

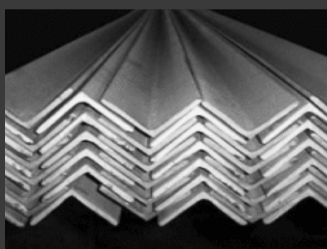
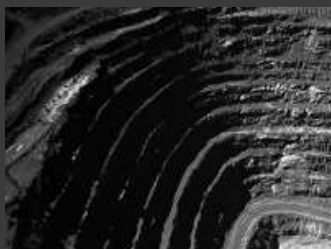


Government of India
Ministry of Mines
INDIAN BUREAU OF MINES

IRON & STEEL

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INDIAN BUREAU OF MINES PROJECT CREDIT

FORMULATION & GENERAL GUIDANCE

C.S.Gundewar

Controller General

Concept, Compilation
& Drafting

Mohan Ram

Suptdg. Officer (Ore Dressing)

A.T. Sutaone

Retd. Suptdg. Officer (Ore Dressing)

M.S. Rao

Deputy Ore Dressing Officer

A.K. Sengupta

Deputy Ore Dressing Officer

Computer Drawings & Graphics

T.H. Banerjee

Deputy Ore Dressing Officer

S.B. Borkar

Senior Technical Assistant (OD)

R.K. Bendre

Stenographer Grade-I

Layout Design, Editorial,
Production & Printing Control

A.K. Singh Chief Editor

M. Sumesh Editor

Typeset & Designed at
Esskay Advertising,
Nagpur

Printed at
Aqua Process,
Nagpur

PREFACE

The growth in the Indian Iron & Steel Industry is nothing but staggering. Iron & Steel industry's exponential growth particularly in the past decade is attributable to factors, such as, strong global demand and buoyant domestic scenario. These favourable prospects have led the Ministry of Steel to project steel production of the country to be around 180 million tonnes by the year 2019-20, a threefold rise from the present level of 65 million tonnes (2009-10). To meet such ambitious target in steel making several of the Industry's key concerns, viz. increasing raw material insecurity, constraints in creation of new projects, expansion of existing projects and infrastructure bottlenecks need to be prioritised and addressed.

Taking cognisance of issues at hand in relation to the Iron and Steel Industry and owing to the magnitude of attention that iron and steel could attract, the Ministry of Mines, Govt. of India, entrusted Indian Bureau of Mines to conduct a relook on policy orientation on the basis of techno-economical parameters and all other parameters with respect to availability of reserves, environment, expansion of technical know-hows etc. Born out of such imperatives is this comprehensive book entitled "Iron & Steel—Vision 2020" that aims at revisiting a whole gamut of interconnected issues that exists and confronts the Indian Steel Industry in all its strata from Mines to Metals. This publication endeavours to cover the status of each specific type of industrial units of iron in the country in detail, covering all aspects, viz. iron ore resources & exploitation, beneficiation & agglomeration and Iron & Steel making processes and in furtherance identify the gap areas in all the concerned units in the Sector so as to devise modus operandi to achieve optimum utilisation of available iron ore reserves and augment standards in order to meet the set national goal in steel production.

The dependence on the iron ore, namely, haematite for steel making in the country presently is far too high. Haematite being high-grade and lumpy in nature easily meets the specifications for steel manufacturers. However, increased dependence on haematite - 45% of iron ore lumps (haematite) are utilised in India for steel making as opposed to 15-20% used globally - has engendered its short supply and the country is staring at diminishing prospects of availability of high-grade lumpy haematite ore. Increasing the life of the reserves have become an essential imperative and is vital for sustenance and progress of the country's economy. To ensure adequate and prolonged availability of raw material, critical measures for utilisation of low-grade ore, use of stored slimes in tailing ponds and exploration of new deposits must be exhorted. The fragile nature of sizeable Indian iron ore with the present proportion of lumps to fines used in the country being around 2:3, axiomatically leads us to believe that large chunks of fines either are unutilised or are exported. This trend needs reversal, utilisation of fines must be encouraged and for this beneficiation followed by agglomeration is the need of the hour.

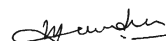
Every effort to collect, assimilate and incorporate actual data from the industry was pursued to authenticate the facts reflected in the book. Questionnaires were circulated to all concerned parties and one Workshop on Agglomeration was also conducted to acquire data. Besides, views of eminent personalities in the respective field of specialisation were also carefully studied and integrated to widen the scope and comprehensiveness of this title. In-house R & D works on beneficiation of various types of iron ore across the country carried out at IBM's Ore Dressing Laboratories and flow sheets thus developed have been interspersed at relevant portions. These flow sheets could provide the much-needed roadmap for likely process routes of beneficiation of iron ore (area and character specific) in the country.

Centric on a gamut of technical insights especially on the need of enhancement in iron ore reserves; value addition/beneficiation of low-grade ores, fines & slimes; development of agglomeration activities especially pelletisation of beneficiated fines; use of pellets in iron making specially coal-based DRI units and integrated steel plants; conservation of limited high-grade iron ore lumps; etc., this book attempts to steer a pathway to the future and that which could lead the country's Iron & Steel prospects into a realistic dimension of growth.

The prelude to the origination of this publication is the persuasion and guidance of Shri S. Vijay Kumar, Secretary to the Govt of India, Ministry of Mines, who was ever insistent that the data on iron & steel amassed during the course of the Study be transformed into a publication for public consumption. Indian Bureau of Mines owes profound gratitude to the Secretary (Mines) for his invaluable counsel and direction.

Coalescence of dedicated minds and integration of efforts from teams of Bureau's officers especially from Ore Dressing Division and Publication Section have made this publication a reality that it is today. It would be unfailing on the part of the Bureau if the stupendous contribution of Shri A.T. Sutaone, Retd Suptdg Officer (Ore Dressing), IBM, whose astuteness and expertise in shaping the contents of this publication is not recognised and due indebtedness to him is not conveyed.

It has been our persistent effort, over the years, to evolve, moderate and implement strategies for development of Mineral & Mines Sector, this publication is one small step in that direction. It is believed that this publication will find interest and acceptance among all those Policymakers, Regulatory Agencies & Consultants who are associated and connected to this discipline of study and are concerned with the development of the country's Mines & Mineral Sector.



C.S. Gundewar
Controller General
Indian Bureau of Mines

Nagpur
August, 2011

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Pvt. Ltd; Triveni Earthmovers Pvt. Ltd & Oasis Minerals - whose generous contribution vis-à-vis technical data, guidance and knowledge were of immense worth in shaping the contents of the publication.

Vast bodies of prevalent and existent information that have connection with the object of study in this publication were resourced and consulted during the course of the preparation of the publication. Plenitude of published and unpublished reports of Geological Survey of India (GSI), Central Geological Programming Board (CGPB) Committee-I and Central Pollution Control Board (CPCB) have had their share in formulation and manifestation of the technical details reflected in the publication. The Bureau is grateful to each one of these Source Agencies and would place on record its profound indebtedness and appreciation.

Contribution of in-house Divisions of Indian Bureau of Mines viz. Mines Control & Conservation of Minerals (MCCM) Division, Mining & Mineral Statistics Division, Mineral Economics Division, Mineral Map Cell, Ore Dressing Division and Publication Section besides efforts of several in-house experts have been instrumental in the evolvement of the publication from its nascent stage to what it is today. Every modicum of contribution received is worthy of praise and is thankfully acknowledged.

ABBREVIATIONS

ABC	A After Burner Chamber	LD	L Linz and Donawitz
ACCAR	Allis Chalamers Controlled Atmosphere Reactor		
BF	B Blast furnace	MML	M Mysore Minerals Ltd.
BHJ	Banded Hematite Jasperite	MoS	Ministry of Steel
		MOU	Memorandum of Understanding
BHQ	Banded Hematite Quartzite	MSP	Mini Steel Plants
BIF	Banded Iron Formation	mm	Milimeter
BMQ	Banded Magnetite Quartzite		
BOF	Basic oxygen furnace		
CGPB	C Central Geological Programming Board	NMDC	N National Mineral Development Corporation
daN/pellet	D Deca newton per pellet	OMC	O Orissa Mining Corporation
DHIMS	Dry high intensity magnetic separators	OMS	Output per man shift
DR	Direct reduction	O/F	Overflow
dR	Degree of reduction	O/S	oversize
DRC	DAVY Reduction Corporation	OSIL	Orissa Sponge Iron Limited
DRI	Direct reduced iron		
DSC	Dust Settling Chamber	RDI	R Reduction Degradation Index
DTA	Differential Thermal Analysis	RHF	Rotary Hearth Furnace
EAF	E Electric arc furnace	Rashtriya Ispat Nigam Limited	
EPMA	Electron Probe Micro Analyzer		
ESP	RNL Electrostatic Precipitator	SR	S Smelting Reduction
GCT	G Gas Conditioning Tower	SAIL	Steel Authority of India
GOI	Government of India	SIIL	Sponge Iron India Limited
GSI	Geological Survey of India	TPD	T Tonne per day
HBI	H Hot briquetted iron	TDR	TISCO Direct Reduction
HGMS	High Gradient Magnetic Separators	TISCO	Tata Iron & Steel Company
HMC	Heavy- Media Cyclone	TPH	Tonne Per Hour
HMS	Heavy- Media Separation	U/F	U Underflow
IBM	I Indian Bureau of Mines	UMSP	Ultra mega steel projects
IF	Induction furnace	UNFC	United Nations Framework Classification
ISO	International Organisation for Standardization	UHP	Ultra High Power
ISP	Integrated Steel Plants	WHIMS	W Wet high intensity magnetic separators (Electric)
kWh	K Kilowatt hour	WLIMS	Wet low intensity magnetic separators
KIOCL	Kudremukh Iron Ore Co. Ltd,	WMIMS	Wet medium intensity magnetic separators
		XRD	X X-ray Diffraction

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References

1. Indian Minerals Yearbook, 2009 (Advance Release), IBM Publication
2. Monograph on Iron Ore (Revised Edition-1997), IBM Publication
3. Iron Ore—A Market Survey, IBM Publication
4. Iron making and Steel making—Theory and Practice by Ahindra Ghosh & Amit Chatterjee
5. Base Document on Ferrous Minerals (CGPB Committee-I) Iron Ore—August, 2010
6. Unpublished Report of Investigation on Iron ore carried out at IBM's Ore Dressing Division
7. Detailed Information Dossier (DID) On Iron Ore In India-2010
8. Sponge Iron Industry by Central Pollution Control Board, MoEF, March, 2007
9. Proceedings of the Workshop on Agglomeration & its Futuristic Trend in India Held at 11.11.10 at Nagpur, Organised by Ore Dressing Division of IBM
10. Net Information from SIMA and Other Updated Information from Industry
11. Statistical Profiles of Minerals Year: 2005-06, 06-07, 07-08, 08-09 & Unpublished 2009-10
12. Proceedings of Seminar on Iron Ore—Value Addition through Technology & Financial Instruments; January, 2011 By Federation of Indian Mineral Industries (FIMI)

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