International MAGMA User Meeting 2024

October 9-11, 2024

RADISSON BLU – Frankfurt

BE PART OF IT

Using a Neural Network with MAGMASOFT® Optimization Data

Selecting optimum conditions for the HPDC process

Fredrik Cooper (MSc Eng)

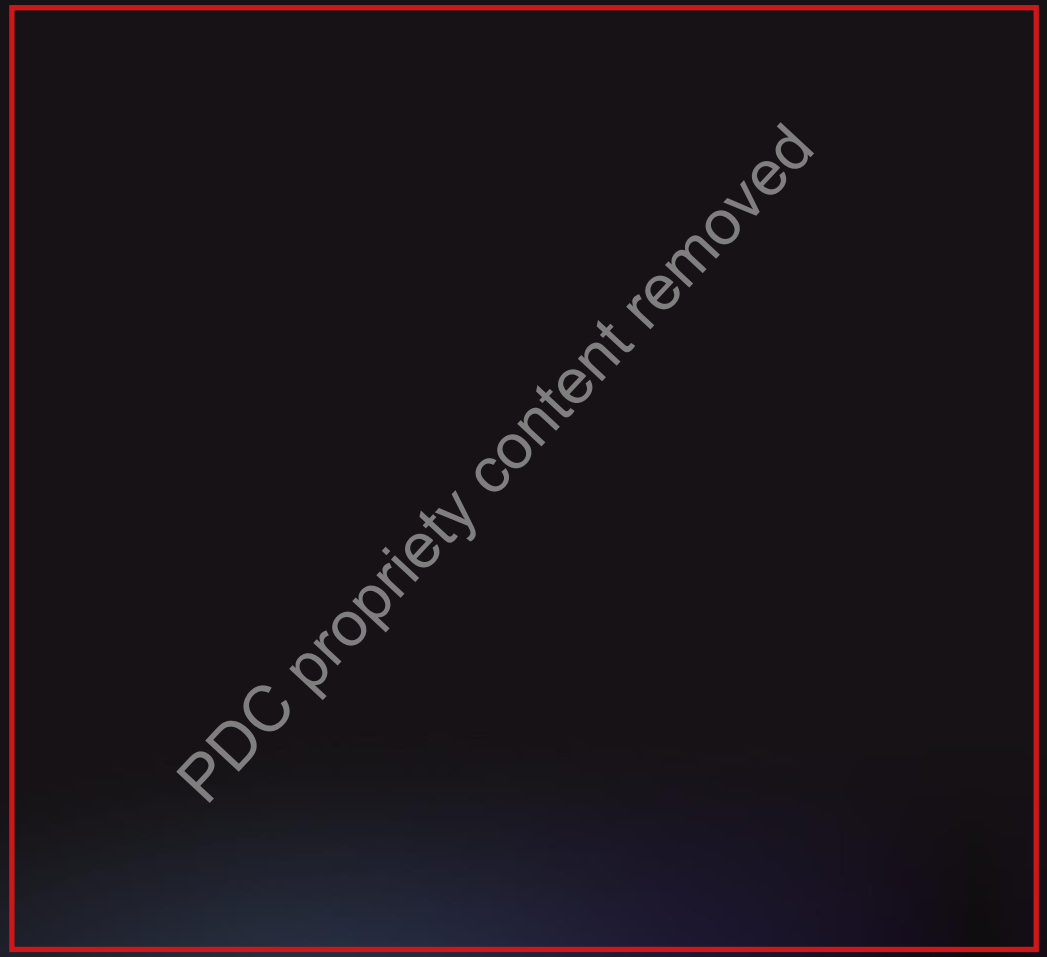
Pietermaritzburg, South Africa

PDC - South Africa

- Innovative, non-ferrous foundry supplying the automotive (tier 1 and tier 2 supplier), electrical transmission and building sectors, locally and internationally.
- Operating for 72 years from Pietermaritzburg, South Africa.
- Several 280t to 630t high pressure die castings machines, with material alloying capability.
- In-house tool development, simulation, manufacturing and maintenance.
- ISO 9001, 14001 and IATF accredited.
- PDC is focussed on finding technically accurate solutions in a cost-effective way and implementing them to be practical and robust.

Project objectives

- Keep existing tooling and cavity layout
- Reduce rejects in critical volumes of casting
- Determine
  - causes for rejects
  - process parameters for optimum settings

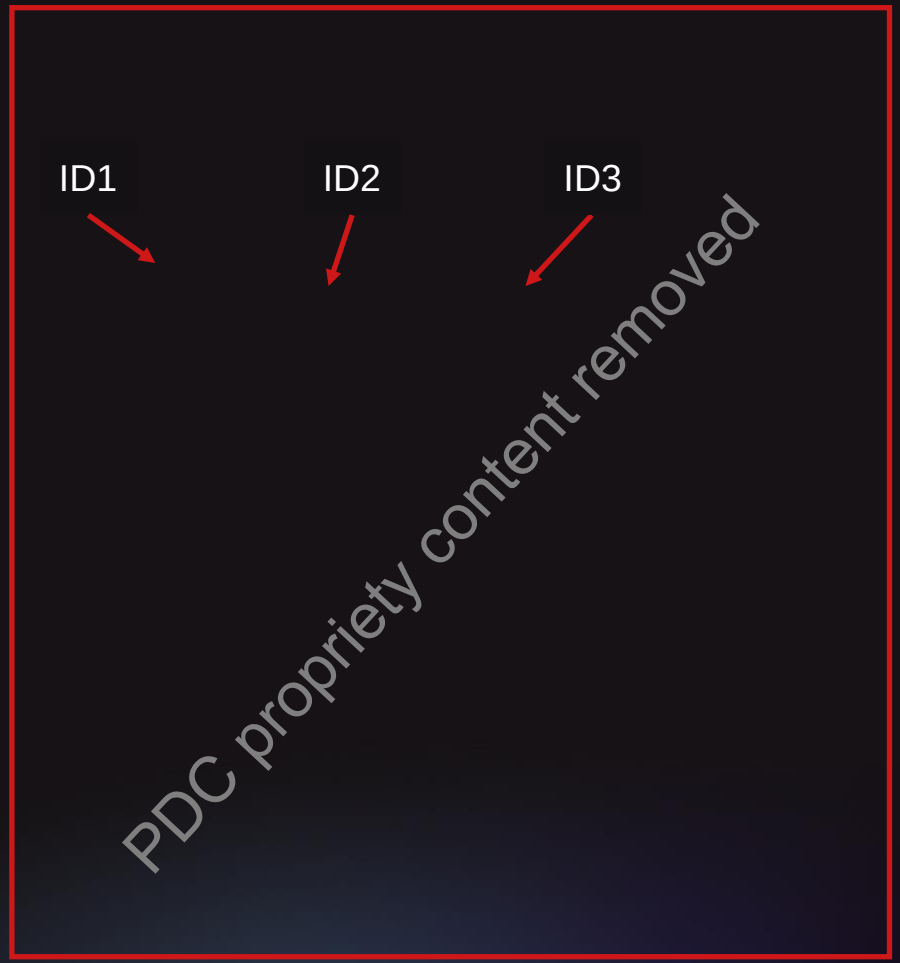


Geometry changes

- Biscuit size
- Gate area
- Runner area
- Gate entry angle
- Overflow size
- Overflow ingate area
- Temper channel depth

Process changes

- Times
- Temperatures
- Positions
- Velocities
- Pressures



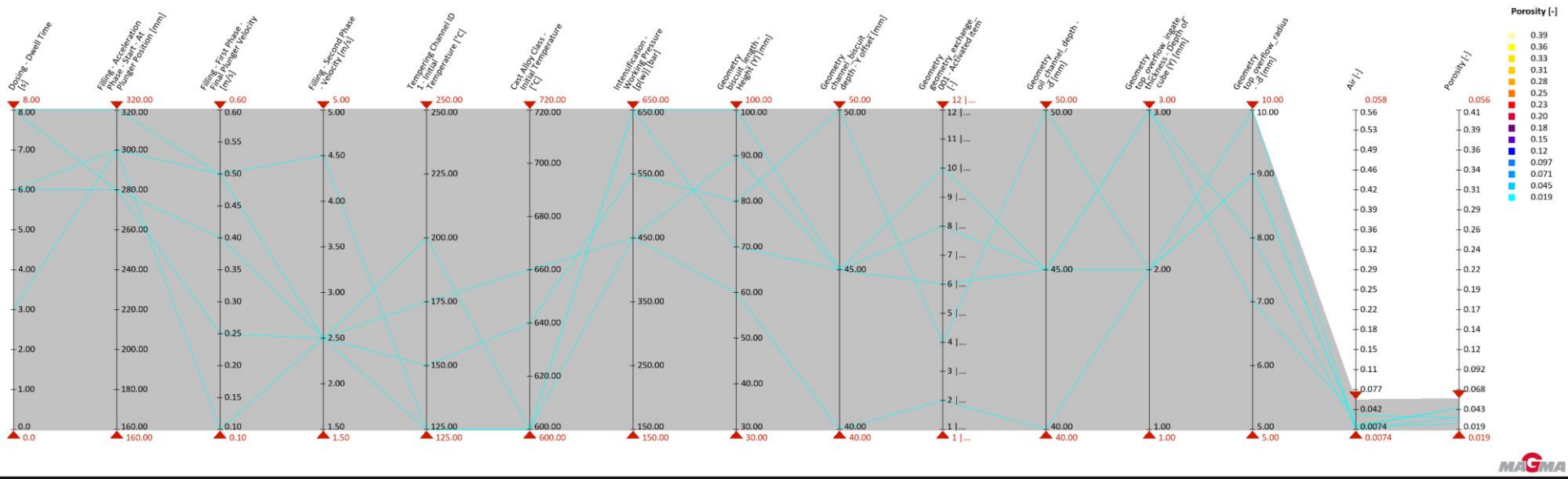
- 14 variables:
  - Allowed die design changes
  - All process related changes done in past trials
- 10 results:
  - Quality objectives in the casting
  - Process limitations of the HPDC cell
- 9.3 trillion possible designs

AIMS:

Investigate effects of HPDC process variables and allowed die design variations

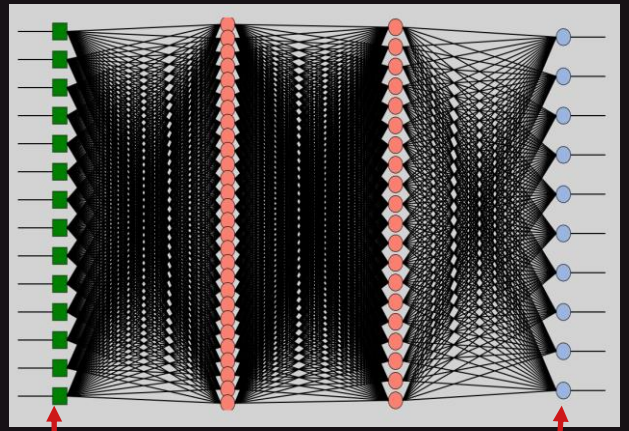
Evaluation Areas ID2 and ID3 require zero porosity/entrapment

4 core license constraint

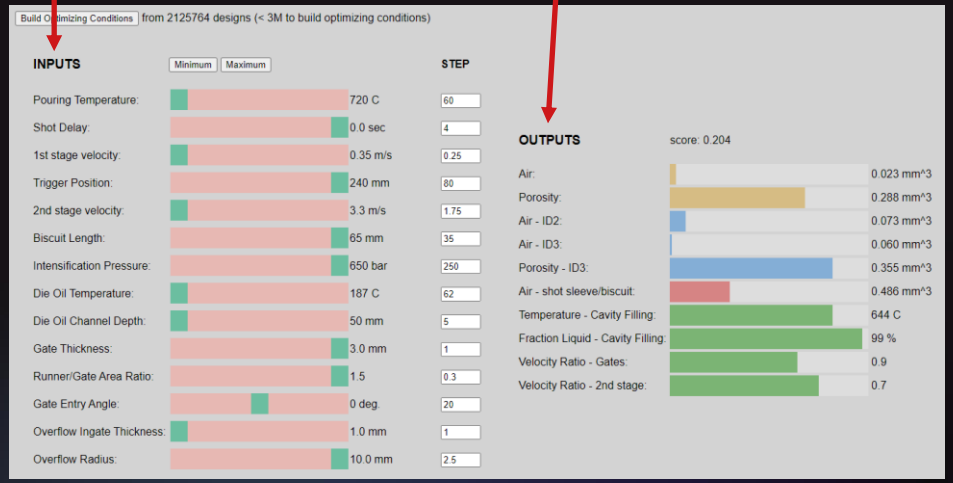


- Influences and interactions difficult to interpret from static graphs.
- Number of visible variables and results are limited.
- Selection of data points and design selection cumbersome with double sliders.
- Selection points limited to the levels simulated – more resolution requires more simulation.

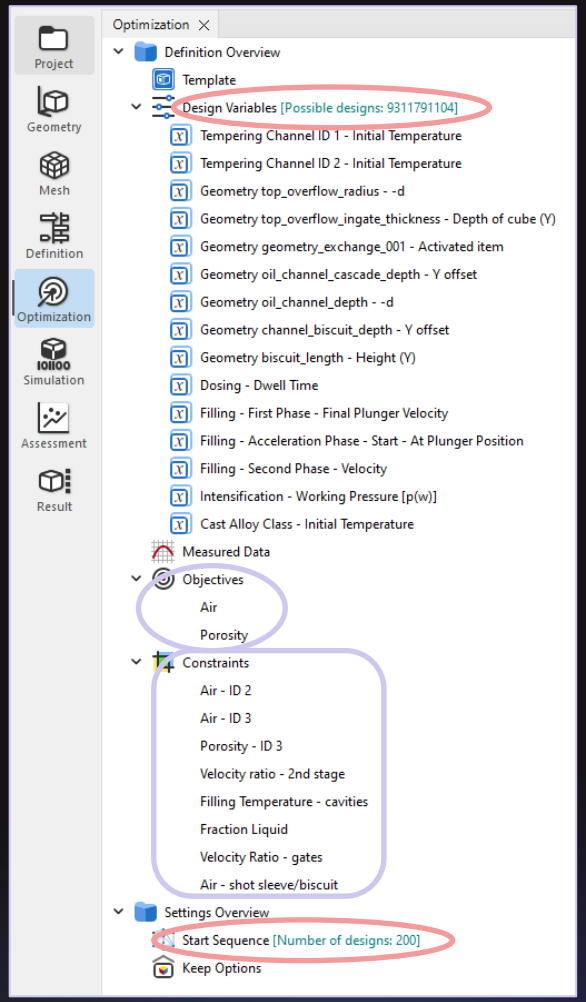
Neural Network



- All variables and results are considered simultaneously.
- Trained with data exported from Optimization Perspective.
- The NN is an estimation of the model space simulated.



- Interactive manipulation of variables and dynamic visualization of all results simultaneously.
- Higher design resolution can be achieved because more setting steps can be applied.
- All possible designs and many more can be assessed without further simulation.



The NN required unbiased data of the whole design space for training – no Magmasoft optimization methods were used.

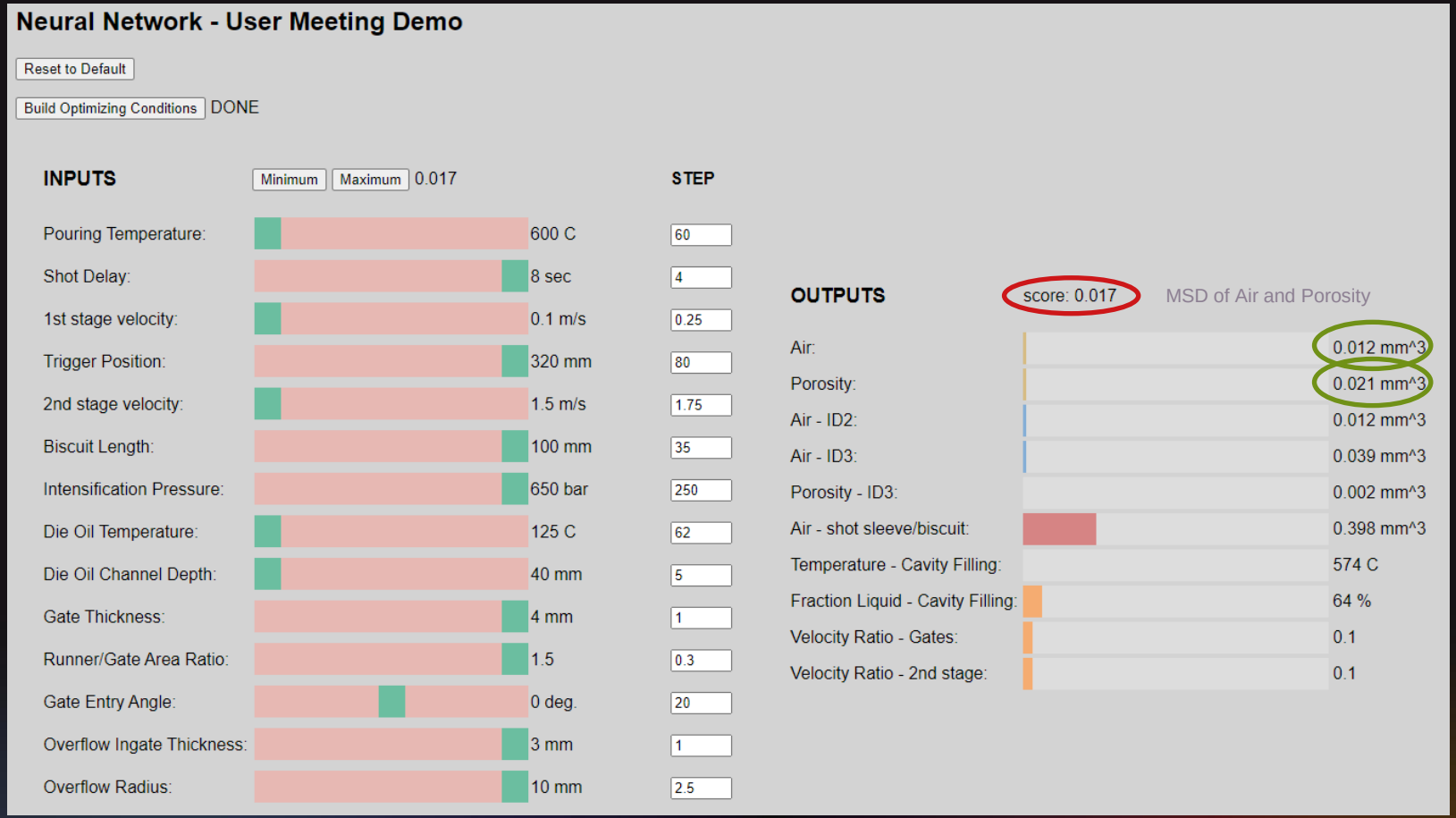
- 1 generation Sobol – 200 designs.
- Objectives applied to Air and Porosity only.
- Constraints used as data capture of relevant quality and process information.

Project statistics

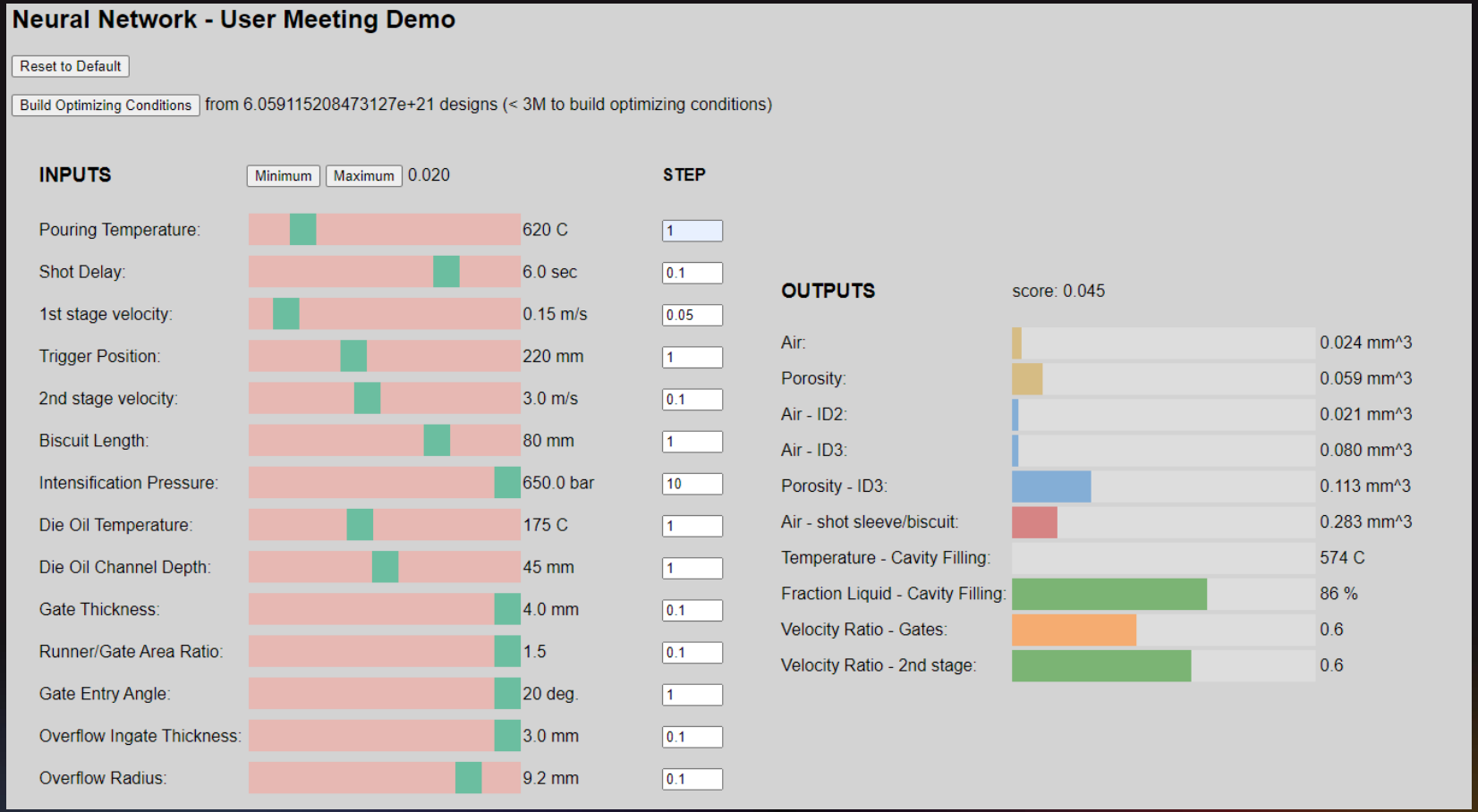
- 60 hours (4 core license)
- 186 designs calculated
- 14 design errors

186 designs were used for training the NN

Minimum Optimum Condition



Practical Optimum Condition



Neural Network optimum results compared with training dataset

Rank	Design	Air (-)	Porosity (-)	
Rank 1	(1) Version 2/d1	0.00912	0.0	Minimum Optimum
Rank 2	Design 10	0.0107	0.0262	
Rank 3	Design 30	0.00741	0.0339	
Rank 4	Design 2	0.0121	0.0448	
Rank 5	Design 167	0.0144	0.0445	
Rank 6	Design 82	0.0325	0.0331	
Rank 7	(2) Version 2/d2	0.021	0.0448	Practical Optimum
Rank 8	Design 55	0.0843	0.0187	
Rank 9	Design 83	0.0261	0.0745	
Rank 10	Design 133	0.0101	0.0873	
Rank 11	Design 63	0.0189	0.0961	
Rank 12	Design 37	0.0331	0.088	

Air Entrapment

Minimum optimum

Practical optimum

PDC propriety content removed

Shrinkage Porosity

Minimum optimum

Practical optimum

PDC propriety content removed

- Porosity result bars had most movement with following variables:
  - 1st stage velocity,
  - trigger position,
  - shot delay,
  - pouring temperature,

- The rejects visible in real world castings were therefore primarily Shrinkage Porosity, then secondly Air Entrapment.

- Overflow size had some influence on improving Air Entrapment.

- Gate thickness had some influence on improving Shrinkage Porosity.

- Lowest Air and Porosity levels were discovered with the NN method.
- A Practical Optimum was established and its impact could be assessed.
- Causes of rejects were determined and the influence of geometric parameters established.
- Large order of design possibilities were assessed with a 4-core license.

Thank You for your attention

Demonstration Neural Network available at:

https://www.modelit.co.za/projects/UserMeeting/

Fredrik Cooper (MSc Eng)
fredc@modelit.co.za
www.modelit.co.za