TATA STEEL

TATA

Investigating different rapid alloy prototyping approaches to develop alloys to allow for higher scrap steel content

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M2A MATERIALS AND MANUFACTURING ACADEMY YR ACADEMI DEUNYDDIAU A GWEITHGYNHYRCHU

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Sample Slide – Agenda / Summary slide

1. Introduction
2. Process one – 20g
3. Process two – 140g
4. Process three – remelt
5. Application and conclusion

Introduction

Overview and relevance

- Scrap steel is a key component of the steel making process, but it introduces unwanted elements known as residuals or tramp elements
- Residuals alter the mechanical properties of the final product
- Increasing scrap content in new steel has economical and environmental benefits
- Future predictions show an increase in residual content in scrap, requiring a better understanding of potential effects
- Many tramp elements are very difficult to remove from the melt so the effects are important to study

RAP research

- Rapid alloy prototyping (RAP) allows for faster alloy development by accelerating the production of test specimens
- Mechanical properties of RAP specimens are not exactly the same as samples from full scale trials but they do show trends
- There are different RAP approaches with different advantages and disadvantages, these will be discussed

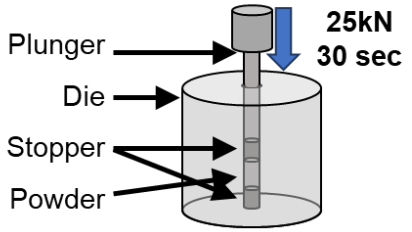
Process one – 20g

Methodology

1

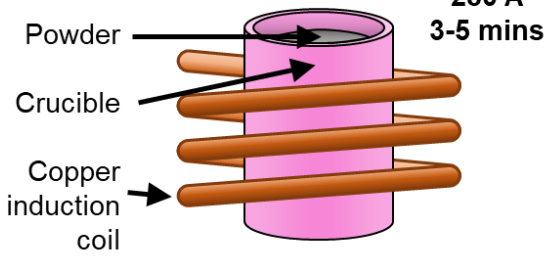
Powder measurement

2



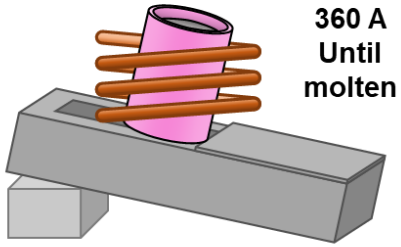
Powder compaction

3



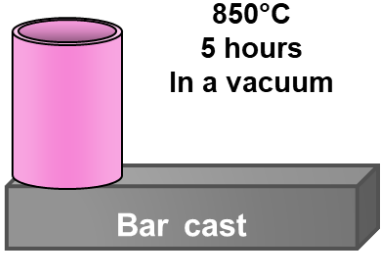
Melting

4



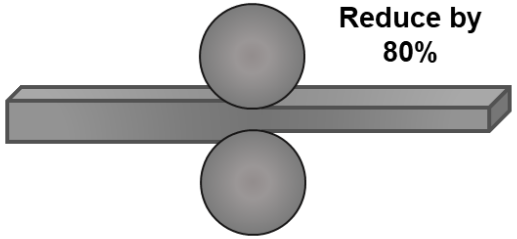
Casting

5



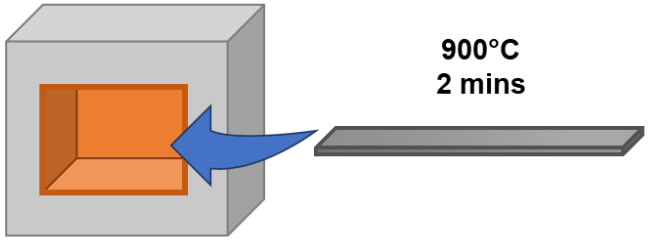
Homogenisation

6



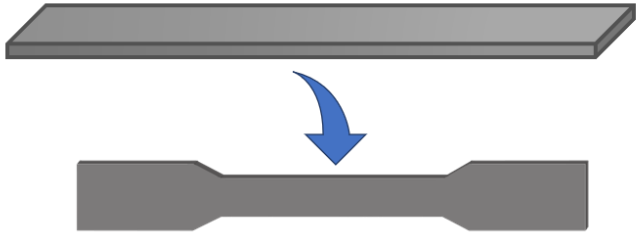
Rolling

7



Normalising

8

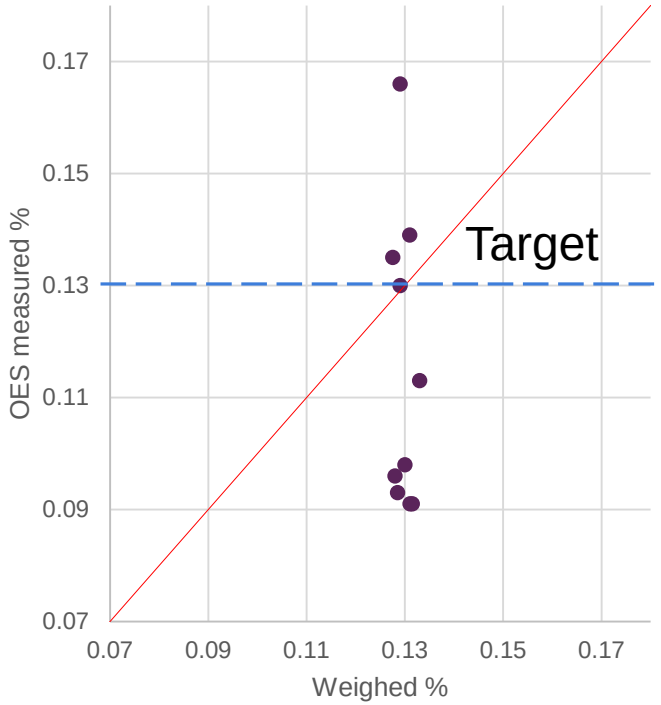


Cutting tensile bars

Process one – 20g

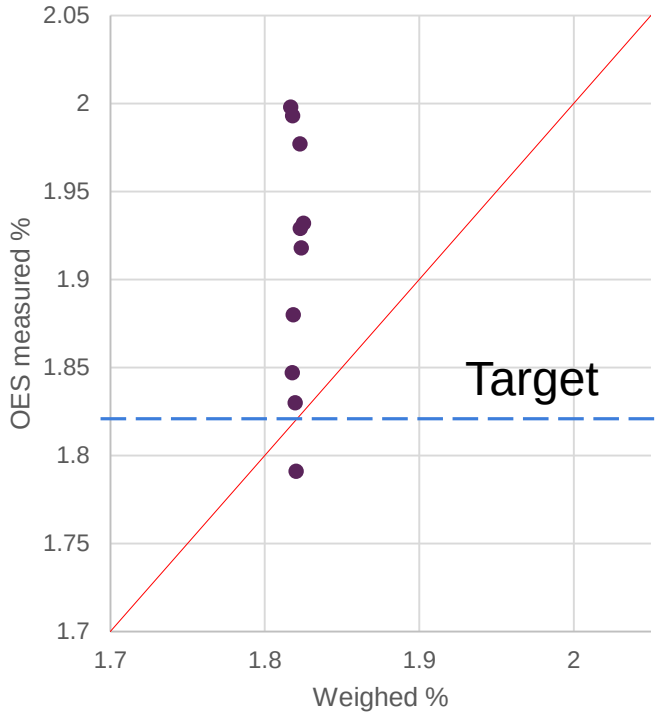
Red line is x=y

Composition



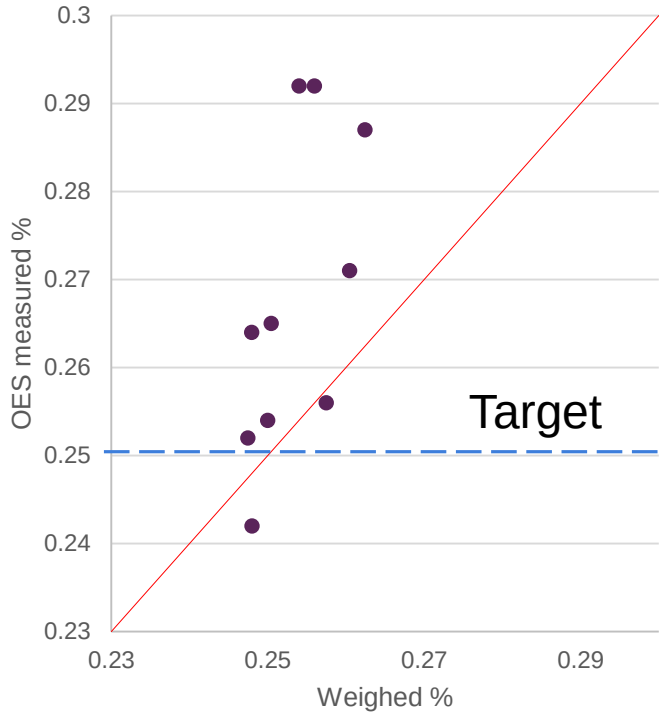
Carbon

Varies by +/-30%



Manganese

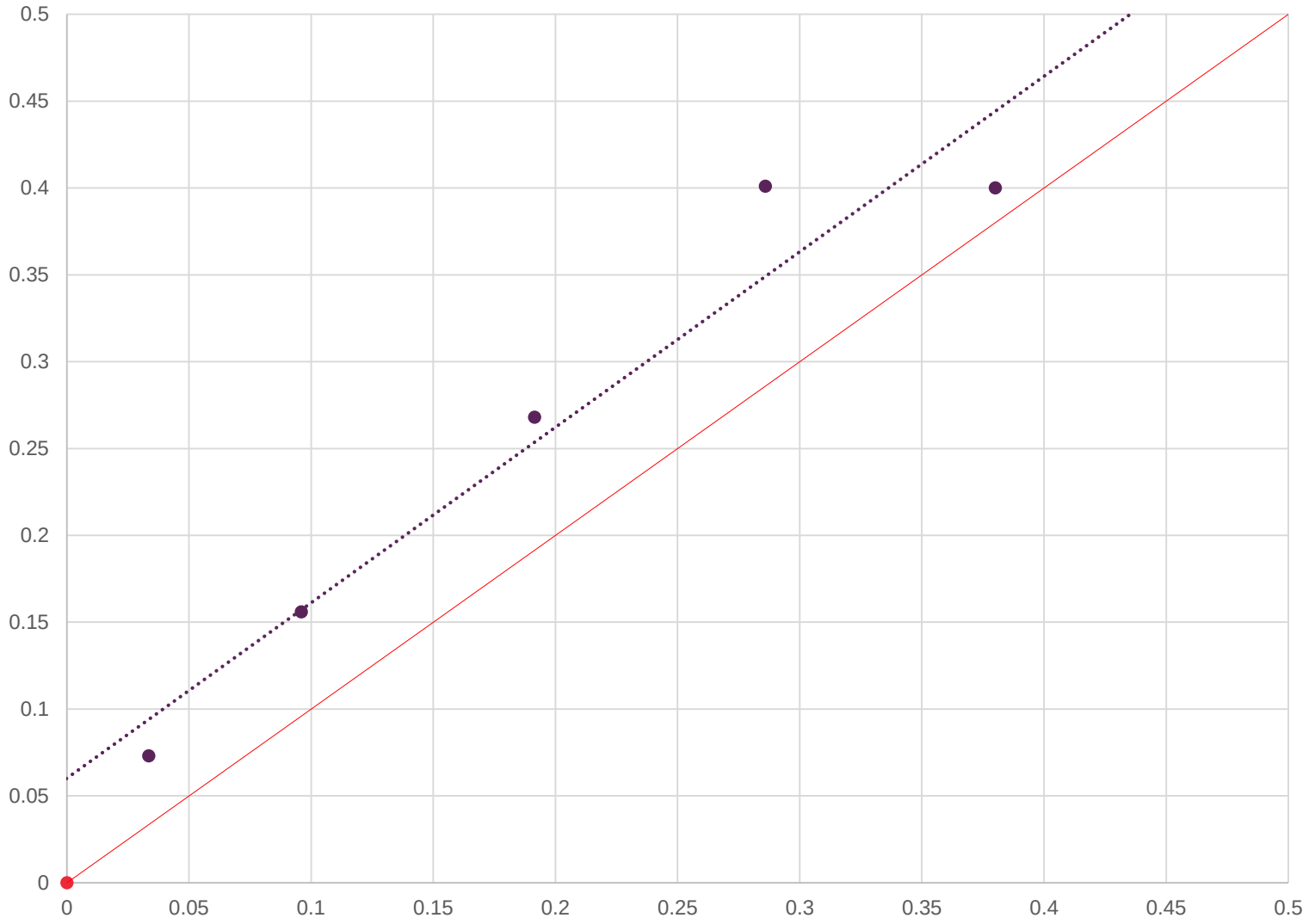
Varies +/-10%



Silicon

Varies +/-7%

Process one – 20g

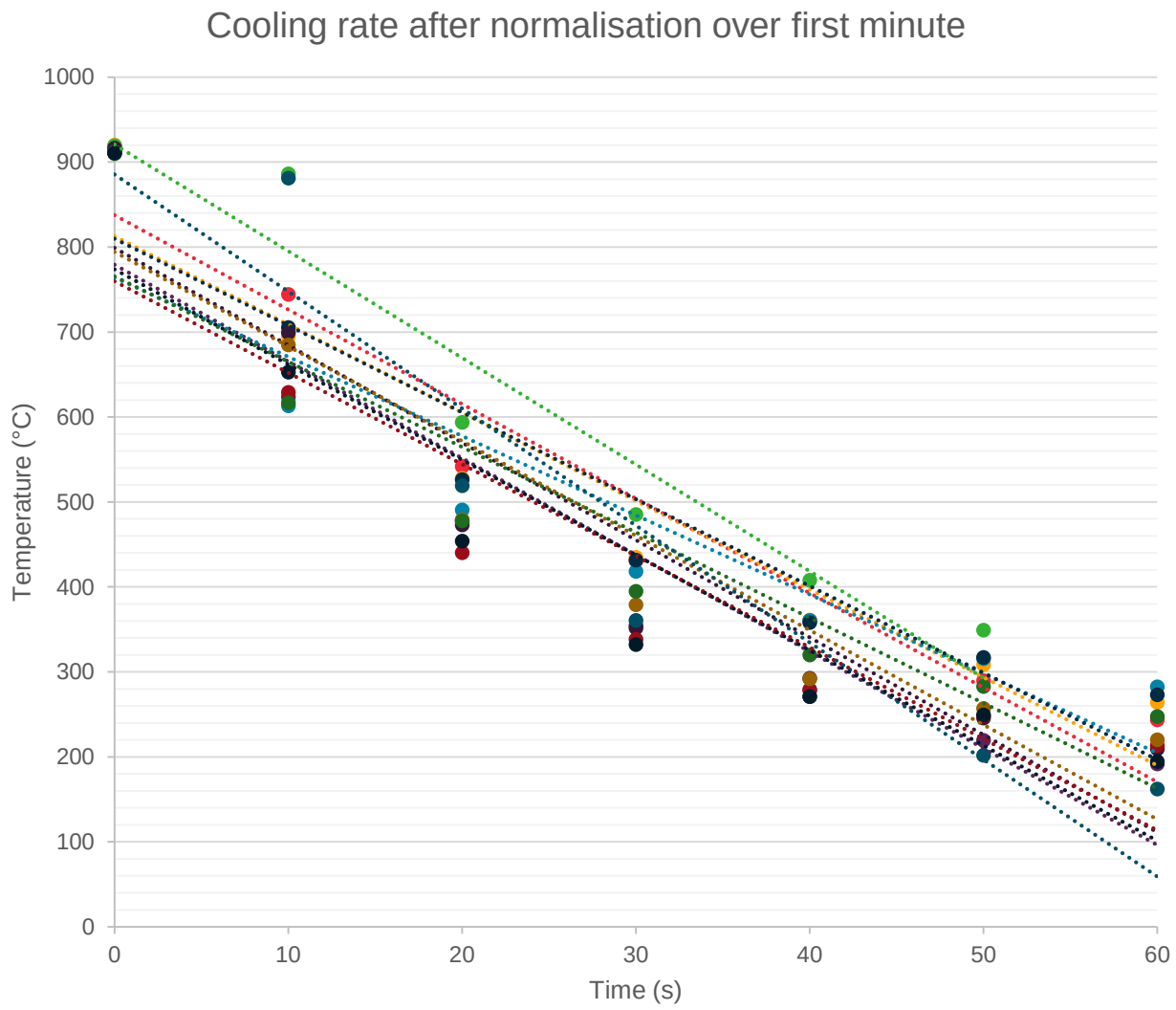


Copper

Good correlation

Predictable and can be accounted for

Process one – 20g



DP800 Cooling rate after normalisation

Cooling rate (°C/s)	
Average	11.114
Range	4.440
Standard deviation	1.122

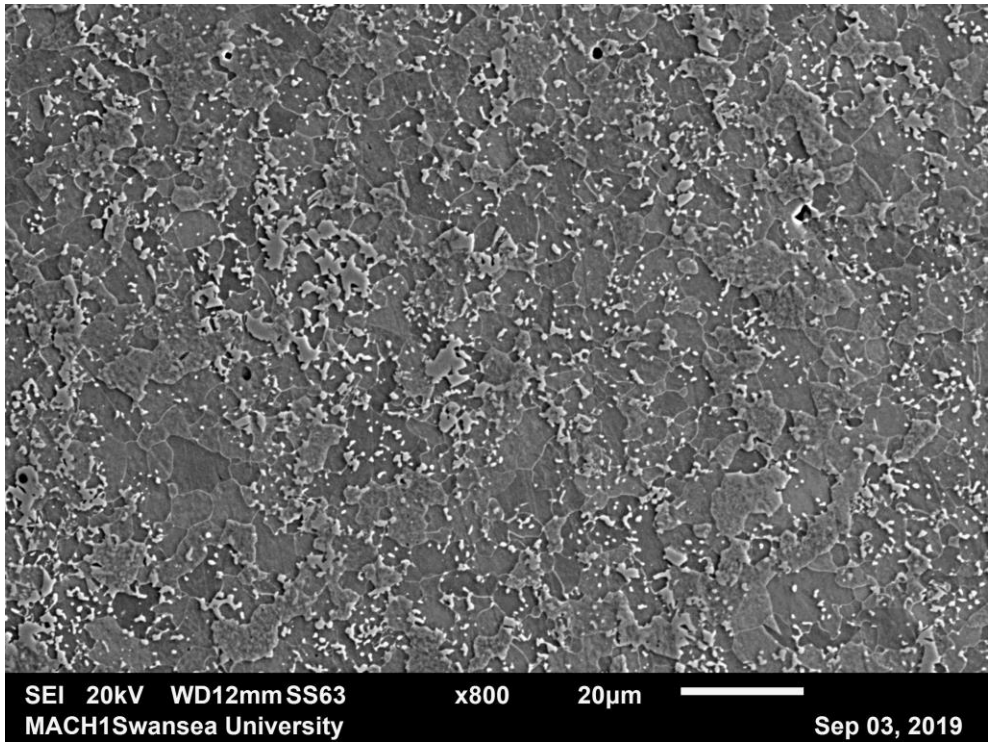
Process one – 20g

Advantages

- Quick process
- Minimal material wastage
- Produces unique alloys

Disadvantages

- Hot rolling is challenging
- No repeats per sample
- Composition accuracy is difficult
- Method has many sources of inconsistency
- Composition is a simplified version of industrial grade

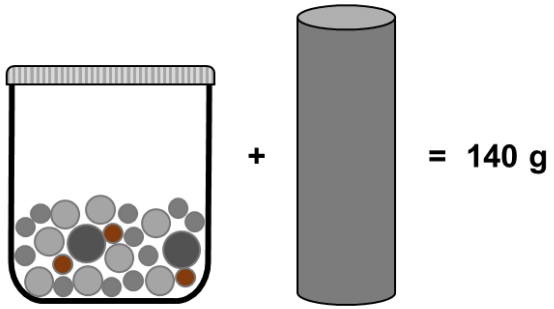


Synthetic automotive steel +0.268wt% Cu after 80% cold rolling and normalising heat treatment

Process two – 140g

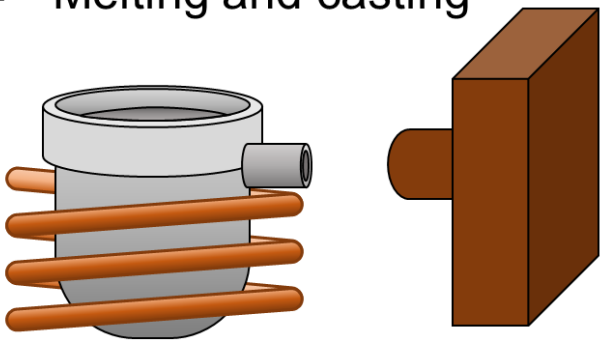
Methodology

1 Weigh components



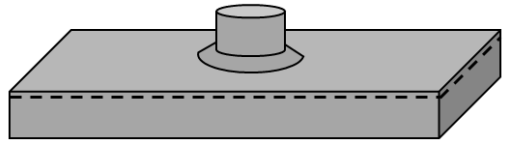
Element additions + iron bar

2 Melting and casting

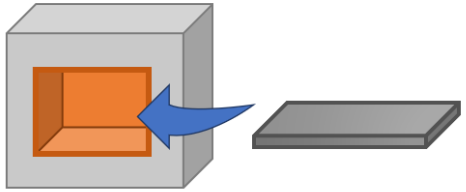


Crucible Copper mould

3 Centrifugal cast block

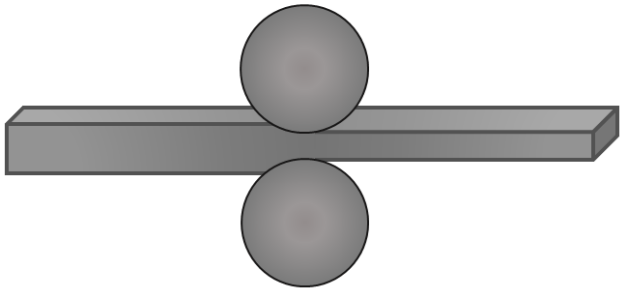


4 Pre-heat



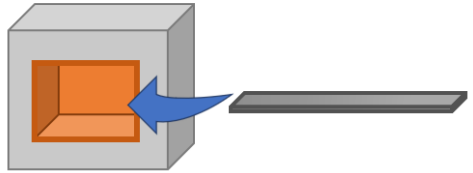
1225°C
5 mins

5 Rolling



Reduce by 20%*

6 Heat treatment

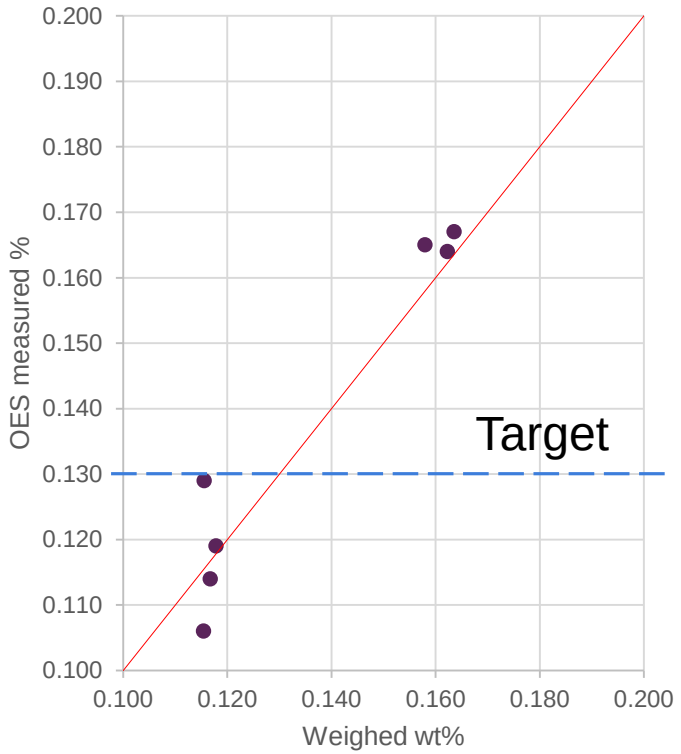


600°C
10 mins

Process two – 140g

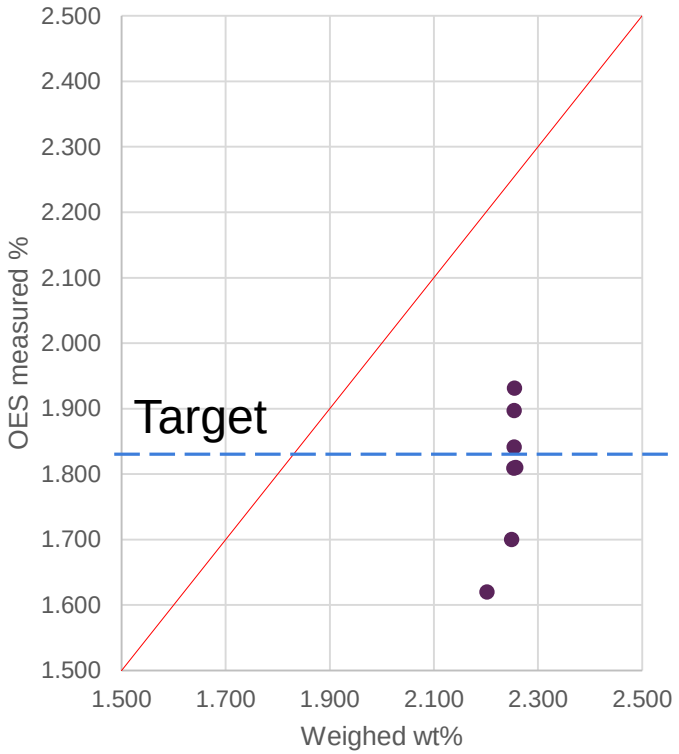
Red line is x=y

Composition



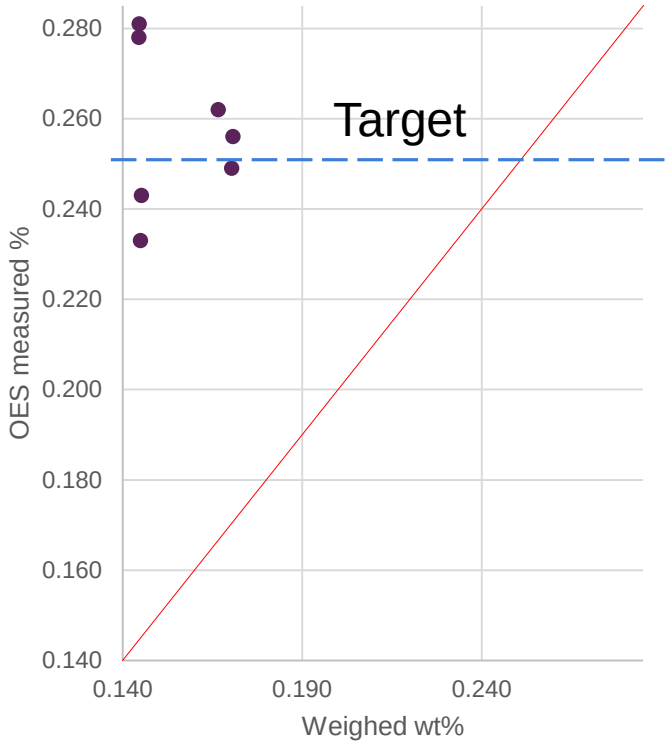
Carbon

Varies +/-30%



Manganese

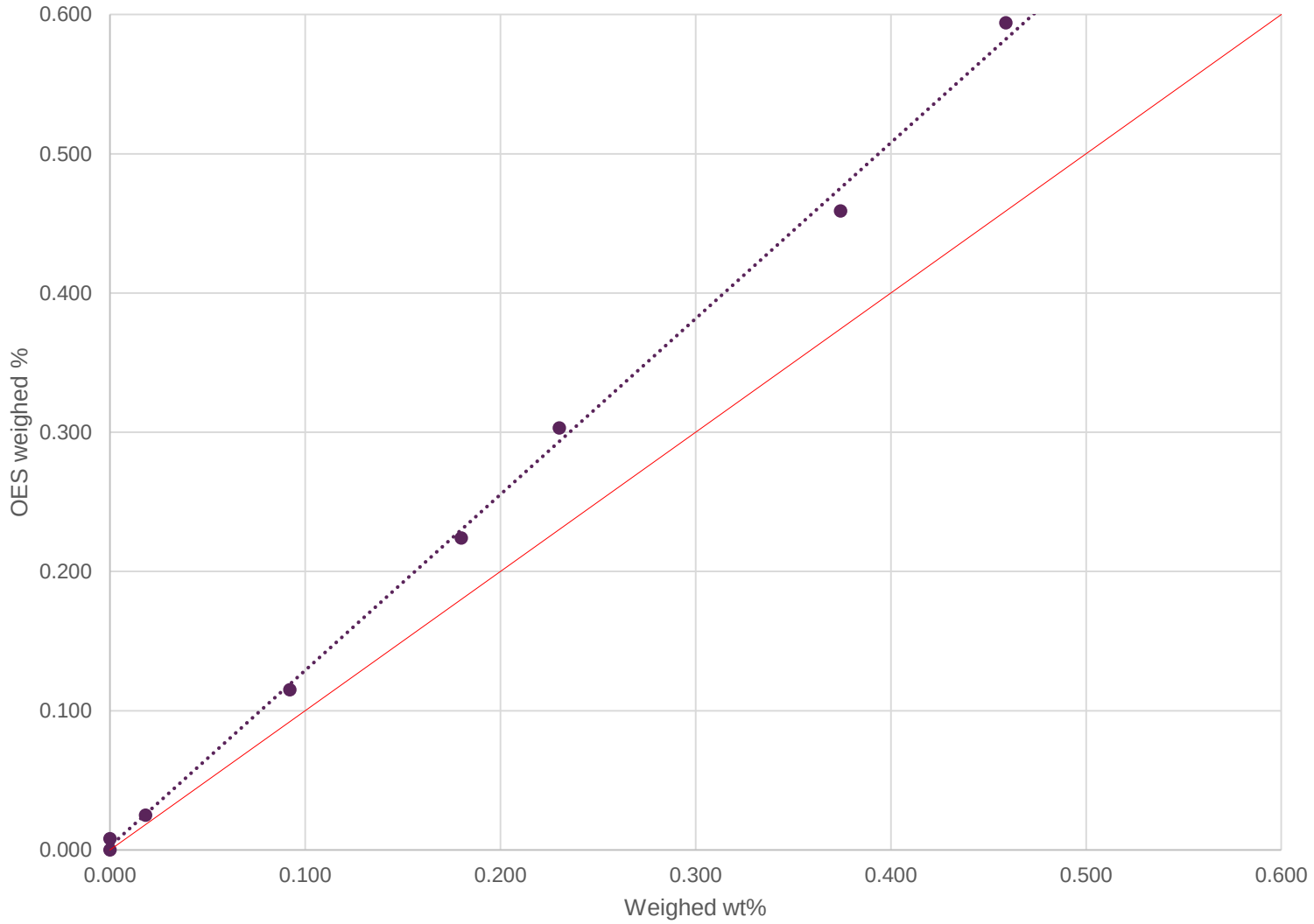
Varies +/-7%



Silicon

Varies +/-27%

Process two – 140g



Copper

Good correlation

Still varies but less critical

Copper is the only intended variable

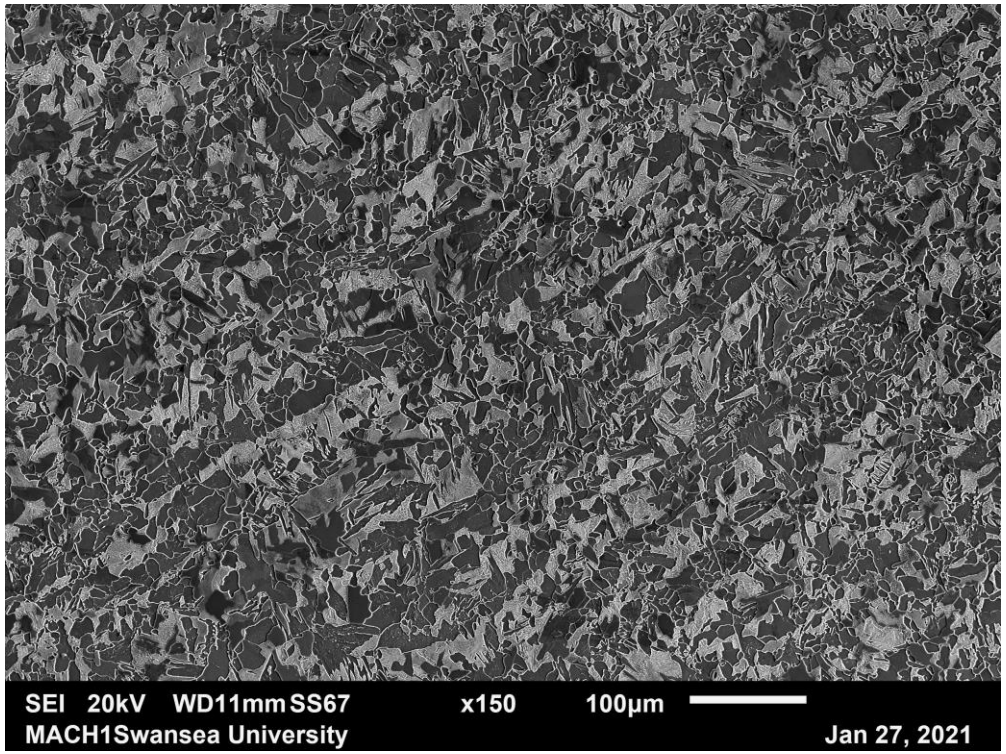
Process two – 140g

Advantages

- Faster sample production
- Sample repeats from one sample
- Easier to adjust composition
- Hot rolling possible

Disadvantages

- Composition inconsistences still present
- Composition is a simplified version of industrial grade

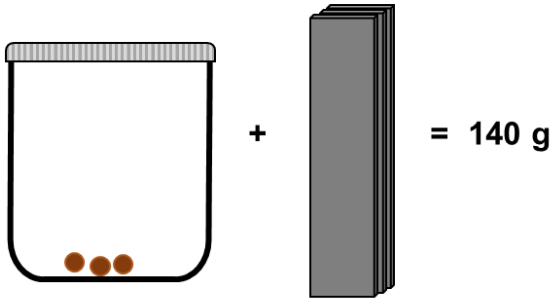


Synthetic automotive steel +0.6wt% Cu after 20% hot rolling preheated to 1225°C

Process three – remelt

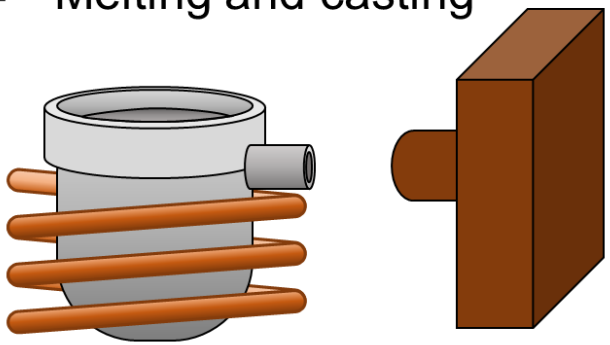
Methodology

1 Weigh components



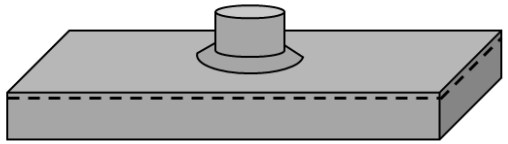
Residual additions + steel strips

2 Melting and casting

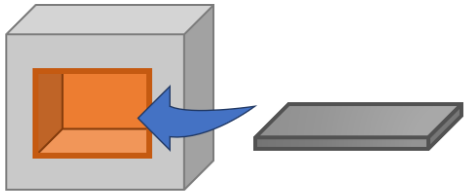


Crucible Copper mould

3 Centrifugal cast block

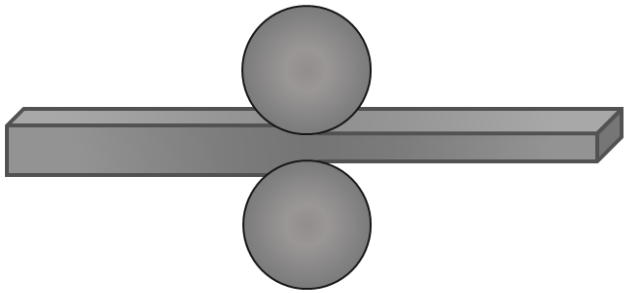


4 Pre-heat



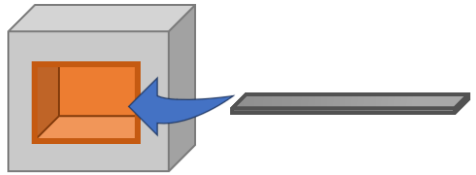
1225°C
5 mins

5 Rolling



Reduce by 20%*

6 Heat treatment



600°C
10 mins

Process three – remelt

	% change
C	-9.09
Si	-5.33
Mn	+2.40
P	+10.00
S	+12.82
Cr	-3.91
Ni	+31.15
Al	-14.86
Co	+18.97
Ti	-14.74
V	-8.70
W	-1.23
Fe	-0.21

Composition accuracy

- Less composition variation
- Reduced element losses
- Improved consistency expected

Advantages

- Less element loss
- Very quick process
- Sample size allows for repeats

Disadvantages

- New alloys are more difficult – existing base alloy is required
- Composition still is not predictable and consistent

Composition change of Tata produced steel and remelted steel with copper additions

Application and conclusion

Application

- This work contributes towards raising the limits of copper and other residual elements in steels
- Increasing residual limits will allow for more use of scrap steel leading to significant environmental benefits

Conclusion

- 20g samples are challenging to get a good composition but are best suited to tests that do not require specific microstructures
- The 140g route is an improvement on 20g route in most regards and would be best for investigating new alloys not based on existing compositions
- Remelting provides the best composition accuracy so far and, when possible, provides the best possible route

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Conclusion

Thank you for listening - any questions?

Contact details: Caroline Norrish 823495@Swansea.ac.uk