Solid Waste Utilisation – An Initiative at Bhilai Steel Plant, Sail, India.

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Abstract

Steel Authority of India Ltd, Bhilai Steel Plant at Sintering Plant-3 has been taking various steps towards continual improvement in waste utilization , pollution control & safe working conditions in the quest to become an environment friendly Steel Production Organization. Being one of the most modern Sintering Plants in the country, it has various environment and pollution control facilities, state of the art technology and modern technological equipments for efficient utilization of steel plant wastes. SP-3 has the zeal to take initiatives to address the issues related to productivity, environment, and safety. To improve the waste utilization through the safe transportation systems and to reduce consumption of raw material is a challenging task in Sinter Making.

Unavoidable byproducts at Refractory Material Plant process are Sintered Dolo fines, Calcined Lime fines and RMP chimney dust which are collectively called RMP arisings. These arisings are not useful in steel processing and are usually disposed off in open places or landfills. This poses environmental hazards when dumped in open places and also during transportation in open haulpacks. The high percentage of fines in RMP arisings lead to considerable air and land pollution. It was a serious area of concern for the management to explore the possibility of enhancing RMP arisings utilization to avoid the negative impact on environment.

The RMP arisings being CaO and MgO bearing material can be blended with limestone and dolomite in small percentage during flux preparation in the sintering process. The RMP arisings were usually dumped at the Ore Handling Plant from where it was transported by haulpacks to SP-3. Due to limitations of utilization of this material in sintering process there has been a considerable accumulation (1, 00,000 T) of RMP arisings in the OHP.

The paper deals with an overview of solid waste management and pollution prevention opportunities in the steel industry, with the primary focus on innovations in development of automated system for the bulk transportation of dumped RMP arisings from Ore Handling Plant to SP-3 and effect of enhanced utilization of RMP arisings in sintering process and productivity. The opportunities for 100% utilization of RMP Arisings in Sinter Making without dumping are equally applicable to the iron and steel industry in India as well as in a global context.

Keywords : Sinter Making, RMP Arisings, Raw Material Transportation, Automation.

1. INTRODUCTION

Bhilai Steel Plant (BSP) is a flag ship unit of Steel Authority of India Limited and an integrated steel plant with an annual production capacity of 4.0 million tonnes of steel and progressing towards 7 MT. Bhilai Steel Plant has been performing consistently despite many odds and has achieved profits for the 22nd consecutive year in 2009-10. The Plant continued to operate well above the rated capacity in all major areas of production and achieved a capacity utilization of 114.3 % in Hot Metal, 130.2 % in Crude Steel & 138.6 % in Saleable

Steel. Its Gross Margin to average capital employed at 182% is a Global Benchmark. In addition to this, it has made its mark in ensuring a high level of environment friendliness.

There is worldwide concern on how to combine the need to produce steel with the increasing requirement to protect the environment and achieve sustainable development. Significant progress in Iron & Steel making has been made towards environment management and sustainable development by reducing, recycling and recovering solid and liquid wastes and by decreasing gas emissions into the atmosphere. Zero waste and 3R (reduction, recycling and recovery) approaches have become common concepts which are included in the strategic policy of SAIL and several global steelmakers who view the environmental issue as a priority as much as more traditional aspects concerning productivity, production cost cutting, etc. In line with the environmental concerns expressed in National Steel Policy 2005, BSP has reduced emissions, effluent, specific water and energy consumption. Bhilai Steel Plant has been awarded all the four certifications of ISO 9001 for quality, ISO 14001 environmental certifications for plant, mines and township, OHSAS 18000 for safety and health and SA 8000 for social accountability.

Bhilai Steel Plant produces both basic and special steels for domestic construction, engineering, power, railway, automotive and defense industries and for sale in export markets. The current market share of BSP in India is given below-

Table 1. Current market share of BSP in India

Main Products	Mkt. Share
Rails	**100%**
Plates	19.8%
Bars & Rods	5.1%
Structurals	6.1%

BSP has made immense contribution to the national economy by continuously upgrading the quality of its products to meet the requirements. It is the single supplier to Indian Railways, the largest network of rails under one umbrella and supplied rails whose length is many times the periphery of the earth. It is a case of classic partnership and collaboration to contribute to the development of the nation. The nation moves on Bhilai Rails.

2. SOLID WASTE GENERATION AND ITS UTILIZATION

Large quantities of solid wastes are generated in an integrated steel plant through iron & steel making processes. Production of one tonne of crude steel, in an integrated steel plant, as per International Iron and Steel Institute (Belgium), may require 5 T water, 1.5 T iron ore, 0.61 T coking coal, and 0.59 T other materials and can contribute to 3 T wastewater, 0.455 T slag, 0.15 T other wastes (including dust/sludge, mill scale, refractoriness etc.). The percent-wise solid waste generation and their utilization in general at Bhilai Steel Plant is shown in the table -2.

Table 2. Percent-wise solid waste generation and their utilization at BSP

Description	% Generation	Utilization
BF (Iron making) Slag	70-74%	-BF Granulated slag is sold to Cement Manufacturers -Air cooled slag is sold to Slag Wool Manufacturers
SMS (Steel making) Slag (THF + LD)	14-15%	-Recycled to Sinter Plants & Blast Furnaces, -Road making, Rail Ballast -Dumped / Landfill,

Mill Scale	4 %	- Recycled
Fly Ash	1.3 %	-Utilized in cement making and brick making. Scheme for utilization is in progress
RMP Arisings &Others	11.5 %	- Recycled to Sinter Plants (small Quantity) - Dumped / Sold

3. RMP ARISINGS GENERATION IN BSP

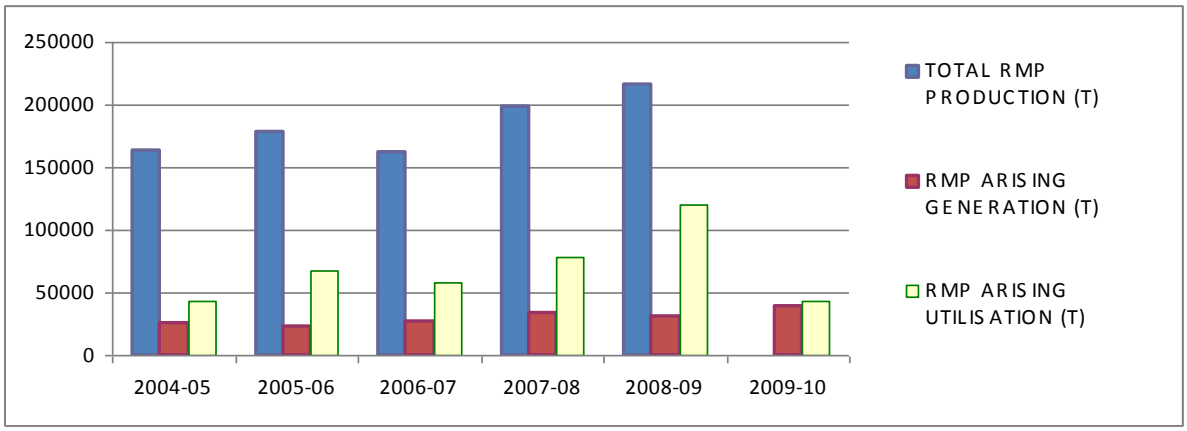
As an integrated steel plant, there is a huge requirement of refractory materials in the plant. The requirement of Sintered Dolomite, Mortar, Calcined Lime and Dolomite for refractory works of steel melting shops and other major shops are fulfilled by the two Refractory Materials Plants (RMP-1 & RMP-2).

An unavoidable byproduct of the RMP process is the Dolomite, Limestone Fines and RMP Chimney Dust which are collectively called RMP arisings. There is considerable generation of RMP arisings to the extent of 30000T per annum of limestone arisings and nearly 6000T of sintered dolo fines from both the plants.

The arisings generated in the Refractory Material Plants have a large percentage of fines. This poses environmental hazards land pollution when dumped in open places and also Air emissions are generated as both particulate and gaseous emissions during transportation in open haul packs and its processing. The priority is to find an environmentally suitable means of recycle/reuse of arising generated in the Refractory Material Plants, to minimize environmental and occupational hazards.

The year wise RMP production, RMP Arisings (solid waste) generation and their utilization in Sinter Plant is shown in the Table 3.

Table 3. Year wise RMP production, RMP Arisings generation and Utilization in Sinter Plant



The chemical analysis of the RMP arisings indicates that these can be effectively used as flux where limestone and dolomite fines are required for the process. Iron ore sintering is one process where such utilization is possible.

4. SINTERING PLANT – 3 IN BRIEF

Sintering Plant-3 with capacity of 3.2 MTPA has been commissioned in 2001 and produced 3.618 MT of sinter in 2009-10 with productivity of 1.476 T/Hr/m^2 & 73.7%.Yield. The state of the art technology viz. Energy efficient ignition furnace, integrated control system for quality product, Pollution control system and most modern fire detection and alarm

systems. Such infrastructure facilities make it easier to adopt sustainable methods of dealing with waste through reduction, reuse and recycling.

The sintering process provides a perfect avenue for utilization of solid wastes especially fines. The major wastes generated in the steel plant and utilized in Sintering Plant – 3 are Mill scale, Flue Dust, sinter return, sludge, LD Slag, quenching pond coke residues and RMP arisings. While the stress is on maximum utilization these wastes and their recycling in the iron making process, it is important to ensure the proper proportioning and blending of these materials to get the required Chemical and Physical properties of Sinter, as it directly affects Blast Furnace productivity. The table below shows the DPR Norms for utilization of solid wastes in Sintering Plant 3.

Table 3. DPR Norms for utilization of Solid Wastes

Solid Wastes	DPR Norms
RMP Arisings	10 Kg/T-sinter
Mill Scale	25 Kg/T- sinter
Flue Dust	17 Kg/T-sinter

UTILISATION OF RMP ARISINGS IN SINTER MAKING

The RMP arisings being CaO and MgO bearing materials can be used as flux in sintering process by adding this material in proper proportion with the limestone and dolomite during flux preparation.

Table 4. Chemical composition of RMP Arisings

ARISINGS	CaO	MgO	SiO2
Sintered Dolo fines (RMP-1)	56-58%	37-39%	1.5-1.9%
Limestone Arisings (RMP-2)	53-55%	-	1.4-1.7%

Earlier RMP arisings generated in the Refractory Material Plants of BSP were dumped at the Ore Handling Plant & transported by haul packs to location where they were required i.e. in Sinter Plant-I or Sinter Plant-II. But since this material was infrequently used and there were several problems associated with its consistency of chemical analysis and transportation by haul packs, there was a huge accumulation of RMP arisings to the extent of 1,00,000 T spread over a vast area in bed No.-7A of OHP. Provision for utilizing this RMP arising was incorporated at project stage in Sintering Plant-3 with DPR Norm 10 Kg/T-S. The huge gap between the generation and utilization led to further accumulation of these arisings.

5. ORIGINAL SYSTEM FOR UTILISATION OF RMP ARISINGS IN SP-3

The RMP Arisings are transported from RMP-1, RMP-2 and OHP to SP-3 by Haulpacks and stored in six underground bunkers of 80 T capacity each at RMP Arisings Building. This material is then transported through conveyors to the Flux Receiving and Proportioning Building where it is stored in a bunker of 800 T capacity. It is mixed in the required proportion with limestone and dolomite and is crushed to the required –3mm size; this processed flux is added to the sinter charge for sinter making. As per table 3, The DPR norms for utilization of RMP arisings in sinter making are 10 Kg/T-sinter implies yearly consumption of about 32000 T of RMP arisings.

The Technological process of receiving, storage, blending, processing and proportioning in sinter charge is fully automated through the Allen Bradley PLC system installed in the Raw Material Preparation area of SP-3 and controlled centrally from the control room by operators.

6. Constraints And Technological Problems In Enhancing Utilization of Rmp Arisings

6.1 Inconsistency of chemical analysis of dumped RMP Arisings

Since the arisings were dumped from years together and were not segregated uniformly, the chemical analysis of the reclaimed material varied in every sample. This lead to the doubt in the minds of Sinter Technologists that enhanced utilization of this material may adversely affect the Sinter chemistry.

6.2 Transportation Problems

The transportation of the RMP arisings to SP-3 is through open haulpacks posed several problems.

- Non-availability of Haul packs for transportation.
- Environmental issues like air and land pollution due to transportation of dusty arisings by open haulpacks.
- Spillage of material during transportation,
- During Monsoon season difficulties of transportation and frequent jamming of the bunkers as the dust forms slurry.

These problems made the system not only unreliable but also led to increase in pollution on the whole route from OHP to SP-3.

6.3 Reluctance in utilization of available arisings

The reclamation and transportation of this material is an additional job for the Ore Handling Plant Operation staff along with their routine Raw Material Supply responsibilities. The job became still more complicated during monsoon season. In Sinter Plant, the Raw material handling and processing personnel have an important role to play in maintaining the physical and chemical properties of the Flux. The Blast Furnace Slag Basicity and Viscosity are affected by the quality of flux in Sinter. So during utilization of RMP Arisings adherence to strict technological discipline is required to ensure the consistency of chemical analysis of processed flux. Due to unpredictable variations in the chemistry and size fraction of the arisings, there was a reluctance to use the same in Sinter making.

6.4 Environmental and Occupational Hazards posed by RMP arisings

Dust emissions are among the most significant impacts of RMP arisings. Due to the high percentage of fines open storage as well as transportation through haulpacks of RMP arisings lead to considerable air and land pollution which directly affect the people in and around the area. Exposure to dust causes lung related diseases called pneumoconiosis. The limit values for lime dust as per factories act is 2.0 mg/cum. Exposure to calcium hydroxide dust for 8 hour TWA (Time Weighted Average) is 5 mg/cum. For comparison, the TWA for nuisance dusts or particulates not otherwise classified is 10 mg/cum. During open storage and transportation, this limit is often exceeded. Lime dust can lead to thermal and chemical skin burns in presence of moisture. Lime dust is an irritant to the eyes and mucous membranes. Calcium oxide dust or mists from concentrated solutions are very irritating to the nose, throat and upper airways. Extended exposure of lime dust to skin can lead to burns due to presence of moisture leading to eczema.

Due to above reasons it is important that the arisings generated in the RMPs are properly handled and disposed off. Any possibility of its enhanced utilization has to be explored so

that this does not lead to an environmental and occupational hazard.

7. Experimentation And Trials For Enhanced Utilization Of Rmp Arisings

The technologists of Sinter plant -3 conducted various experiments and trials with increased usage of RMP Arisings in flux. The RMP Arisings were added to the flux material in different proportions and processed. Effect on Flux Crushing Index and final chemical composition was studied. Also data generation of its effect on Sintering Process with respect to Optimization of Process, Vertical Sintering Speed and Sinter chemistry was done. The results and analysis were not only promising but also pointed to further enhanced use of this material in Sinter making. It has been established that the use of RMP arisings leads to a direct reduction of Raw Limestone consumption. Analysis of a sample monthly data in Fig-1 clearly shows that while percentage flux in sinter charge is more or less constant at 18-20%, the percentage increase in RMP arising has led to proportionate percentage drop in Lime Stone + Dolomite addition.

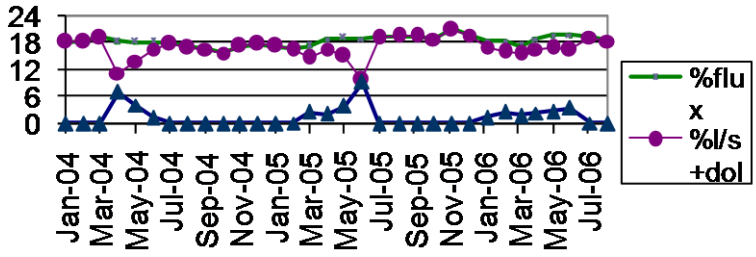


Fig-1 Percentage of Limestone + Dolomite, RMP arising and Total Flux in Sinter charge

It is also found that the addition of RMP arising in flux has virtually no adverse impact on the Flux related Sinter chemistry parameters like Basicity, CaO & CaO-SiO_2.

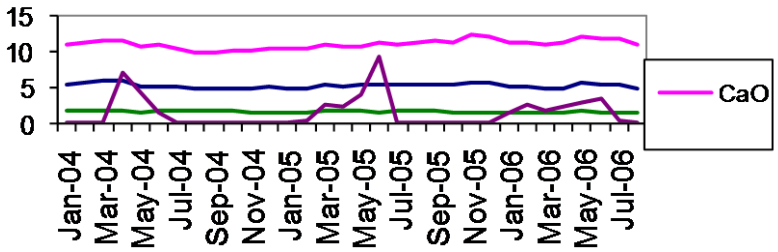


Fig 3 Effect of RMP arising addition on sinter chemistry

Apart from RMP Arisings, experiments were also conducted in Sintering Plant-3 towards increasing the utilization of other solid wastes. These experiments have yielded very positive results and based on this many Process Modifications have been done to enhance the utilization of wastes. From the Table 5 it can be seen that Sintering Plant – 3 has increased the use of solid wastes much above the prescribed norms.

Table 5. Increased consumption of solid wastes in SP-3

Solid Wastes	DPR Norms	Consumption experimented	Actual consumed Till date in SP-3
RMP Arisings	10 Kg/T-sinter	116 Kg/T-sinter	419473 Tonnes
Mill Scale	25 Kg/T- sinter	54 Kg/T-sinter	345829 Tonnes

Flue Dust	17 Kg/T-sinter	34 Kg/T-sinter	275623 Tonnes
LD Slag	-	15 Kg/T- sinter	91055 Tonnes

But in the process of increasing the consumption of RMP arisings in SP-3, it was found that there was inconsistency of the chemistry of the material since the RMP arisings generated in both the plants are mixed during dumping at OHP and the RMP arisings in flux reduced the efficiency of the bag filter system due to high percentage of microfines. In subsequent experiments done at SP-3 it was found that RMP arisings can be effectively added upto 15% of total flux charged in the sinter without any detrimental effect on the sinter chemistry and also on the efficiency of bag filters installed for pollution control.

8. Analysis of Transportation Problems

Once the technologists were confident of higher utilization of RMP Arisings, the avenues for better transportation of this material from OHP to SP-3 by reliable and less polluting means was explored in view of scarcity of haulpacks.

For transportation of Ore Fines, Limestone and Dolomite from OHP to SP-3 a conveyor system with two parallel routes is installed inside enclosed galleries. The probability of transporting RMP arisings directly through this route to the Proportioning Bunkers is thought off. An analysis was done for the route availability and available unutilized time was calculated. It was evident that this route can facilitate the transportation of dumped RMP Arisings to SP-3 resolving many of the problems associated with the transportation through haulpacks. The automated transportation software of the Allen Bradley PLC did not have variant / designed route for direct transportation of RMP Arisings from OHP to RMP Arising bunkers or to FRPB (Flux receipt and Proportioning building) of SP-3, this necessitated the automation engineers to design new software for inclusion of new variant / route for material transportation.

9. Automation for Rmp Arisings Transportation & Utilisation

In view of the advantages perceived in the new scheme, the software was designed to transport the RMP arisings from the OHP through the same conveyors that transport Limestone and Dolomite. The PLC software was modified to include new variant in addition to the existing variants for transportation of the RMP arisings from OHP through conveyors directly to the bunker at FRPB (Flux Receipt and Proportioning Building). User friendly HMI Screens were developed to enable the operators to select the new route. In the HMI screen for Group-2A, the following changes have been made –

1. Belt animation for L-101, L-102, L-103A, L-103B, L-104, L-104Tr., BF-26 to 31
2. Arrow animation for L-101, L-102, L-103A, L-103B, L-104, L-104Tr., BF-26 to 31
3. Route selection object key (new selections F9 & F10)
4. Control panel for variants – 5 & 6.
5. Belt feeder selection/ de-selection keys.

The new system was successfully tested and implemented after several trials.

10. Overcoming Reluctance In Utilization Of Arisings

The new automated conveyor transportation greatly reduced the difficulties faced by the OHP operators. It facilitated positive mindset of the workforce due to reduced efforts in transportation and handling and better environmental conditions at workplace.

The user friendly HMI Screens and ease in blending and proportioning as per the chemical

analysis of the blended flux material boosted morale of the production staff for increased utilization of RMP Arisings.

11. RMP Arisings Utilisation With Reduction In Environmental And Occupational Hazards

The fact that RMP wastes can be added upto 15% of the total flux implies that there is scope for consistent use of upto 35 Kg/T-Sinter of RMP arisings i.e. approx 1, 00,000T per year. The new system has the potential to increase the transportation of RMP arisings from 300 T/day with haulpacks to 450 T/day through the conveyors. Transportation of RMP Arisings with haulpacks was not possible on rainy days but due to enclosed gallery conveyor transportation utilization of this material in Monsoon season was also possible.

After the introduction of the new system-

- There was substantial reduction in the environmental pollution during transportation due to conveyorisation.
- The occupational hazards due to lime dust have been mitigated.
- 100% Consumption of RMP arisings has stopped dumping inside the plant leading to better land utilization.

Air pollution remains the most significant environmental issue for Sinter making, but the solid waste management is closely linked to reduction or prevention of atmospheric emissions and related occupational hazards.

12. Benefits

The experimentation for enhanced utilization of RMP arisings and complete utilization of RMP arisings dumped at OHP lead to the confidence building of the sinter technologists.

1. Use of haulpacks for transportation of RMP arisings from OHP to SP-3 was completely stopped.
2. Facilitated for complete gainful utilization of RMP arisings in Sinter Making.
3. By the end of third quarter of 2008-09 Bed No 7- A of OHP which was earlier utilized as land fill for RMP arisings is completely emptied. It is now utilized for unloading of critical raw material like Mandla Low Silica Limestone.
4. Due to confidence gained of enhanced utilization, the daily generation of this material is 100% transported, stored and utilized by SP-3.

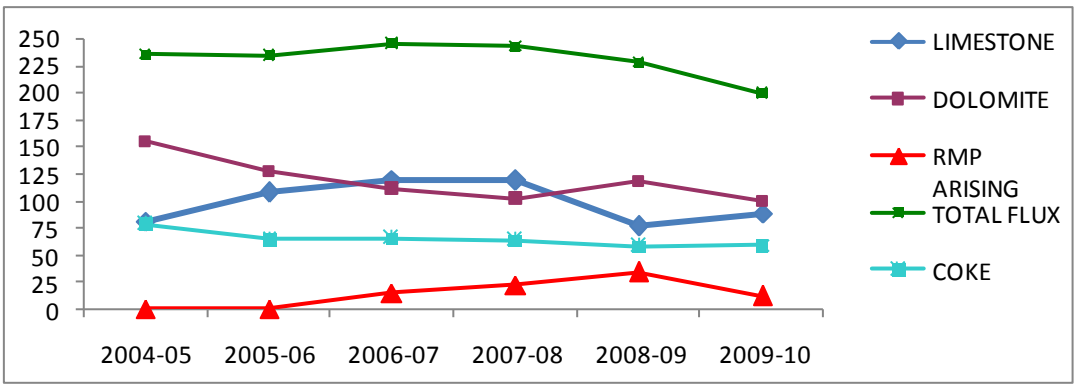


Fig 4 Annual specific consumption of Flux components in SP-3

The Oldest Sinter Plant SP-1 utilized this material with great reduction in consumption of Raw Limestone, reduction in consumption of Flux, reduced Coke Breeze consumption and

improvement in technological parameters of Sinter. Fig-4 shows that SP-1 was using only limestone till 2006-07. Utilization of RMP arisings drastically effected the consumption of limestone which was reduced to nearly half .

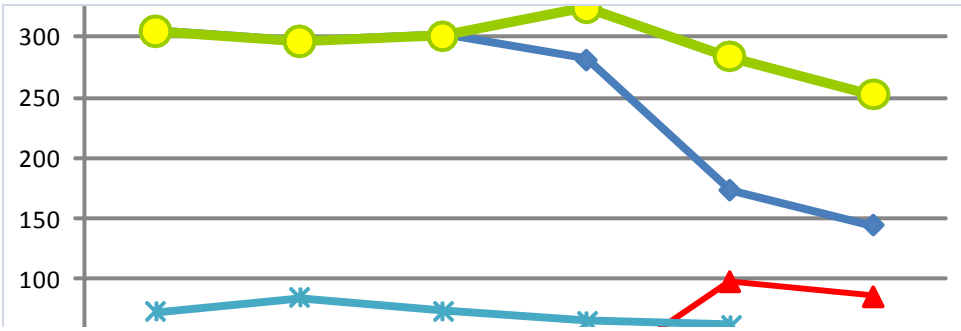


Fig 4 Annual specific consumption of Flux components in SP-1

The use of RMP arisings have provided many viable benefits to Sintering process at Sintering Plant 3 –

- Direct reduction in the consumption of limestone to the extent of RMP arisings used, without appreciable change in sinter chemistry.
- Coke consumption for dissociation of flux in green charge is slightly reduced as RMP arisings is already processed material.

13. Conclusion

After the conveyorisation of the route the bulk transportation of RMP arisings to SP-3 has greatly improved ensuring complete utilization of all the RMP arisings generated in the BSP. The Sintering Plant-3 has utilized 3,28,500T of RMP arisings till date resulting in considerable reduction of limestone consumption. It has also provided a solution for consumption of the wastes generated in the steel plant thus reducing the hazardous impact on environment. Full utilization of the available resources has also ensured that the pollution caused inside and around the plant due to lime and dolomite dust is greatly reduced leading to a cleaner environment. BSP won the Golden Peacock Eco-Innovation Award 2009 & Greentech Environment Excellence Gold Award 2009.

With the proposed expansion of the Bhilai Steel Plant to 7 MT, the requirement of limestone and dolomite for flux for Sinter making will nearly double and will ensure 100% utilization of the RMP arisings in the Sinter Plants. The sinter plant which is considered as 'the digester of an integrated steel plant' plays an important role of recycling residues for which no adequate alternatives exist. The opportunities for 100% utilization of RMP Arisings in Sinter Making without dumping are equally applicable to the iron and steel industry in India as well as in a global context.

Bhilai Steel Plant is one of the leading iron & steel companies in the country and together with achieving the high benchmarks in production and quality; it has also taken important steps towards controlling and mitigating the adverse impact of the steel making process on the environment. Solid waste management and the 3-Rs form the foundation for process improvement in BSP. The present work has been carried out in this context to eliminate one type of waste in its progress towards zero waste.

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