Novel Approach for economic production of Low Alloy & Stainless Steel by utilising over- burden of Sukinda Nickeliferrous ore

by

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- **Reserves of Nikeliferrous laterite deposits in India are in Sukinda valley & Samlipal area of Orissa**

- **Sporadic reseves are also reported from Singhbhum district of Jharkhand & Tuensang district of Nagaland**

- **98% of laterite reserves are confined in Sukinda valley spread over a 200 sq km .**

- **Total gross reserves : 231.4 Mt of nickel ore containing 0.2 to 1.2 % Ni**

- **Large resources of nickel in overburden of chromite mines which varies from 0.5% to 1% nickel.**

- **Chromite ore reserves in Sukinda area : 50 Mt**

- **Presently 1.0 Mt chromite ore mined annually by TISCO & OMC**
- **For every tonne of chromite ore mined, 10 tonne of nickeliferrous limonites along with lateritic overburden is extracted**
- **About 75 % of overburden is accounted for nickeliferous limonites**
- **10 Mt of nickeliferrous overburden is generated annually by TISCO & OMC & 140 Mt has been accumulated over several years of mining**
- **This overburden average o.7 % nickel of which 40-50% of material average 1% nickel if dumped through grade control**
- **On account of mechanised mining & lack of market demand of such overburden, chromite ore producers are not segragating richer nickeliferous limonites**

Process for production of Ferro –Nickel

- **Rotary Kiln – Submerged Arc Furnace (RK – SAF)**
- **Shaft Furnace – Submerged Arc Furnace (SF- SAF)**
- **Ugine Process**
- **Oheyama Process**
- **Blast Furnace Process**

► **With high capital cost coupled with small requirement & with not so attractive international price of Fe- Ni , over burden of Sukinda was not considered economical viable for Fe-Ni / Nickel production.**

► **Due to high Fe content of Sukinda ore, large quantity of Fe is to be converted into oxide slag to get Fe-Ni of desired Ni content.**

- **In order to take advantage of presence of high iron content, this novel approach has been tried for commercial trial.**

- **Nickeliferous laterite ore / chromite over burden will be utilised for hot metal production through blast furnace extracting maximum iron, nickel and chromium from ore .**

- **Hot metal containing nickel & chromium can be further refined for production of low alloy / stainless steel having nickel & chromium thus saving for ferro - alloy consumption resulting in lower cost of production of alloy steel.**

Diverse Application of Ni- Cr Steel

- Ni – Cr low alloy steel have diverse application in commercial use
- Chromium , a strong carbide former, is an important hardening element in steel & possess corrosion resistance property.
- Nickel , a ferrite strenghter, is a toughening element & also lower critical cooling rate for hardening
- These two elements together render steel quite effective engineering material having good hardenability, impact strength , resistance to corrosion & fatigue resistance.
- Cr – Ni low alloy find vide application as axle shafts, bearing , barrels, other machinery components, stiffeners & other structural members of industry like aerospace, defence, automobile, engineering / construction industries etc.

- **Large variety of stainless steel containing high percentage of chromium & nickel finds its use in various industrial / household applications.**

- **Commercial application of stainless steel usage are :**

  - **Chemical& pharmaceutical machineries**
  - **Dairy equipment / machineries**
  - **Textile machineries**
  - **Paper & pulp machineries**
  - **Hospital & surgical instrument**
  - **Transport sector**
  - **Nuclear industries**
  - **Utensil & cutlery**
  - **Manufacturing industry**
  - **Construction sector**
  - **Transport sector : Railway coaches, bus body etc**

Production of Low Alloy & Stainless Steel

Conventional Method

- Refining of hot metal in BOF & addition of ferro - alloys in Ladle Furnace for low alloy steel

- For Stainless Steel- preferred to have required chromium in initial charge to minimise cost of input material by adding chromium bearing scrap & or charge - chrome/ high carbon ferro- chrome .

- To avoid excessive chromium loss, one of following additional step is required after initial melting

    - Vacuum Oxygen Decarburisation (VOD)
    - Argon Oxygen Decarburisation (AOD)
    - Creuset – Loire & Uddeholm Process (CLU)
    - Metal Refining Process (MRP)
    - Argon Secondary Metallurgy (ASM)

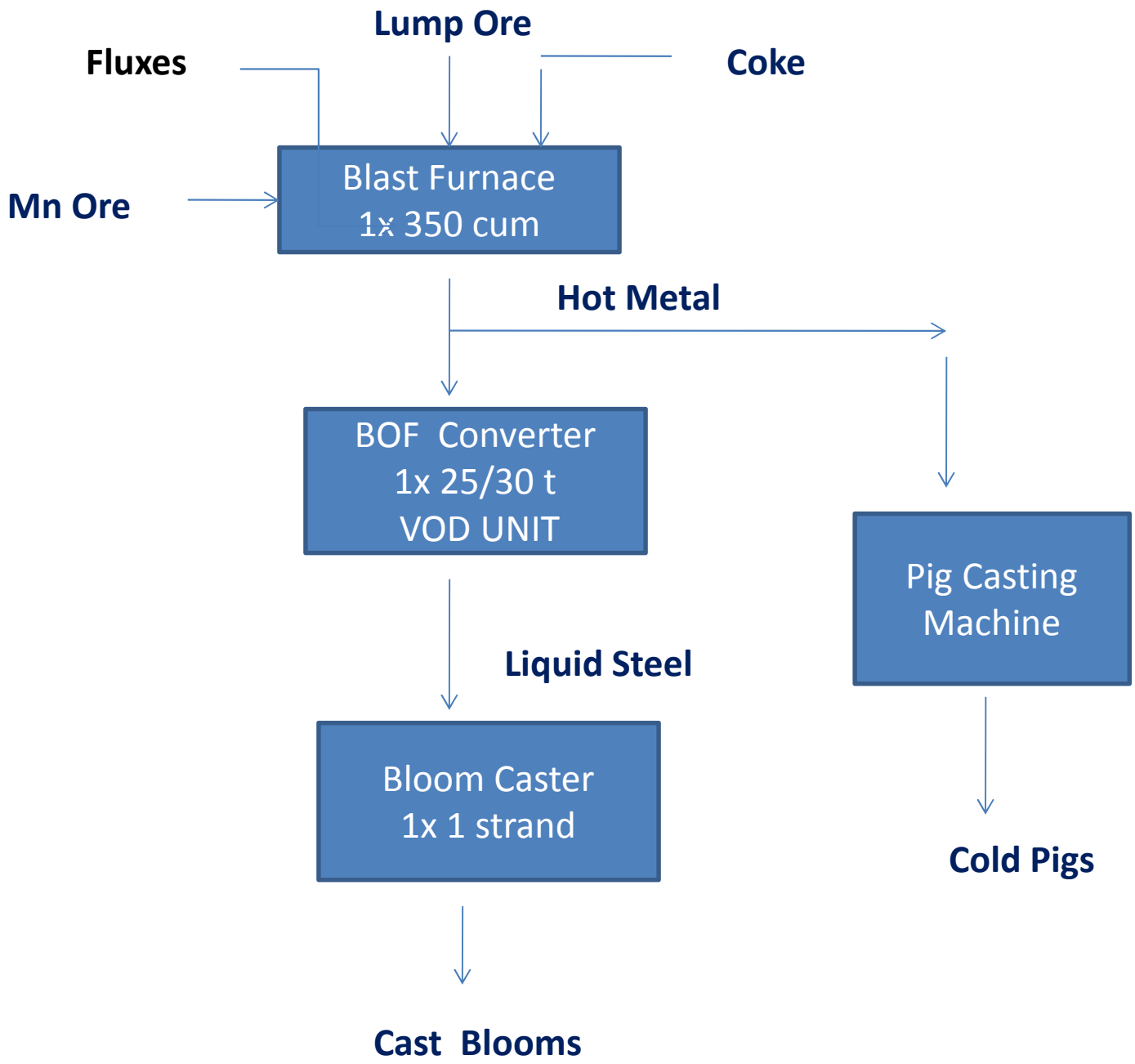
Case Study

- **Base Case - Conventional Method for production of Low Alloy steel & Stainless Steel**

- **Case I : Production of low alloy Ni-Cr-Mo steel (En 24 & 25)**

- **Case II : Production of AISI 302 stainless Steel**

- **Broad economics has been carried out for comparison for production of 170, 000 t /yr cast bloom production**


Lump Ore
Fluxes
Coke
Mn Ore
Blast Furnace
1x 350 cum
Hot Metal
BOF Converter
1x 25/30 t
VOD UNIT
Pig Casting
Machine
Liquid Steel
Bloom Caster
1x 1 strand
Cold Pigs
Cast Blooms

Major plant facilities for cases under consideration

Facilities	Base	Case I	Case II
Sinter Plant	--	1x50 m2	1x50 m2
Blast Furnace	1x 350 m3	1x350 m3	1x350 m3
BOF Converter	1x30 t	1x 30 t	--
CLU	--	--	1x30 t
VOD Unit	1 no. *	--	--
Bloom caster	1x1 strand	1x1 strand	1x1 strand
Services& Aux.	Same	Same	Same

* For production of Stainless Steel

Technological Parameters

Parameters	Base Case	Case I	Case II
Ore Analysis, %			
- Fe	62.0	51.0	51.0
- SiO_2	1.2	5.8	5.8
- Al_2O_3	1.6	4.0	4.0
- Ni	-	1.1	1.1
- Cr	-	2.3	2.3
- Source	Daitari	Sukinda	Sukinda
BF burden			
- % Sinter	Nil	85 /100	100
- % Lump Ore	100	15 /0	0
- Coke , kg/thm	655	620	620

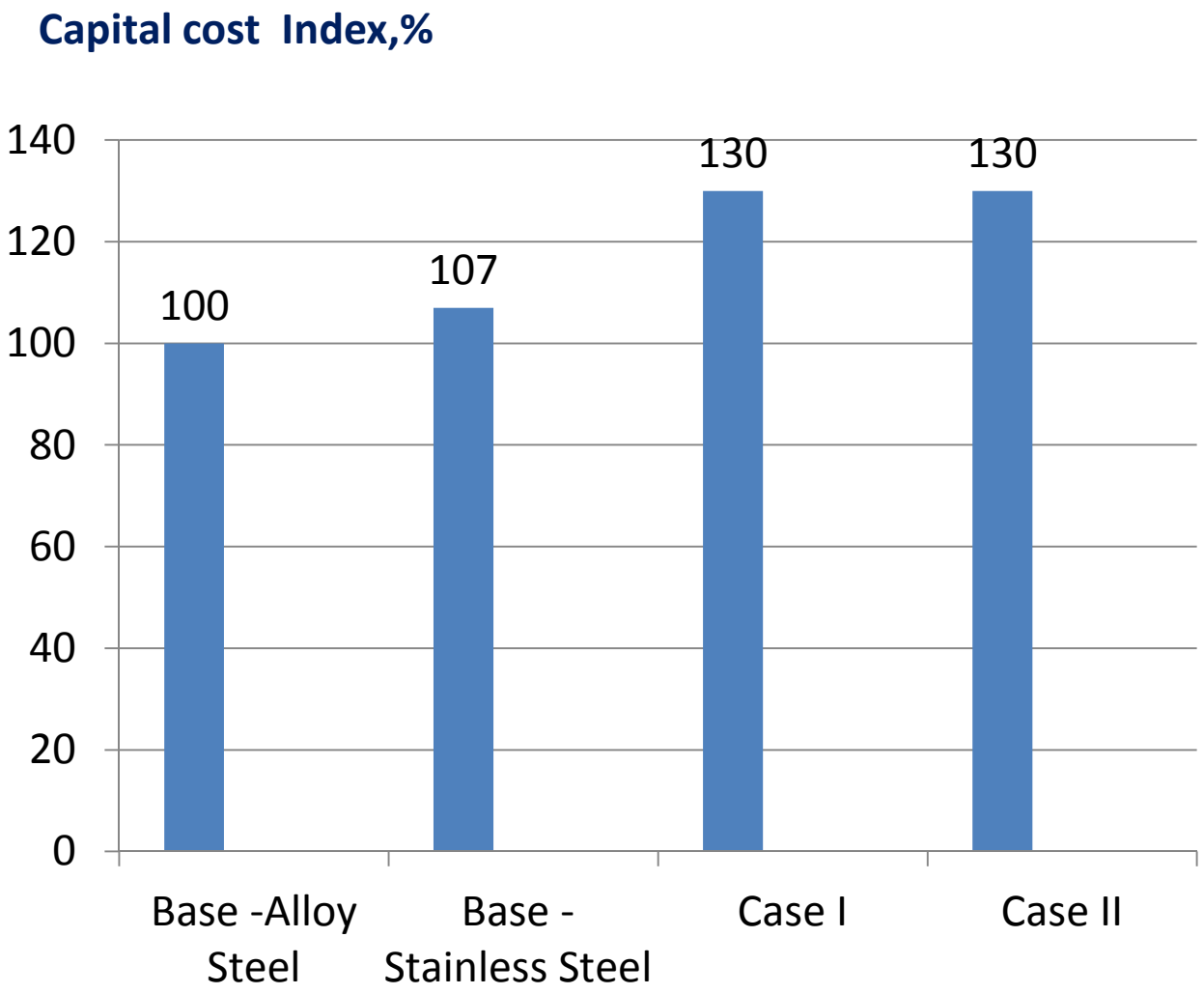
Technological Parameters

Parameters	Base Case	Case I	Case II
Hot Metal Analysis			
- C	3.6	3.6	3.6
- Si	0.8	0.8	0.8
- Mn	0.6	0.6	0.6
- Ni	-	1.7 / 2.1	2.1
- Cr	-	2.4 / 2.8	2.8
- P	0.2	0.2	0.2
BOF			
Metallic input, kg/ tls	1090	1090	905
Oxygen , Nm3/tls	52	55	82
Lime , kg/ tls	55	55	200

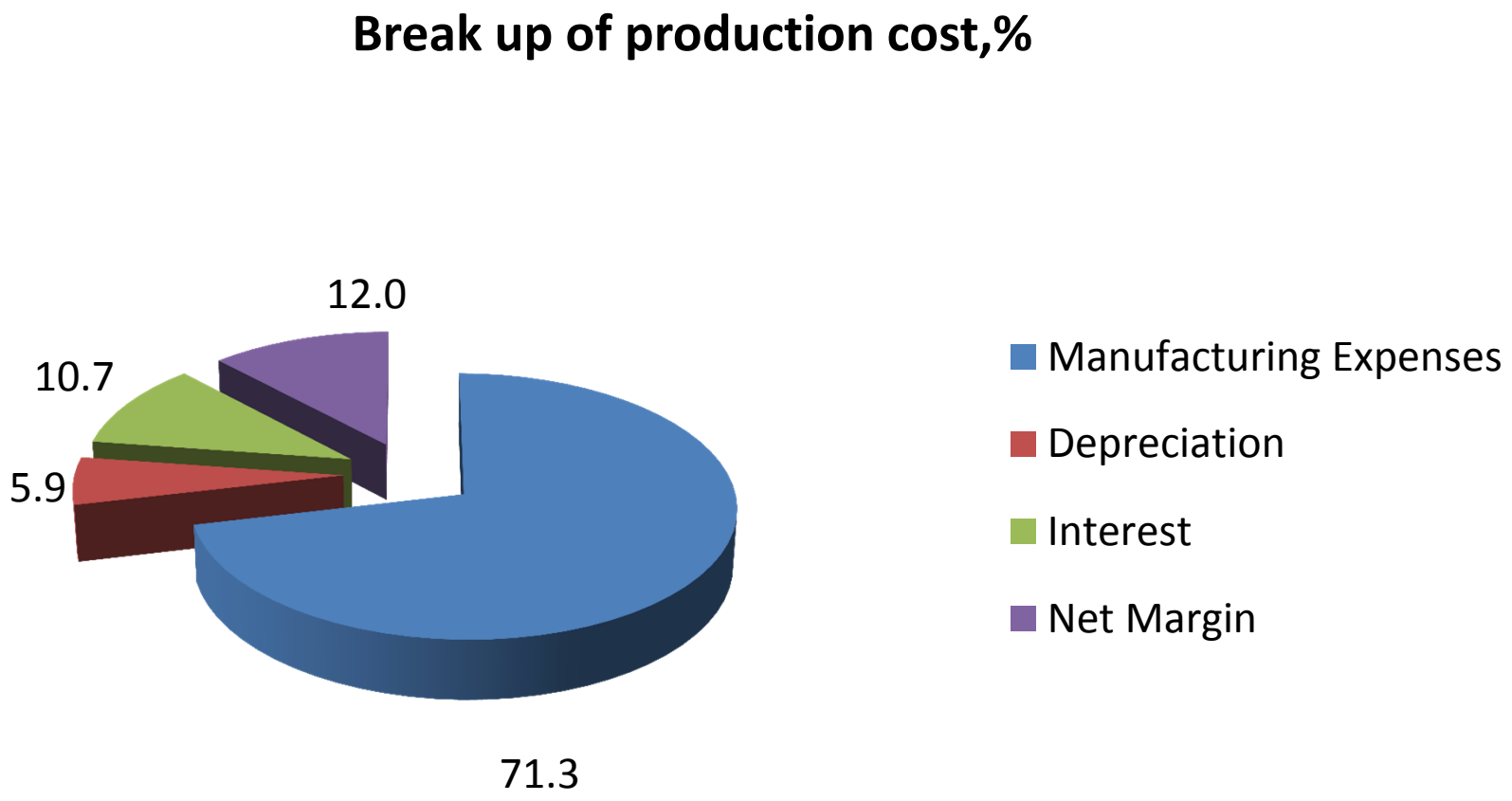
Industrial Trial

- Industrial trial for production of Ni-Cr bearing pig iron was conducted in blast furnace of Kalinga Iron Works Limited , Barbil using 25% to 50% chromite overburden sinter in the burden.

- During three days trial 250 tonnes of alloyed pig iron having Ni in the range of 0.39- 0.9% has been produced successfully first time in the country using the over burden waste from chromite mines

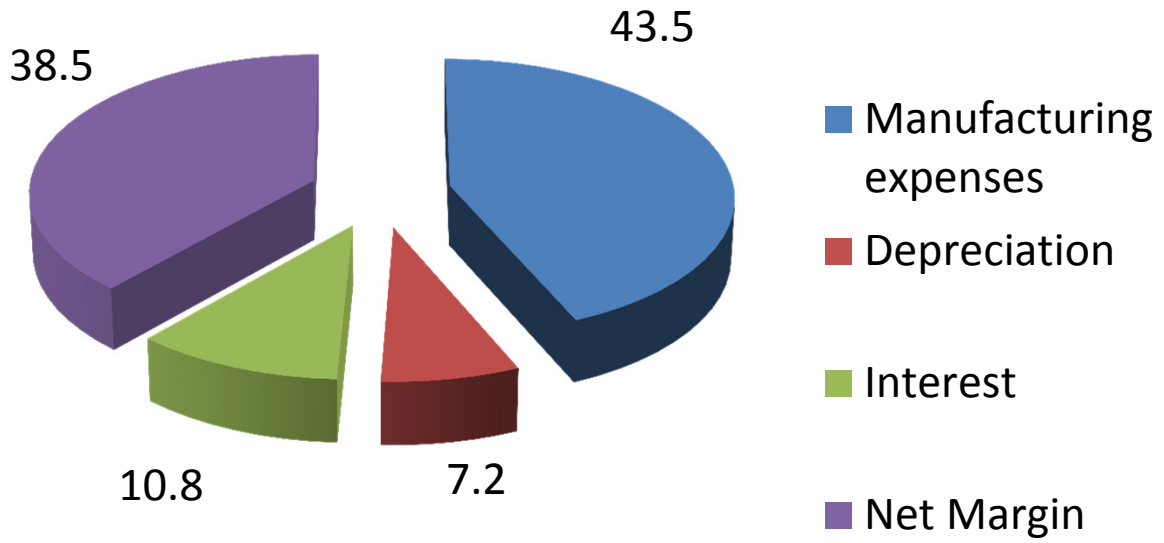


Index of capital investment



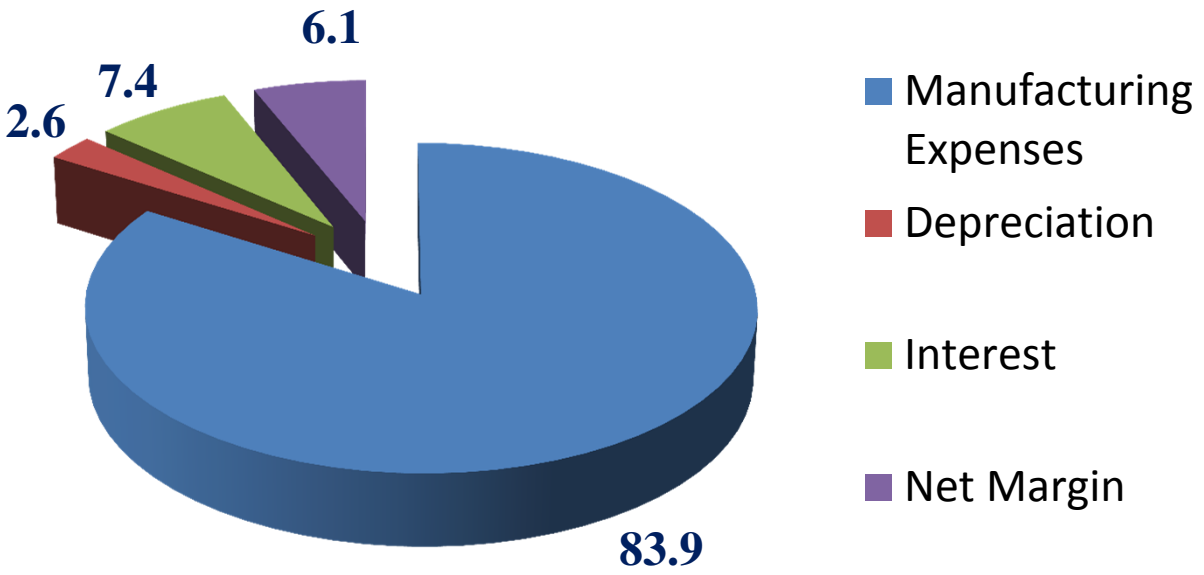
Base Case: Production of low alloy steel

Break up of production cost,%



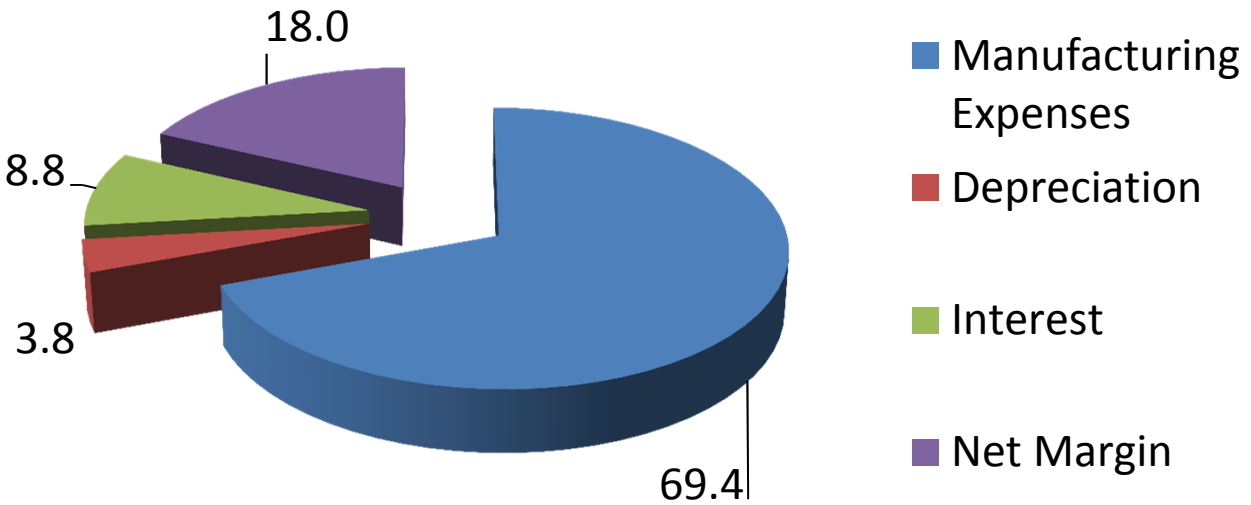
Case I : Production of Low Alloy Steel

Break up of production cost,%

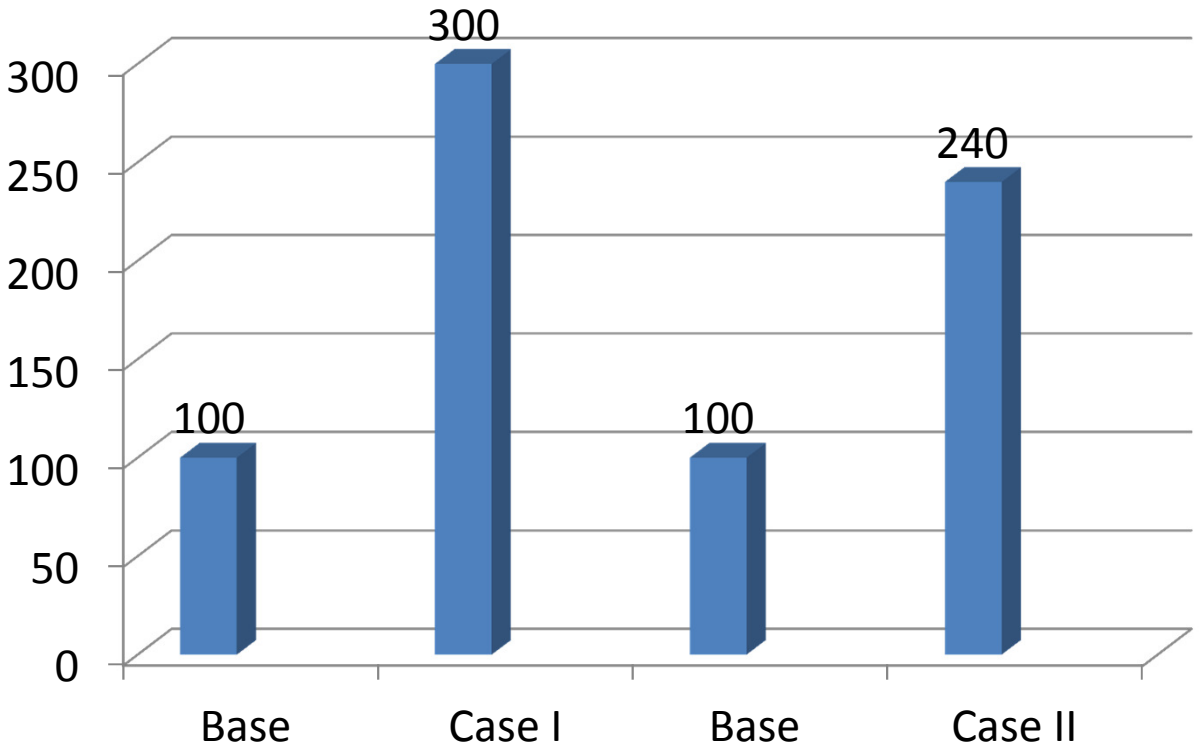


Base Case : production of Stainless Steel

Break up of Production Cost,%



Case II : Production of Stainless Steel



Index for Return on Capital Employed

Conclusion

- Low alloy & stainless steel can be economically produced utilising nickeliferrous lateritic ore/ chromite overburden

- Use of overburden will also reduce environmental problem due to dumping of overburden & clear large area presently occupied by overburden

- Sintering test at IMMT (RRL) Bhubaneswar and industrial trial carried out using 25-50% sinter by using chromite over burden as feed for BF charge at Mini Blast Furnace of Kalinga Works , Barbil has successfully produced 250 t alloy pig iron .

- Alloy pig iron is commercially produced in China & Brazil through small blast furnace using chromite over burden & further treated for production of stainless steel.

THANK YOU