An Overview on high manganese steel casting

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- The influence of chemical composition on Hadfield steel
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Introduction

- The history of sir Robert Abbott Hadfield
- Manganese Ore reserves in SA and grades of manganese
- Production of manganese ore in the world and the use of manganese as an alloy element

HISTORY OF SIR ROBERT ABBOTT HADFIELD

- High percentage of manganese was added to steel
- He added 7 – 20% of manganese to steel, according to the type of application.
- The carbon to manganese ratio was 1:10
- The steel showed superior properties when having a composition of 1-1.4% C and 10-14% Mn

Why Manganese steel

- He invented the steel for good toughness and extreme hardness.
- Good work-hardening capacity
- The is no need to strengthen by:
  - ✓ Forging, hammering, Rolling ,quenching and tempering

Global Manganese reserve for Mn ore (2009)

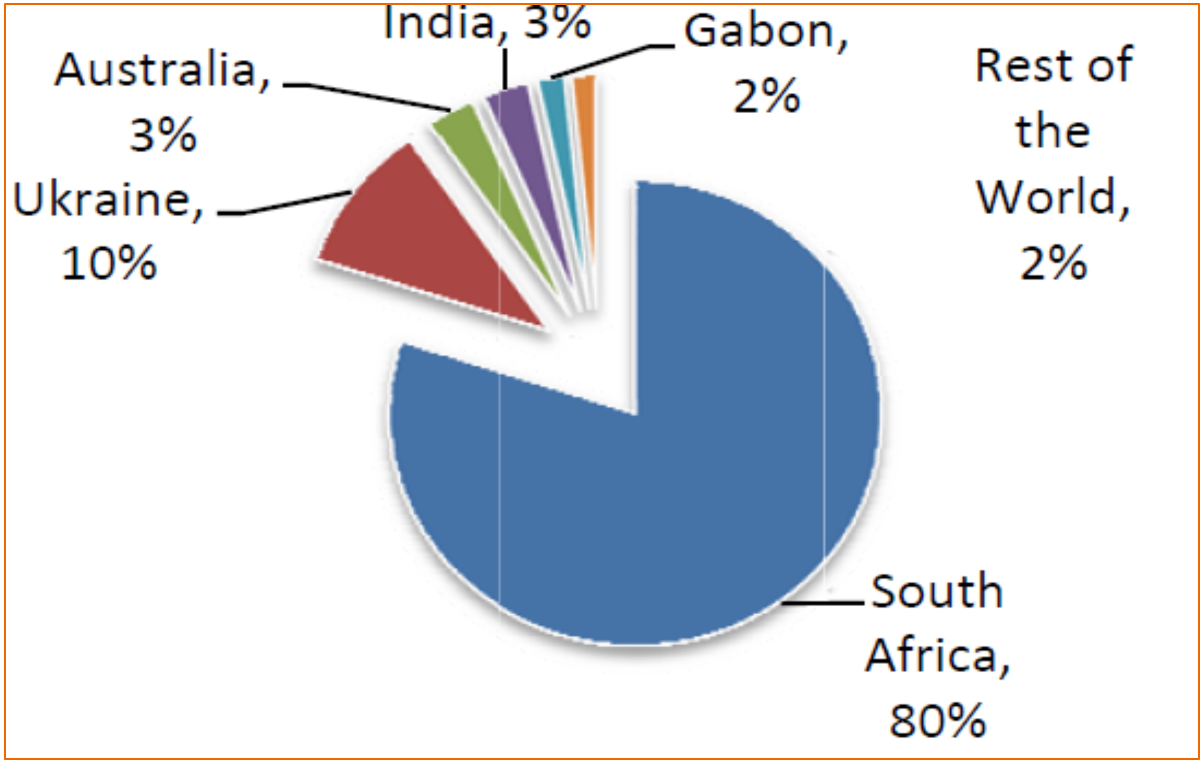

Figure 1:Global Manganese reserve 2009

MANGANESE ORE PRODUCTION AND STEEL PRODUCTION FOR 2009

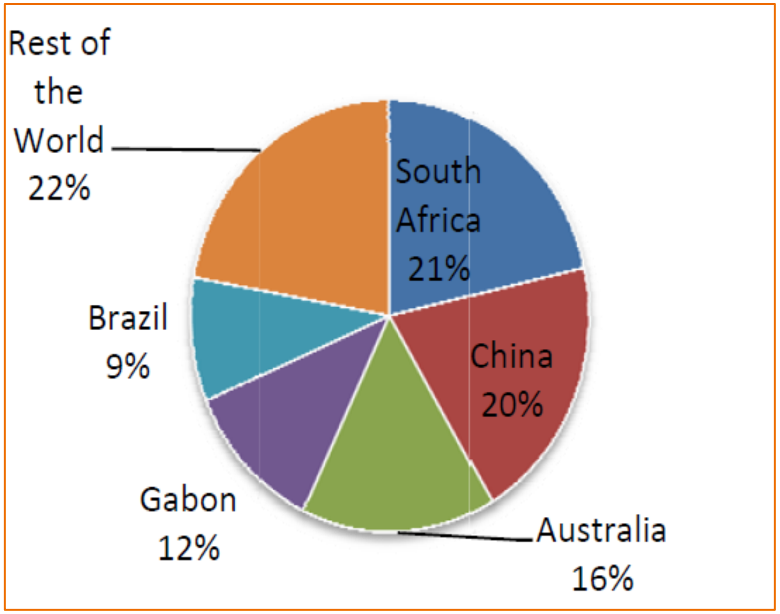

Figure2: Manganese ore production for 2009

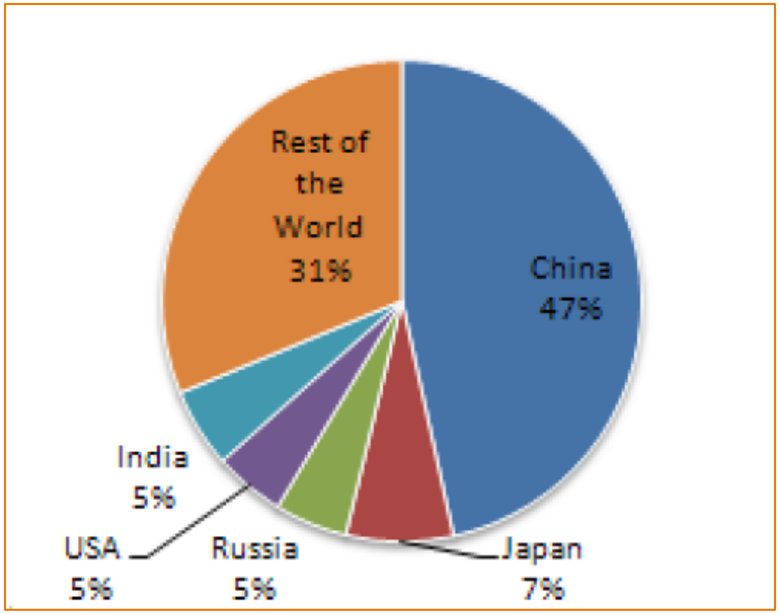

Figure3: Steel production for 2009

Manufacturing process of Hadfield steel

- Importance of steel scrap and Manganese returns
- Effect of melting and pouring temperature
- Heat treatment of manganese steel
- Mechanical properties of Hadfield steel

STEEL SCRAP AND MANGANESE RETURNS

Clean steel scrap

Figure 4: Clean scrap

Manganese returns

Figure 5: Manganese returns

EFFECT OF POURING TEMPERATURE

HEAT	H1	H2	H3
TEMP ^{o}C	1550	1450	1380

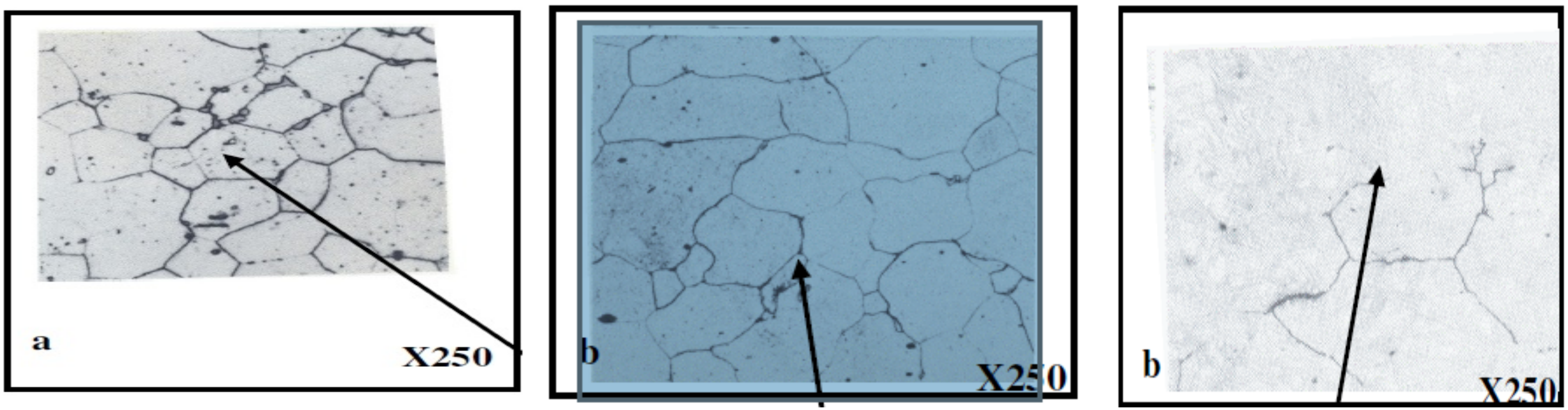

Figure 6: Microstructure of Hadfield manganese steel poured at three different temperatures

Heat treatment of manganese steel

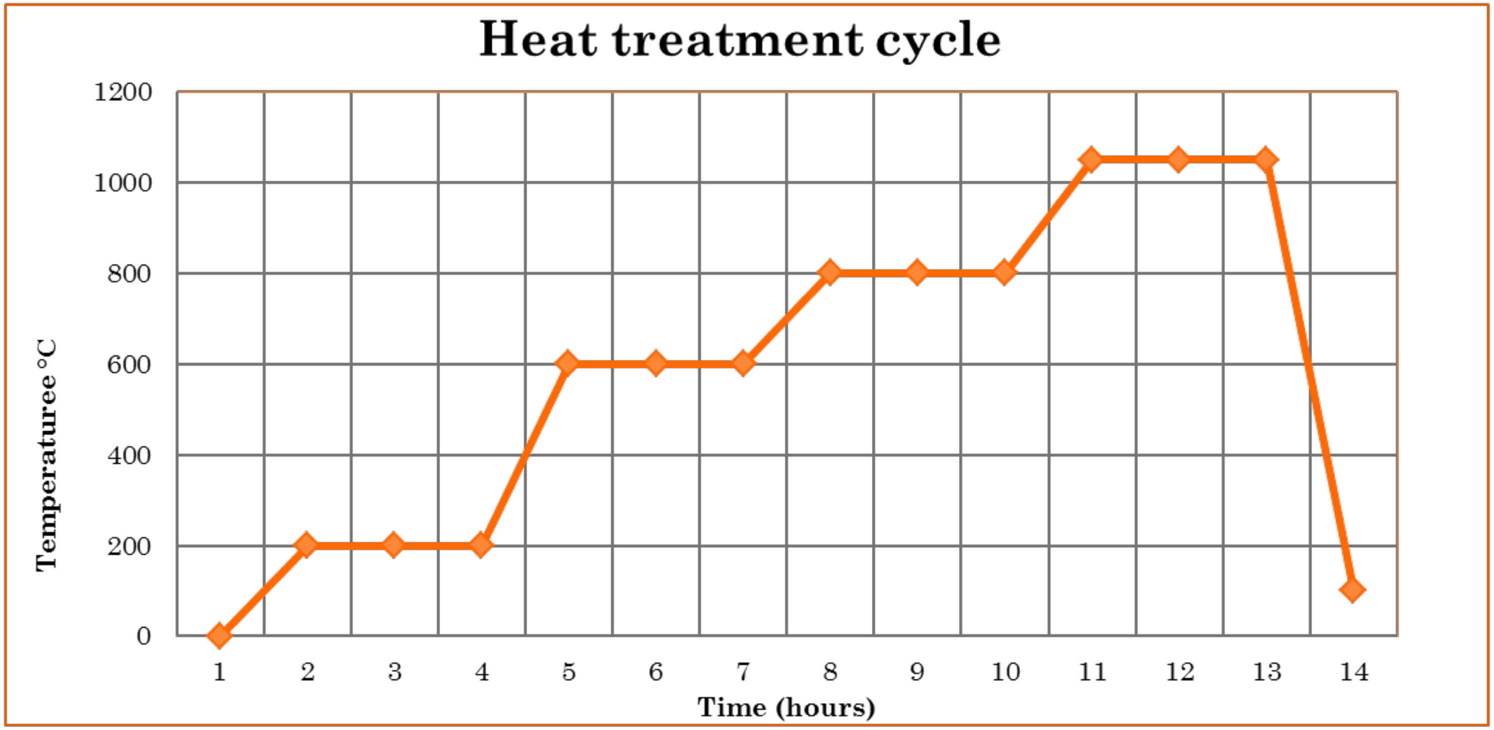

Figure 7: Heat treatment cycle

MECHANICAL PROPERTIES OF HADFIELD STEEL

Table 1: Mechanical properties of 13% Manganese steel

YS MPa	UTS MPa	Elongation %	Modulus	Hardness Brinel	Impact J/cm^{-2}
414	995	40%	$186x10^3$	200	112

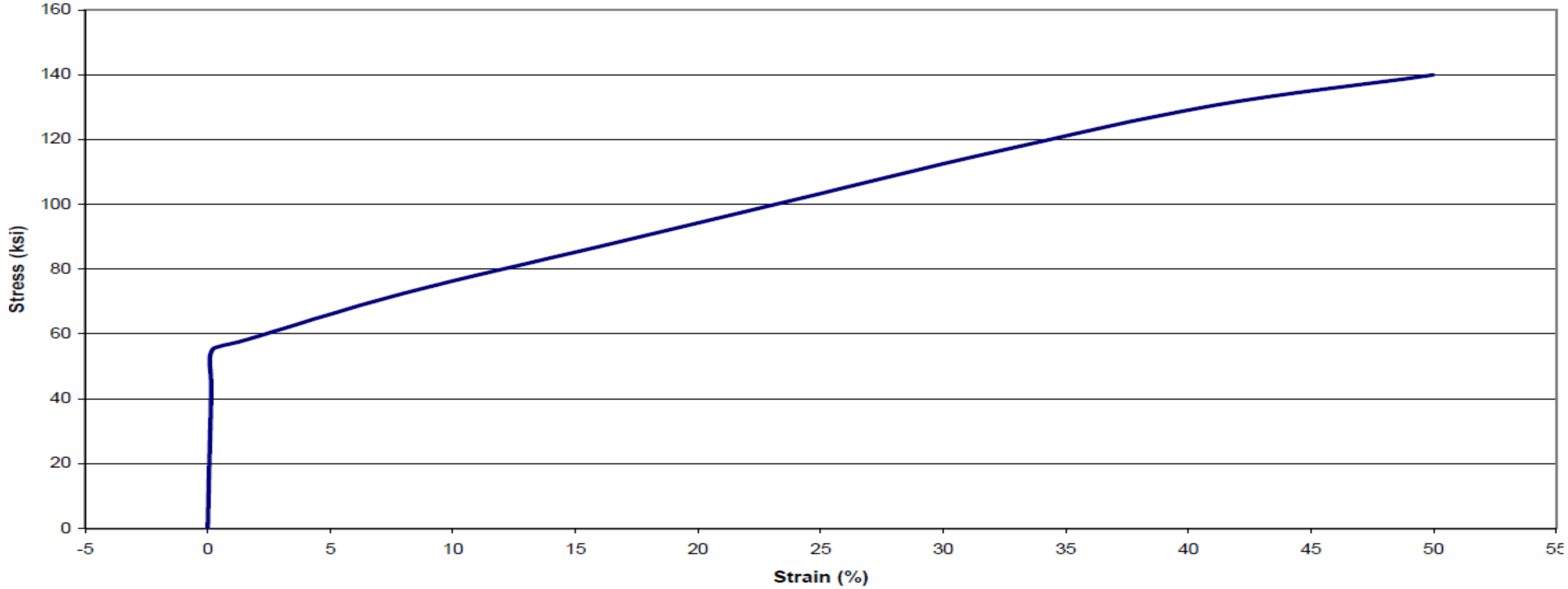

Figure 8: Stress- strain curve for 13%Mn

The influence of chemical composition on Hadfield steel

- Chemical composition of Hadfield steel
- The Influence of carbon and manganese
- Effect of carbide forming element

Chemical composition of Hadfield steel

Table 2: Chemical composition of Hadfield steel

Carbon	Manganese	Silicon	Chromium	Phosphorus	Sulphur
1-1.4	11-14	0.5	-	0.005max	0.005max

Excess carbon will increase yield strength while excess of manganese will decrease it.

The Influence of carbon on Hadfield steel

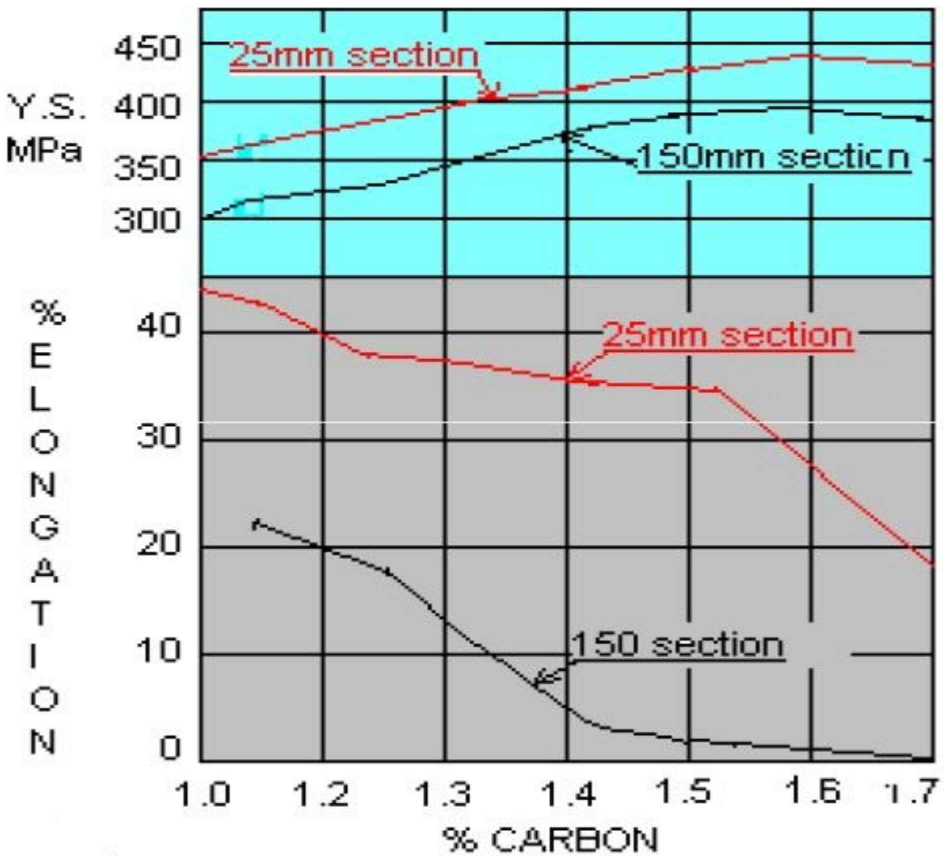

Figure 9: Effect of carbon content on yield strength and elongation

Carbon and Manganese content in manganese steels are not only interrelated, they are also related to the casting thickness.

Phase diagram for a steel containing 13% manganese

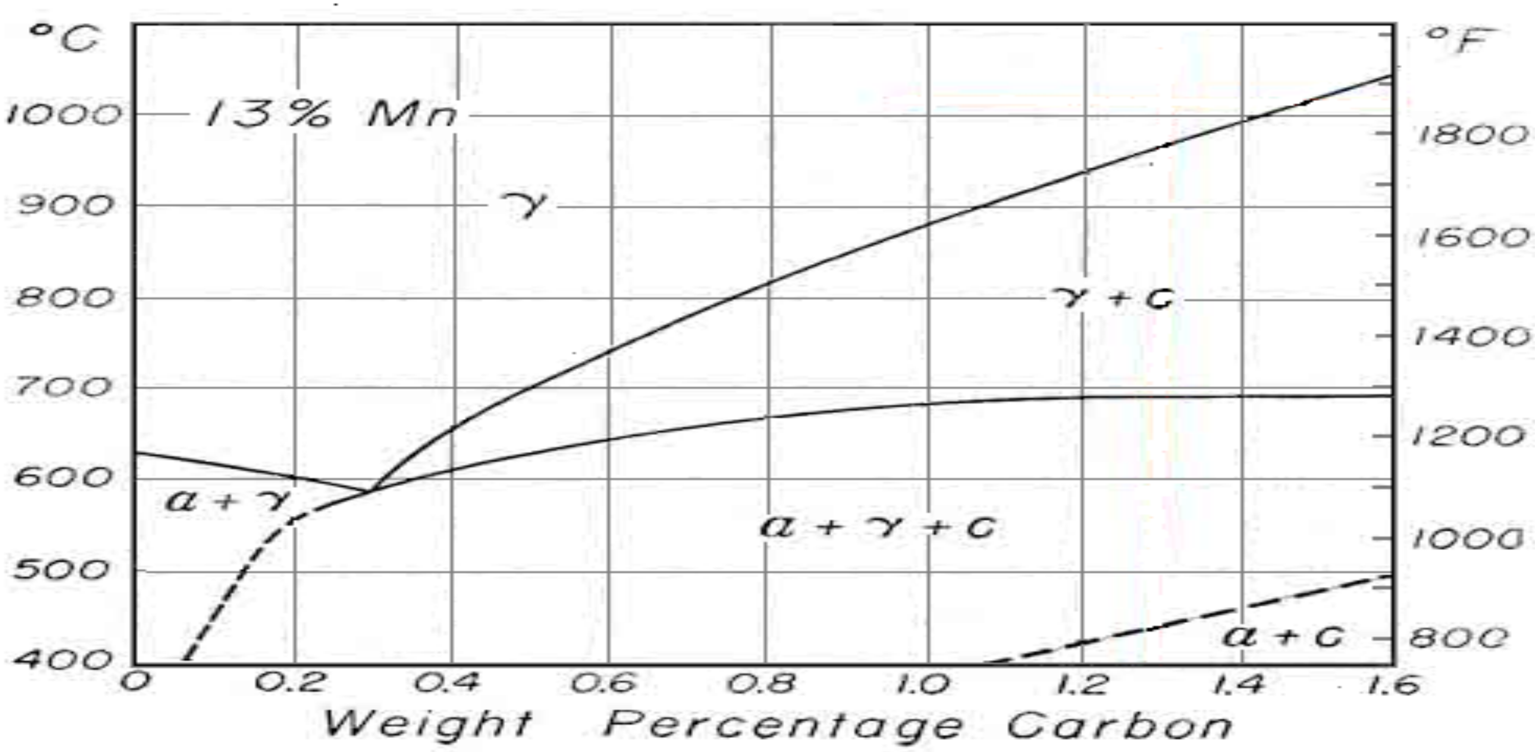

Figure 10: Phase diagram of steel containing 13% manganese

Effect of carbide forming element Chromium

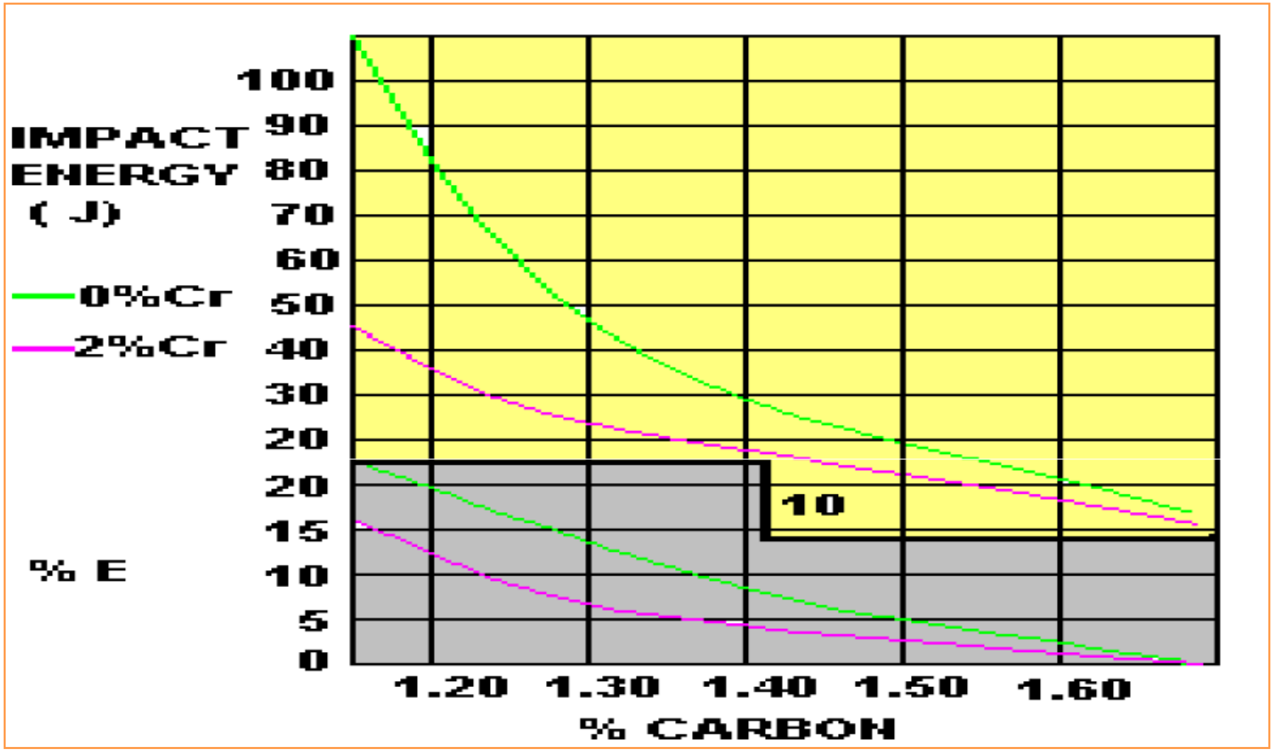

Figure 11:Effect of chromium content in 13% manganese

Effect of carbide forming element Vanadium

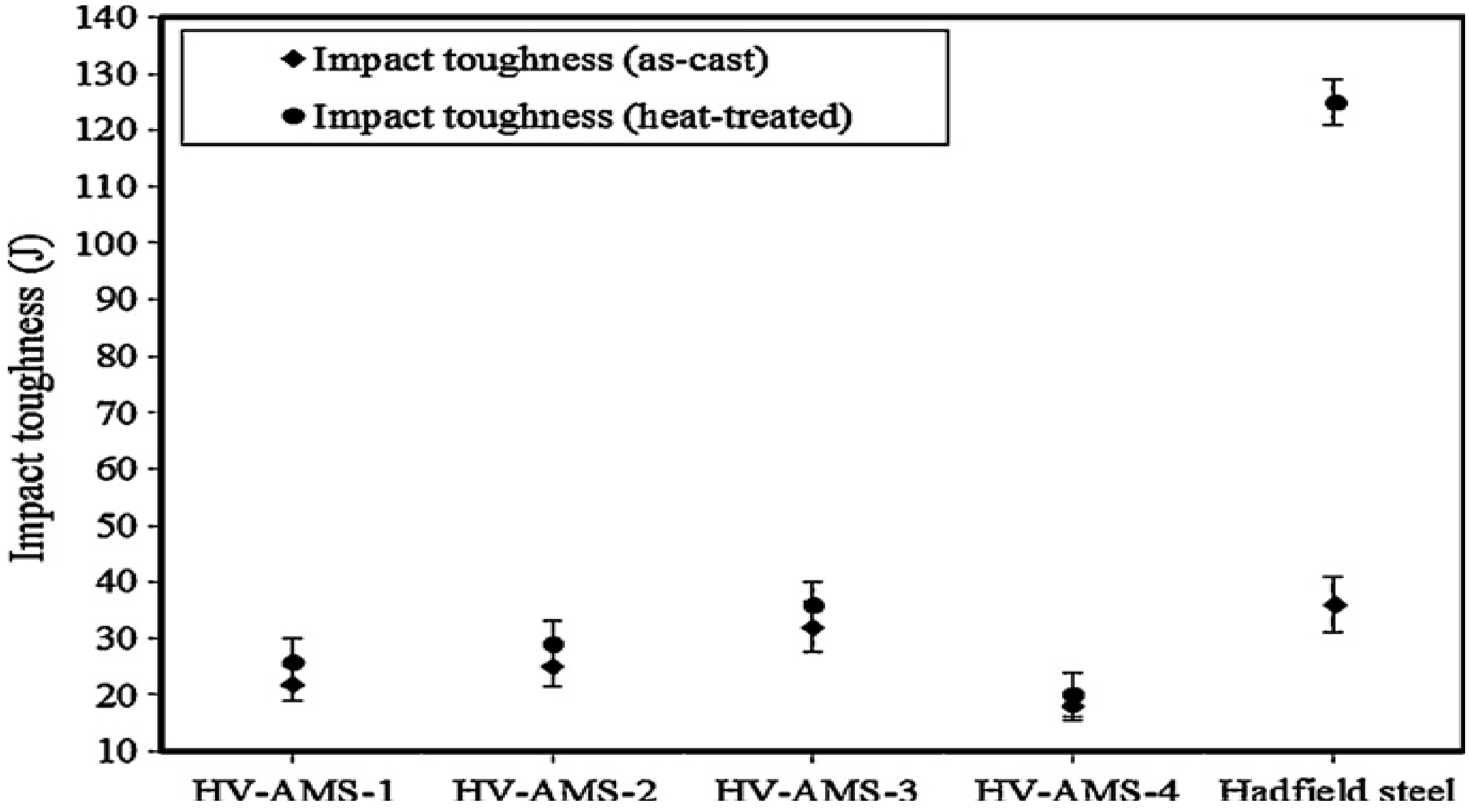

Figure 12:Effect of vanadium content in 13% manganese

Challenges of Hadfield steel based on service life

- Manganese steel is widely used :
- Earthmoving
- Mining
- Quarrying
- Oil and gas drilling
- Steel making
- Dredging

Mechanical properties for high manganese steel will vary with:

- Application and type of wear involved.

Application of Hadfield steel

Figure 13: Jaw

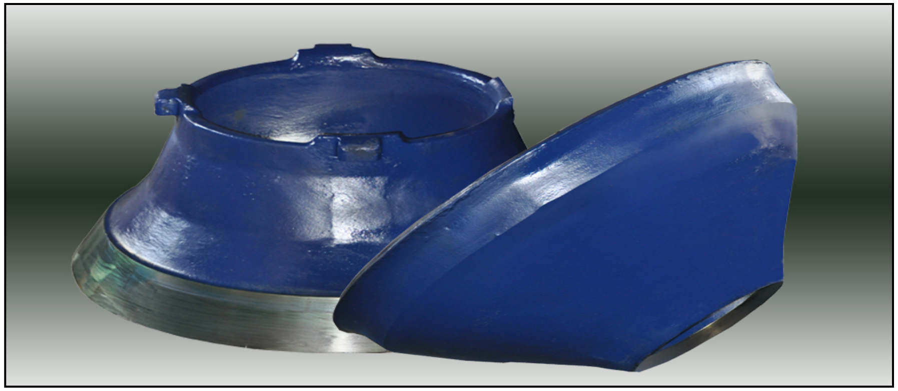

Figure 14: Mantle

Figure 15: Shredder Hammer

Figure 16: Excavator buckets

TYPES OF WEAR

- Gouging abrasion (Primary crusher)
- High-Stress grinding abrasion.
- Erosion or Low-Stress scratching abrasion.

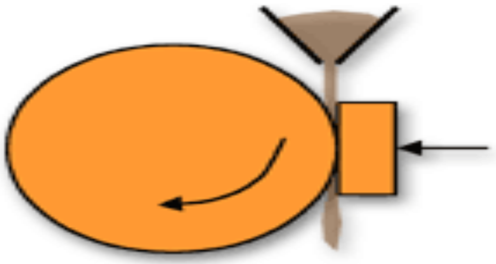

Figure 17: Erosion

Figure 19: Gouging abrasion

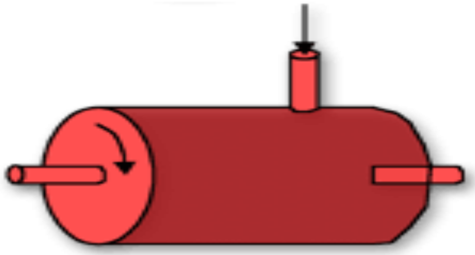

Figure 18: High-Stress grinding abrasion

Challenges

- Many considerations are involved in the selection of the proper grade of abrasion-resisting steel this include:
- Type of service
- The type of material being handled
- The type of abrasion
- The economics of operation

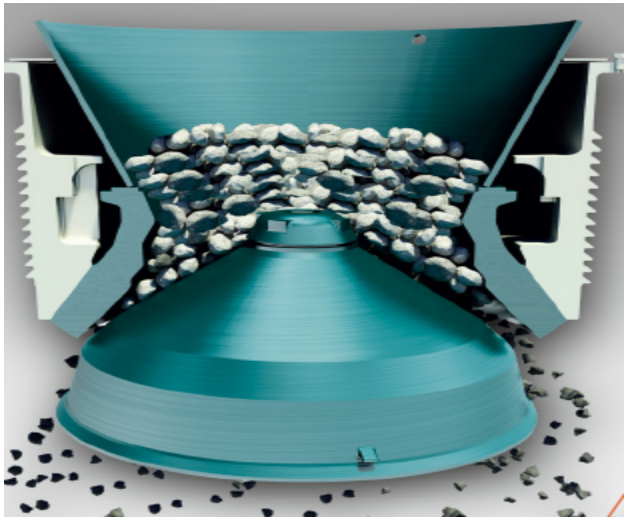

Figure 20:

Type of service

Figure 21: Type of material being handled

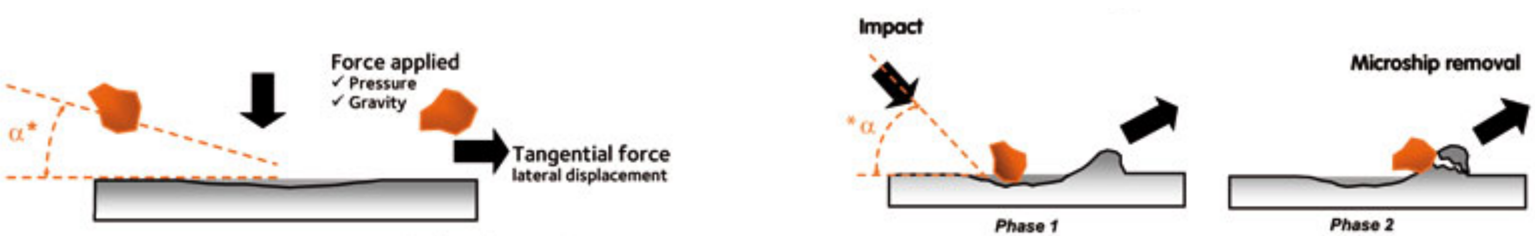

Figure 22 :The type of abrasion

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- The rate of work hardening is affected due to the crushing efficiency of the modern jaw and cone crushers.
- It is also insufficient for excavator buckets and loader shovels when loading fine grain materials.

Conclusion

- An overview of high manganese steel casting was conducted; the emphasis was based on the effect of chemical composition on Hadfield steel where it was shown how chemical composition can affect the final mechanical properties of the steel

- The manufacturing process of high manganese steel casting was analysed and this includes the important of foundry steel scrap, the effect of high melting temperature, the heat treatment cycle for manganese steel and the final mechanical properties of the said steel

DEVELOPMENT
OF
HIGH MANGANESE STEEL CASTING

PROJECT PROPOSAL

Table Of Content

- Introduction
  - ✓ Technical development
  - ✓ Objective
  - ✓ Justification
- Research methodology
- Experimental Procedure

Technical development

- The development was be based on adding different vanadium and chromium content into molten manganese steel.
- This development improved the hardness and wear resistance of high manganese steel used in the mining industry.

Research Objective

1. Reinforce vanadium and chromium carbide particles into the austenitic matrix
2. Increasing the hardness and wear resistance of austenitic manganese steel used in the mining industry.
3. Prolonging the service life of wear resistant high manganese steel used for secondary and tertiary crushers.

Justification of research

- If the rate of work hardening and the wear resistance are not sufficient for modern jaw and cone crushers the following will result:
  - Loss of material
  - Service life is compromised
  - Equipment inefficiency
  - Low production rate
  - High cost

Justification of research

- The reinforcement of carbide particles within the austenitic matrix will bring forth an increase in hardness and wear resistance for secondary and tertiary crushing system
- This increase in hardness and wear resistance for secondary and tertiary crushing system will make the service life of the component to be prolonged.
- Thus the overall objective of this research will save on cost to the company because component will have a longer service life

Research methodology

- Batch makeup

Table 1: Specified Chemical composition for Mn steel alloyed with vanadium (Phase 1)

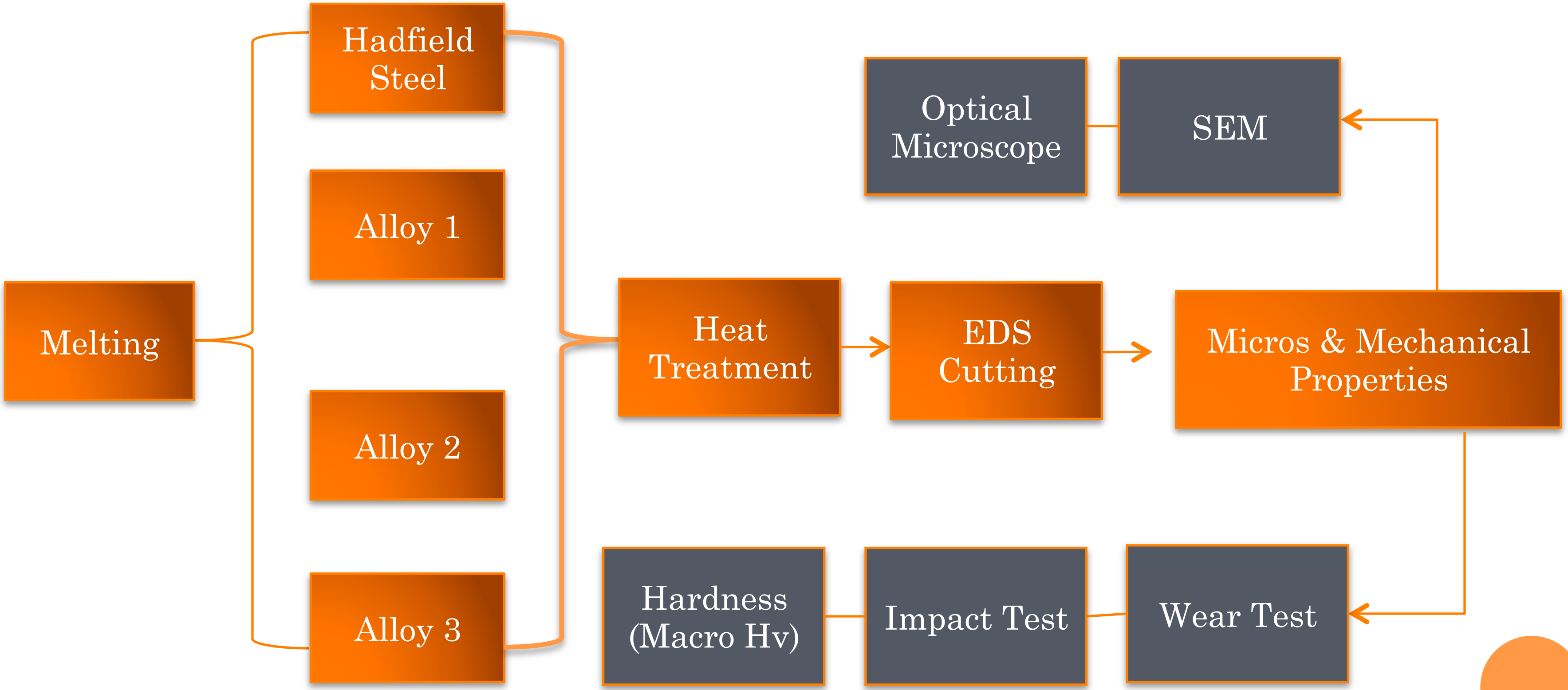
	C%	Mn%	Si%	Cr%	V%	S%	P%
Hadfield	1-1.4	11 -14	0.1-0.5	0.5max	-	0.05	0.05
Alloy1	1 - 2	11-14	0.5 – 1.00	0.5max	2	0.05	0.05
Alloy2	1- 2	11-14	0.5 – 1.00	0.5max	5	0.05	0.05
Alloy3	1- 2	11-14	0.5 – 1.00	0.5max	8	0.05	0.05

Table 2: Specified Chemical composition for Mn steel alloyed with Chromium(Phase 2)

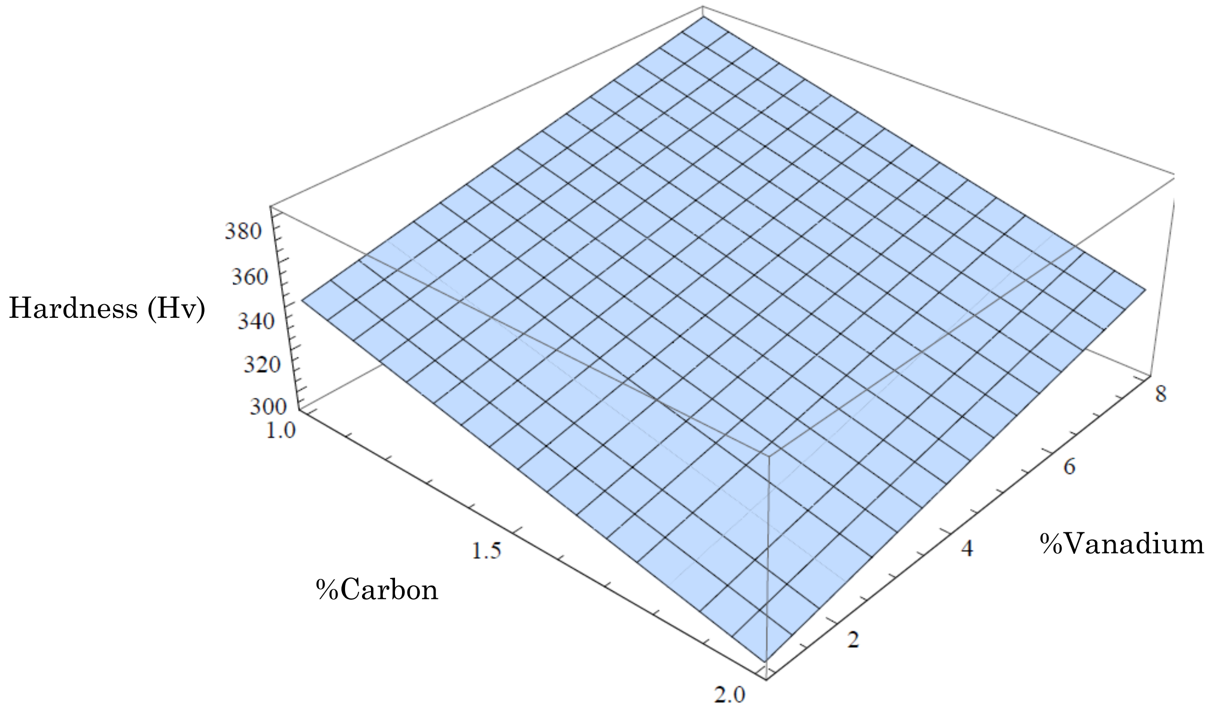
	C%	Mn%	Si%	Cr%	S%	P%
Hadfield	1-1.4	11 -14	0.1-0.5	0.5max	0.05	0.05
Alloy1	1 - 2	11-14	0.5 – 1.00	2	0.05	0.05
Alloy2	1- 2	11-14	0.5 – 1.00	5	0.05	0.05
Alloy3	1 - 2	11-14	0.5 – 1.00	8	0.05	0.05

Experimental Procedure

- Phase 1: Alloying with vanadium at a range of 1%- 2% carbon content
- Phase 2: Alloying with Chromium at a range of 1%- 2% carbon content



Alloy Modelling



- The model will have a theoretical equation of a plane of the form: $Ax + By + Cz = d$ Where $x = \%C$ $y = \%V$ and Z will be either Hardness number, impact energy or wear rate.
- From this modelling one can create an alloy theoretically.

QUESTIONS?