Materials Processing Institute

1944 - 2019 75 YEARS OF INNOVATION

Big Data and Digital Twin Developments

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Funded by Innovate UK

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Agenda

- Data Science Environment
- Machine Learning / AI
- Digital Twin

What is Big Data Analytics?

- Big data analytics is the use of advanced analytic techniques against very large, diverse data sets to uncover hidden patterns, correlations and other insights.

WP 4 - Big Data

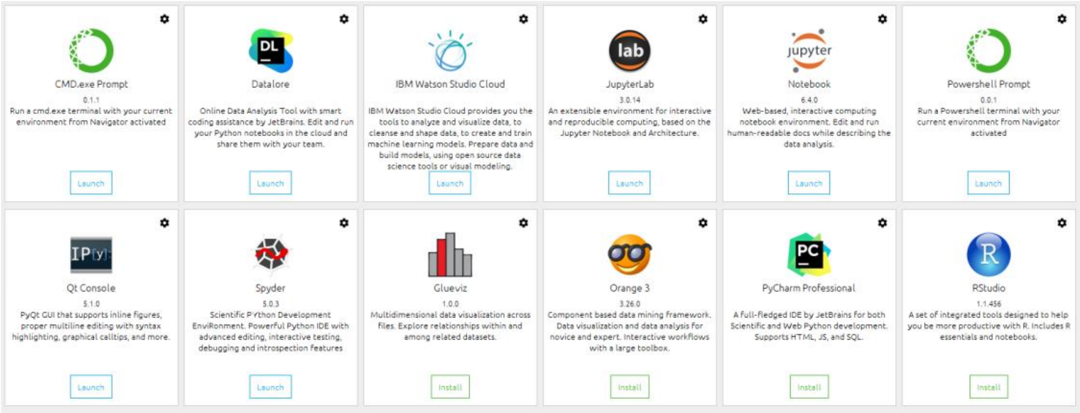
- Objectives:
    1. Gain skills in using the built in ThingWorx analytics AI / machine learning function.
    2. Develop a platform for data cleansing, mining and model development not offered by ThingWorx

- Deliverables

  Provide skills and environment for sellable service of model development for external customers for ThingWorx and Digital Twin

WP 4 - Big Data - Activities

- Self-paced training and tutor led PTC University course for using AI / analytics functions on ThingWorx
- Creation of Data Science Platform separate from ThingWorx to provide analytics not offered within ThingWorx
- Server with NVIDIA Quadro RTX6000 GPU for Deep learning – 4,608 CUDA Parallel-Processing Cores and 576 NVIDIA Tensor Cores
- Anaconda Data Science platform installed
- Activity Complete



What is Machine Learning?

- Machine learning is a method of data analysis that automates analytical model building. It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention.

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WP 5 Machine Learning (AI for Casting Processes)

- Objectives:

1. Realise the true potential of new sensor data and improved PLC communications installed under InTiFi.
2. Generate AI and machine learning models for predictive maintenance.
3. Generate AI and machine learning models for providing operator advice.
4. Generate AI and machine learning models for quality prediction.

- Deliverables

AI / machine learning models for predictive maintenance, quality and real-time decision-making tools.

Sellable service for model development both standalone bespoke models and in conjunction with ThingWorx and Digital Twin service.

WP 5 Machine Learning (AI for Casting Processes) Activities

- Work commenced by establishing ThingWorx signal and data integrity

- Slab grading data has been gathered for four years prior to the start of the digitisation process (4 years preceding March 2021) and further data has been gathered during the digitisation process up to September 2021. However this data are sparse as the slabs are only inspected during specific research casts.

- A slab from a recent RFCS cast (heat 811) has been inspected and grading using a similar system to that used at Teesside concast. The slab was inspected for transverse cracking, longitudinal cracking, surface disruptions, shape regularity and bulging. The slab was of good quality.

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WP 5 Machine Learning (AI for Casting Processes) Activities

- Following the RFCS slab grading a review took place to discuss the usefulness of applying the grading system to slabs in the NPP. It was concluded that due to the coarse nature of the slab grading inspection, it may not show cast to cast variation and other measurements of slab quality should be considered such as:

i) Heat transfer in the mould across all four plates

ii) Water flow pressures and flow (can also detected blocked sprays)

iii) Variability of mould control

iv) Strand surface temperature

WP 5 Machine Learning (AI for Casting Processes) Activities

- Work has commenced on creating a mould heat transfer KPI using heat 811 as the baseline, several methodologies are being investigated. Other KPIs will be developed once signals become available.
- Meetings have taken place with caster process experts to discuss modelling work for caster quality and the additional signals that will be required. Pressure sensors are installed on the strand and have only recently become available in ThingWorx. Three pyrometers were purchased on InTiFi and will be installed to measure strand temperature and a trial will be undertaken next year using embedded thermocouples to verify the pyrometers temperature measurement for use in models.
- Spreadsheets showing the thermocouple locations in the mould pre heat 794 and post 794 have been obtained, however, the data will need manual checking whenever the mould returns from servicing to ensure the thermocouple locations have not changed.
- Available signals for AI modelling work have been identified and documented.

What is a Digital Twin?

- A digital twin is a virtual model designed to accurately reflect a physical object, in our case the caster in the Institutes Normanton Steel Plant
- However, a digital twin is more than a simulation, by including live plant signals real time updates can be included in the simulations and machine learning models
- The digital twin will provide predictive maintenance, identify departure from desired operating conditions and provide real time advice to operators.

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WP 8 - Digital Twin Development

- Objectives:

  1. Incorporate bespoke caster models into a digital twin.
  2. Create a digital twin of the caster.
  3. Improve caster operation.
  4. Improve product quality.
  5. Gain experience of digital twin creation using bespoke models that can be sold as a service.

Deliverables:

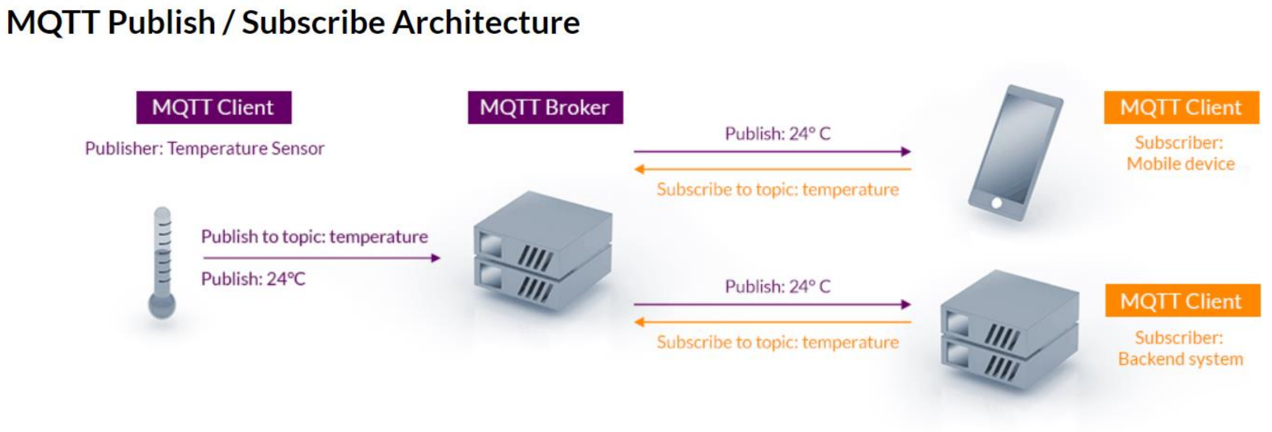
A sellable service around the creation of Digital Twins and the ability to include process models.

WP 8 - Digital Twin Development - Activities

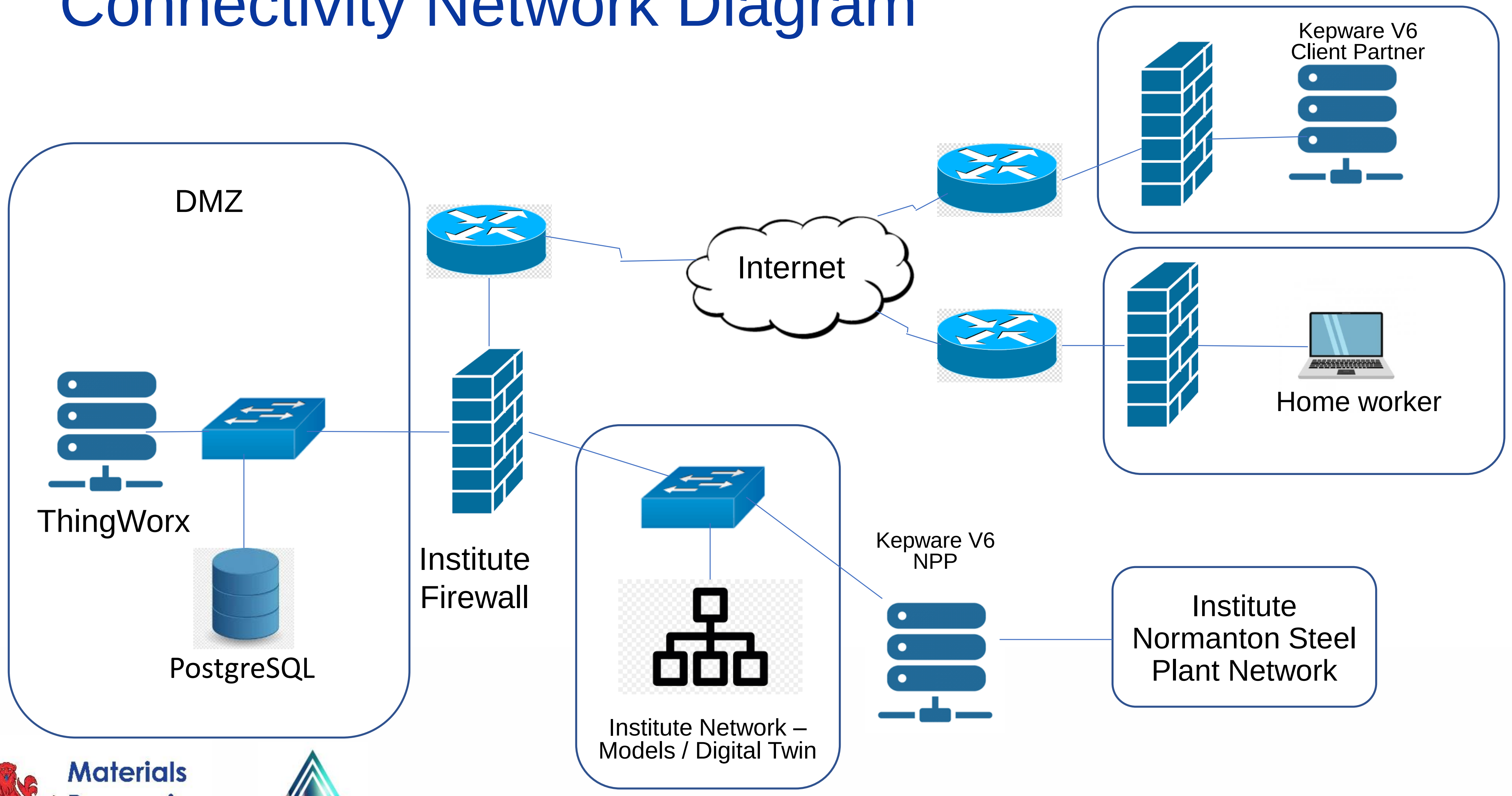
- Python libraries have been created to pull data from the ThingWorx REST API for uses in model deployment trials.
- Discussions have taken place with PTC as to the various approaches to developing the digital.
- Internal meetings have taken place to select the best model for the first implementation and the Solidus model was selected. Meetings have taken place to ensure code sustainability, it was agreed that C# should be the programming language of choice for model implementation, due to its suitability and possible longevity as a language. Azure DevOps will be used as a repository for the programs for version tracking and ensuring the latest model is available to the programming team for collaborative work. Further, this ensures security of the models and their future availability.
- Legacy code Has been archived into DevOps.
- A C# connector has been developed for ThingWorx.

WP 8 - Digital Twin Development - Activities

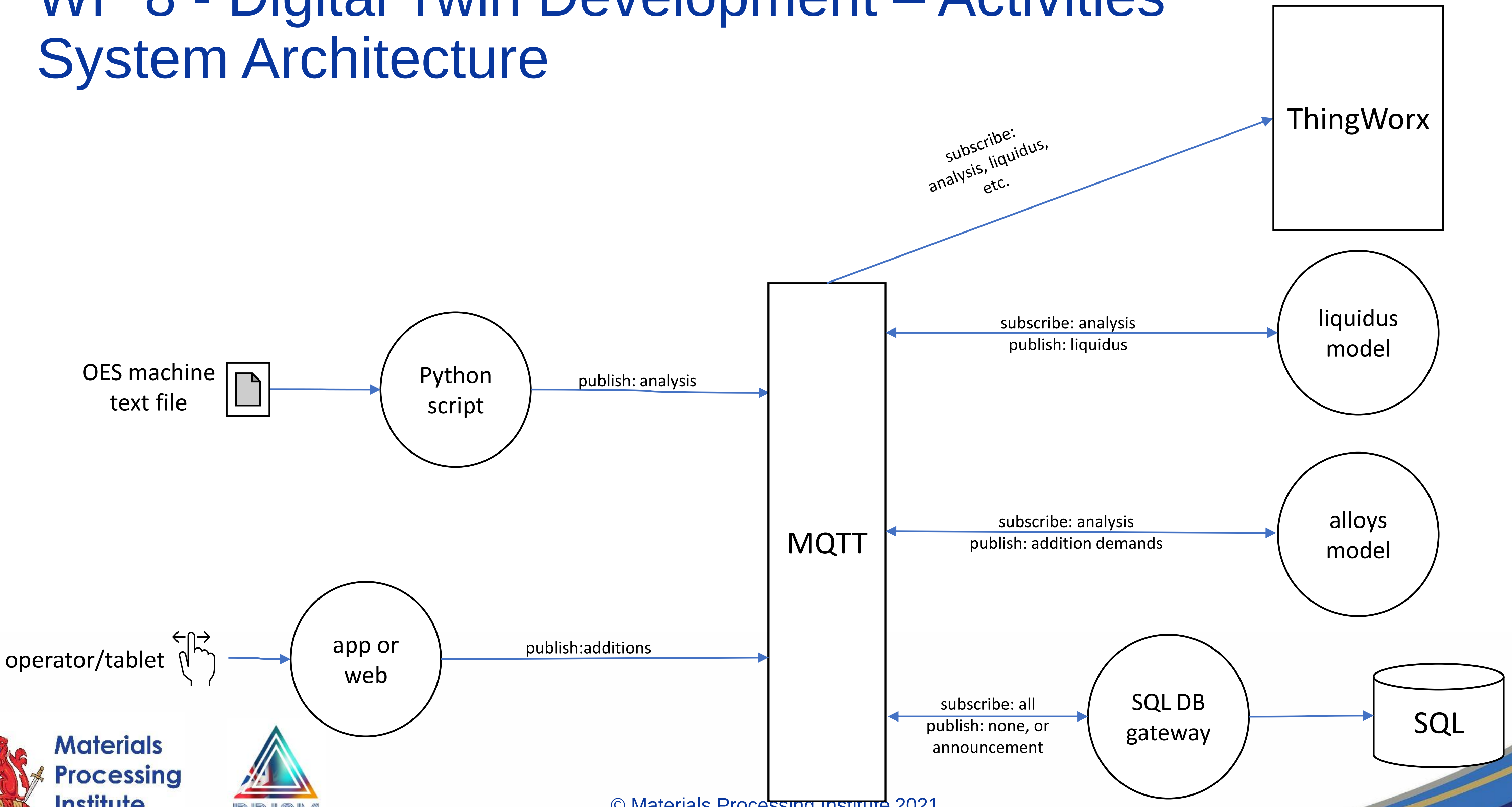
- The solidus model has been deployed on the Institutes SQL server as proof of concept and is receiving data from ThingWorx. However, data cannot be sent to ThingWorx due to Firewall rules. The Institute relies on Concorde for firewall support and their response is very poor. A meeting has taken place to discuss how the liquidus model will be used by the pilot plant team (inputs / outputs and display).
- Following the liquidus model proof of concept a system analysis and design is being undertaken. A different system architecture has been agreed using MQTT (a subscribe / publish protocol for messaging between devices).



WP 8 - Digital Twin Development – Activities -ThingWorx Connectivity Network Diagram



WP 8 - Digital Twin Development – Activities
System Architecture



WP 8 - Digital Twin Development - Activities

- Discussions have taken place with Concorde to establish data flow from the Kepware server to ThingWorx and how to improve firewall routing.
- Two milestones met, firstly the liquidus model was identified as first model to implement, others to follow include the mushy model and dynamic spray cooling model. Secondly, the PLC caster flow model may be of use in identifying disturbances.
- Work is still on going on an in-depth system analysis and database design with several objectives. Firstly to move manual entry forms (melt requisition, analysis requisition etc.) to intranet pages / Windows apps. Secondly to create a scalable future proof architecture for how models, operator tablets and ThingWorx interact and exchange data. This work is linked to all work packages within the Application of Industrial Digital Technologies to the Metals Sector project.

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WP 8 - Digital Twin Development – Activities – Digitising Records

EAF Heat 804

Revision 2
Page 1 of 1

NORMANTON PLANT EAF MELT REQUISITION

Trial Description (Objectives)

Caster melt

OPITILOCALHT #1
PMAPIA Trial #11

Requested Date:	14th July 2021
Depart No:	Pilot
Project No:	TBC
Requested Earliest:	13:30
Tap Time:	11:30
Requested by:	Bridget/Andy
Tel. No:	

1

Engineering Services Requirements

Estimated Time		08:00
Recirculation Water		Yes
Compressor Air		Yes
Fume Extraction		Yes
Secd.Generator reqd		Yes
Cryogenics	O_2	Yes
	N_2	Yes
	Ar	Yes

2

Ladle Compositional Limits

(incl. residuals)	C	Si	Mn	P	S	Cr	Ni	Cu	Sn	Mo	V	Nb	Al	N
Max	0.15	0.45	1.40	[illegible]	0.005	0.35	0.10	0.10	0.00	0.14	0.06	0.040	0.045	0.007
Min	0.13	0.35	1.30	[illegible]	0.001	0.00	0.00	0.00	0.00	0.10	0.04	0.030	0.035	0.000
Aim	0.14	0.40	1.35	0.000	0.003	0.00	0.00	0.00	0.00	0.12	0.05	0.035	0.040	0.000

3

Required Ladle Tap Weight Charge EAF – Dump 769- 2960kg, Darlo Plate 3250kg & 8kg Carbon with ~~100kg of LimeSpar.~~

Ladle Requirements:

Ladle Number	18
Stopper Type	N/A
Slide Gate	Yes
Nozzle Size	40mm
Porous Plug	Yes
Leave LAF Pit °C	1600 to 1605 C
Liquidus °C	1515 C

4

Steelmaking Requirements:

Single Slag	Yes
Double Slag	If needed
Decarburisation	If needed
Low Nitrogen	No
Low Residuals	Yes

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ADDITIONAL COMMENTS

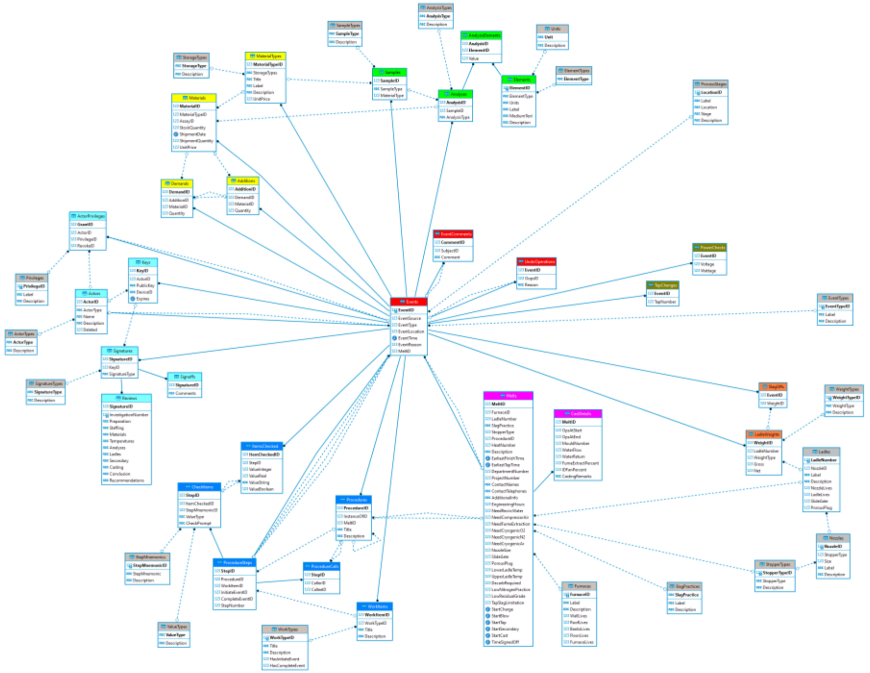
Boron & Titanium Specification
Boron Aim 0.002
Titanium 0.030 – 0.040%Ti

Stir at LAF until 1600 to 1605 Deg C before sending to caster
Assumes opening ladle at 1585 Deg C to give 1560 Deg C in the tundish at start falling to 1535 Deg C by the end.
Stop if tundish <1535 or >1560 Deg C for 2 mins

Aim casting speed 1.2 m/min

1

Specimen	Meaning	Cardinality	Dependent on	Table name	Field name	Data type
Estimated Time	How long we will be needing ES involvement.	One per melt.	Melt ID	Melts	EngineeringHours	Numeric
Recirculation Water	Whether the water supply is needed.	One per melt.	Melt ID	Melts	NeedRecircWater	Boolean
Compressor Air	Whether we'll need the compressor.	One per melt.	Melt ID	Melts	NeedCompressorAir	Boolean
Fume Extraction	Whether we'll need fume extraction.	One per melt.	Melt ID	Melts	NeedFumeExtraction	Boolean
Secd. Generator reqd	Whether we'll need the emergency generator on standby. *(Or spare generator, or*	One per melt.	Melt ID	Melts	NeedSecondaryGenerator	Boolean



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