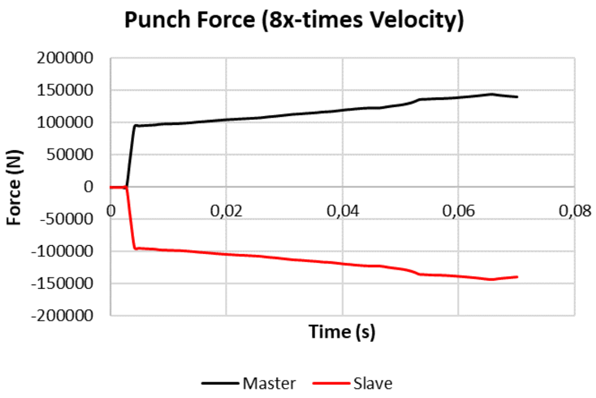
Punch-Blank Contact Force

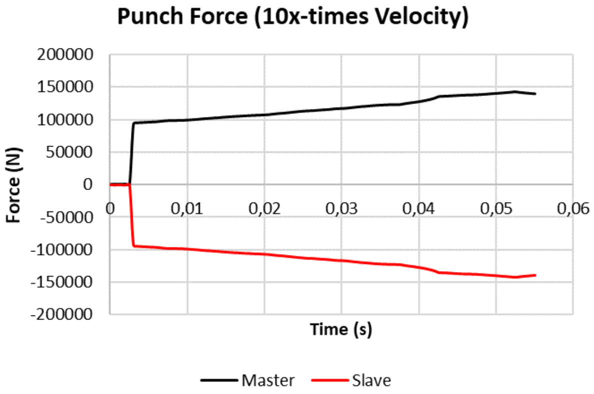












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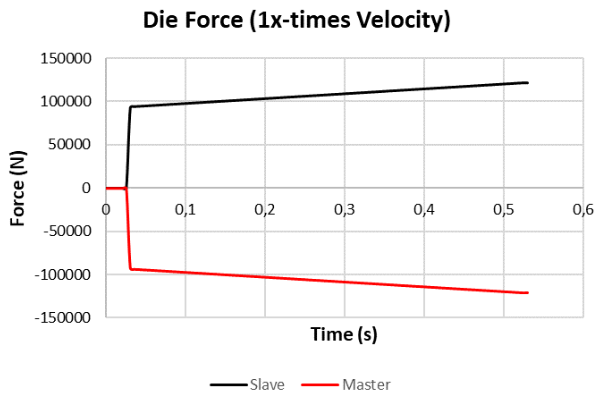
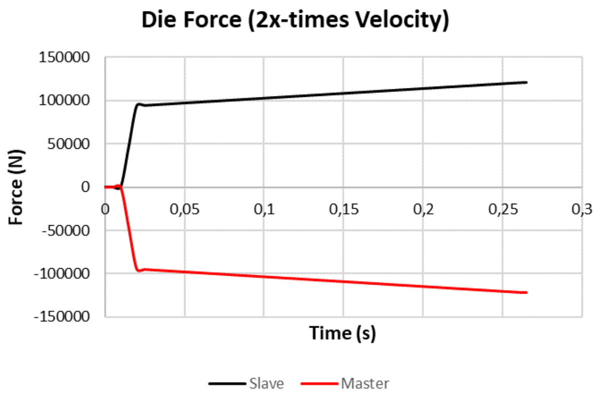
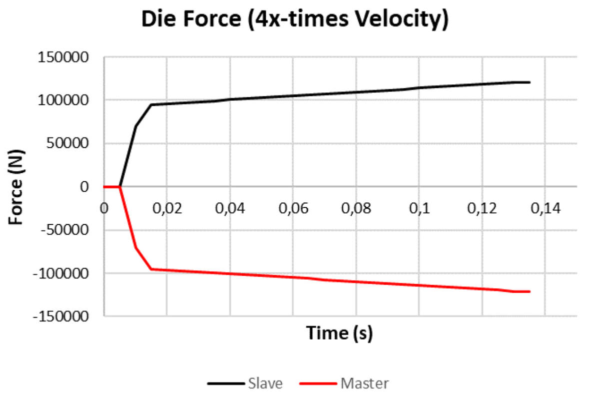
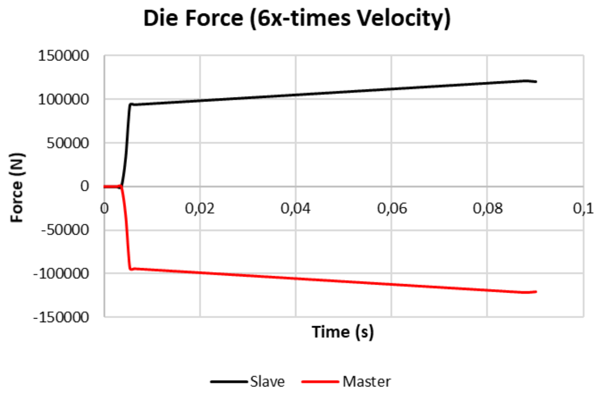
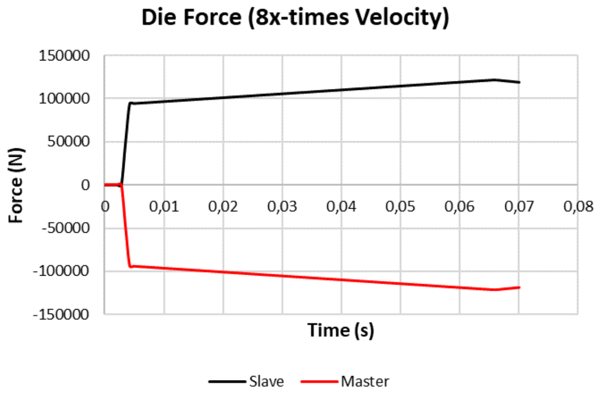
Metal Forming Process in Plate Heat Exchanger(PHE)
Numerical Modelling - Results
Die-Blank Contact Force

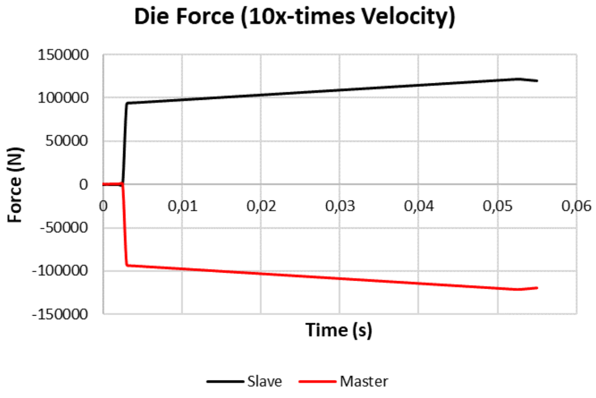












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Metal Forming Process in Plate Heat Exchanger(PHE)
Conclusion

- Velocity can increased 2x without any problem. For 4x velocity increase can be selected by evaluating it on the production capability.
- Gas spring force optimization should be considered in future studies. When the velocity increases, the material strength increases due to the strain rate sensitivity of the material. Gas spring force, which is kept constant, affects the formability performance of plate.
- In the forming process optimization, process parameters should be evaluated as a whole, not individually.

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Thank you for your participation!

For your further questions:

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