ROLLING IN PROFITS

A reference manual on energy-efficient technologies and practices for profitable steel rolling

Australian Aid
Ministry of Steel
Govenment of India
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Empowered lives.
Resilient nations.

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Disclaimer

This reference manual has been prepared after an extensive review of all relevant documents and in consultation with a number of stakeholders. The views expressed in this manual, however, do not necessarily reflect those of the United Nations Development Programme, Australian aid program and Ministry of Steel, Government of India.

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PREFACE

Steel re-rolling mills (SRRMs) contribute to the production of over 60% of long steel products and about 30% of overall steel in India. A re-heating furnace using coal/pulverized coal/furnace oil and rolling mill using electricity form the two main sections in a re-rolling mill. A significant portion of the SRRM sector in the country uses pulverized coal as fuel in their re-heating furnaces. These mills are small and medium enterprises (SMEs) and are usually found in clusters across the country. The stiff competitive market, coupled with low profitability margins, makes it very important that the manufacturing facilities are run efficiently. During the last decades, the sector has faced tremendous challenges in terms of high costs of raw materials, low market demand, growing labour costs, and rising prices for fuel and power. In a typical unit, around 30%–40% of the conversion cost (cost of converting ingots/billets into finished products) is for energy (fuel and power). As these units are categorized by low conversion margins, energy plays a significant role in deciding the profitability and sustainability of the sector.

The entrepreneurs in India's SRRM sector generally have low awareness levels on energy-efficient measures and practices that can decide the long-term sustainability of the sector. For instance, pulverized coal has been the most widespread and emerging fuel for the sector during the past couple of years. However, a substantial number of units are still running on obsolete technologies, combined with inefficient operating practices. All this leads to incredibly high energy consumption and higher costs. Thus, there is great potential for transforming the overall energy consumption patterns in the sector. Some of the important areas that require immediate interventions are as listed below.

- Fuel preparation
  - Coal quality
  - Maintaining optimum coal fineness
  - Pulverizer

- Re-heating furnace
  - Waste heat recovery through recuperator
  - Combustion air flow regulation through variable frequency drive
  - Use of swirl burners for better combustion
- Rolling mill
  - Use of anti-friction roller bearings
  - Universal spindles or cardan shaft for rolling mills
  - Implementation of guides, rest-bars, and roll cooling

This manual addresses the concerns in the above areas. The manual can also be used as a ready-reference publication that provides the following important details.

- Description of technology measures and packages that can result into energy saving and reduction in cost of energy consumed
- Information on estimated investments, key benefits envisaged, and payback for a set of technology packages/measures
- List of technology providers

The technologies described in this manual are not only energy efficient but also cost competitive. Introduction of these technologies can lead to such benefits as improved productivity, fewer breakdowns, efficient production, reduced pollution levels, and better lives for workers.

A large number of industrial units in the country are facing threats to their survival. Under this scenario, continuous technological upgradation will play a vital role in assuring a units' overall economic growth. Energy efficiency is the most viable solution for the long-term sustainability of the sector as a whole.

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(Most of the photographs are from T K Steel Mills Pvt. Ltd)

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ABBREVIATIONS

AusAid	Australian aid program
CV	calorific value
EE	energy efficient
FD	forced draft
FRP	fibre reinforced plastic
GCV	gross calorific value
GoI	Government of India
MoS	Ministry of Steel
PMU	Project Management Unit
SFC	specific fuel consumption
SPC	specific power consumption
SPM	suspended particulate matter
SRRM	steel re-rolling mill
TMT	thermo mechanically treated
UNDP	United Nations Development Programme
VFD	variable frequency drive

%	percentage
µm	micrometre
^{0}C	degree Celsius
d/y	day per year
h/d	hour per day
kcal/kg	kilocalorie per kilogram
kcal/t	kilocalorie per tonne
kg/t	kilogram per tonne
kWh/t	kilowatt-hour per tonne
kWh/y	kilowatt-hour per year
mm	millimetre
Rs	Rupee
Rs/kg	Rupee per kilogram
Rs/kWh	Rupee per kilowatt-hour
Rs/t	Rupee per tonne
tph	tonne per hour
t/y	tonne per year

FUEL PREPARATION

Coal quality
Maintaining optimum coal fineness
Pulverizer

Fuel preparation

FUEL PREPARATION

Coal quality

Description

Pulverized coal is the fuel used predominantly in re-heating furnaces in the steel re-rolling mill (SRRM) sector. For the purpose of pulverizing, lump coal is procured either indigenously or imported and then crushed on site with a hammer mill (also known as a pulverizer) to required fineness. The coal typically used in the SRRM sector is characterized by high ash and low sulphur content. The ash content also varies significantly based on the source (coal mines) from which coal is extracted. The ash content in coal being used currently in the sector ranges from 5% to 25% and gross calorific value (GCV) varies from 4800 to 7200 kcal/kg.

High ash content (>10%) in coal has a detrimental effect on combustion and other operating parameters, especially in the case of pulverized coal-based re-heating furnaces. Some of the disadvantages of using high ash content coal are listed below.

1. Ash deposits on the refractory bricks that react with the iron content of the bricks lead to premature cracks and failure of the refractory lining.
2. Ash deposits on the surface of input material (ingot/billet/scrap) require more heat to be added to the charge (ingot/billet/scrap) for attaining desired temperature. This excess heating increases burning loss in re-heating furnaces.

3. The emission and disposal of fly ash that comes from using high ash coal poses an ecological and environmental problem, especially the increase in suspended particulate matter (SPM).
4. High ash content leads to choking of recuperator tubes, which necessitates frequent cleaning, and thus increases maintenance cost and reduces performance of heat exchangers.

Most of the SRRM units use Indonesian or US or Indian coal based on availability or price. For better fuel preparation and operation, it is suggested that low ash coal (<10%) be used, if available, even if the price is slightly higher than that of high ash coal.

In case low ash coal is not available, better pulverization of coal with lower moisture content (<14%) should be ensured.

However, it may be noted that the calorific value (CV) of coal is indirectly proportional to the specific fuel consumption (SFC) in the re-heating furnace. The higher the CV, the lower the specific coal consumption will be in the furnace. Table 1 provides the key properties of coal with a range of SFCs that can be achieved through the various grades of coal.

Table 1 Key properties of different grades of coal

S. no.	Parameter	Unit	Indonesian coal	US coal	Indian (Steel Grade) coal
1	Fixed carbon	%	35–40	40–42	48–50
2	Moisture	%	10–30	10–15	6–7
3	Ash	%	10–15	10–15	5–10
4	Volatile matter	%	25–35	35–38	40–42
5	Gross calorific value	kcal/kg	5,500	6,500	7,200
6	Coal cost	Rs/kg	10	11	12
7	Thermal energy required for production of 1 tonne of steel	kcal/t	400,000	400,000	400,000
8	Quantity of coal required for production of 1 tonne of steel	kg/t	72.73	61.54	55.56
9	Cost incurred for production of 1 tonne of steel	Rs/t	727	677	667

Note: Steel grade coal is the most suitable for pulverized coal operations due to its inherent properties of low ash, low moisture content, and relatively high CV.

General and suggested practice

General practice

Practice	Current practice	Impact
Use of high ash coal as fuel in re-heating furnaces	High ash coal, with a gross calorific value of 4800–6000 kcal/kg, is being used as fuel in re-heating furnaces.	Use of high ash coal will lead to • inefficient combustion, • ash deposits on refractory lining causing premature failure, • ash deposits on surface of ingot/billet/ scrap resulting in increased burning loss, • environmental issues due to high suspended particulate matter and disposal of fly ash, and • reduced performance of recuperator.

Suggested practice

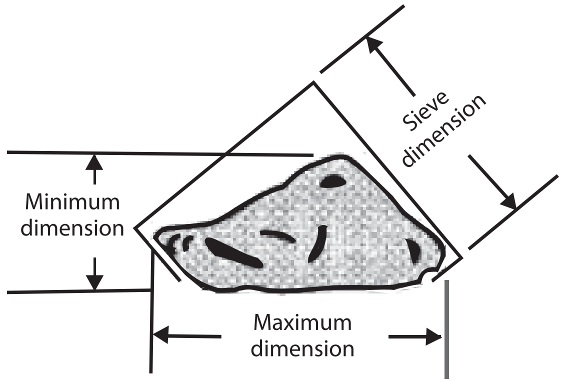
Recommended measure	Proposed practice	Impact
Use of low ash coal (high grade coal) as fuel in re-heating furnaces	Use of low ash coal with ash content less than 10% is recommended. This high-grade coal is also characterized by high gross calorific value of >6000 kcal/kg.	Use of low ash coal will lead to • efficient combustion in re-heating furnaces, • avoiding other problems (as listed above) associated with the use of high ash coal, • reducing the lifecycle cost of re-heating furnaces and other associated equipment.

Maintaining optimum coal fineness

Description

Use of pulverized coal as fuel in re-heating furnaces works on the basic principle of breaking lump coal into smaller particles, thereby increasing the surface area available for combustion. The breaking of lump coal into smaller particles is done in coal pulverizers of different types (hammer type, ball type, etc.). Performance of coal pulverizer is determined by the size and uniformity of the coal output. Finer coal with good uniformity indicates better pulverizer performance. Finer coal means there is more surface area available for combustion and hence, more heat output. It is, therefore, essential to measure and maintain the fineness of the coal coming out of the pulverizer.

Considering the operating practices in the SRRM sector, pulverizing coal to (–)200 mesh or 75 microns fineness is recommended. In order to check the fineness of the coal, it is recommended that an analytical test sieve be used at regular intervals.



Representation for dimension of coal particle

Analytical test sieve

Generally, analytical test sieves or standard screens are used to measure the size of particles in the range between (76 mm to 38 µm). These testing sieves are made of woven wire screens; the mesh and dimensions are carefully standardized.

Analytical test sieve

Mesh count refers to the number of openings per linear inch of screen. A mesh count of (–)200 means there are 200 openings per linear inch. And since the mesh is square, the count is the same in both directions and the total number of openings per square inch is 200 x 200 = 40,000.

In order to ensure optimum combustion in a re-heating furnace using pulverized coal system, at least 65%–80% of the coal particles should be in the fineness range of (–)200 mesh or 75 microns. To understand better, let us consider a typical example of a 1 kg sample of pulverized coal that contains the following size of coal particles:

- (–)200 + mesh - 20%
- (–)150 + mesh - 50%
- (–)100 + mesh - 20%
- (–)50 + mesh - 10%

This coal sample is deemed to be highly non-uniform. The (–)200 mesh (20%) fine particles will participate in complete combustion providing maximum heat and balance, (80%) coarser particles will undergo partial combustion resulting in their deposition on the furnace walls or escape from furnace with flue gas in the form of unburnt carbon or ash. Hence, it is very important to measure the fineness of the coal coming out of the pulverizer at regular intervals. Such measurement will also lead to initiation of preventive actions (in the case of high non-uniformity in pulverizer output) like changing the pulverizer hammer, liner plates, etc.

Pulverizer

Description

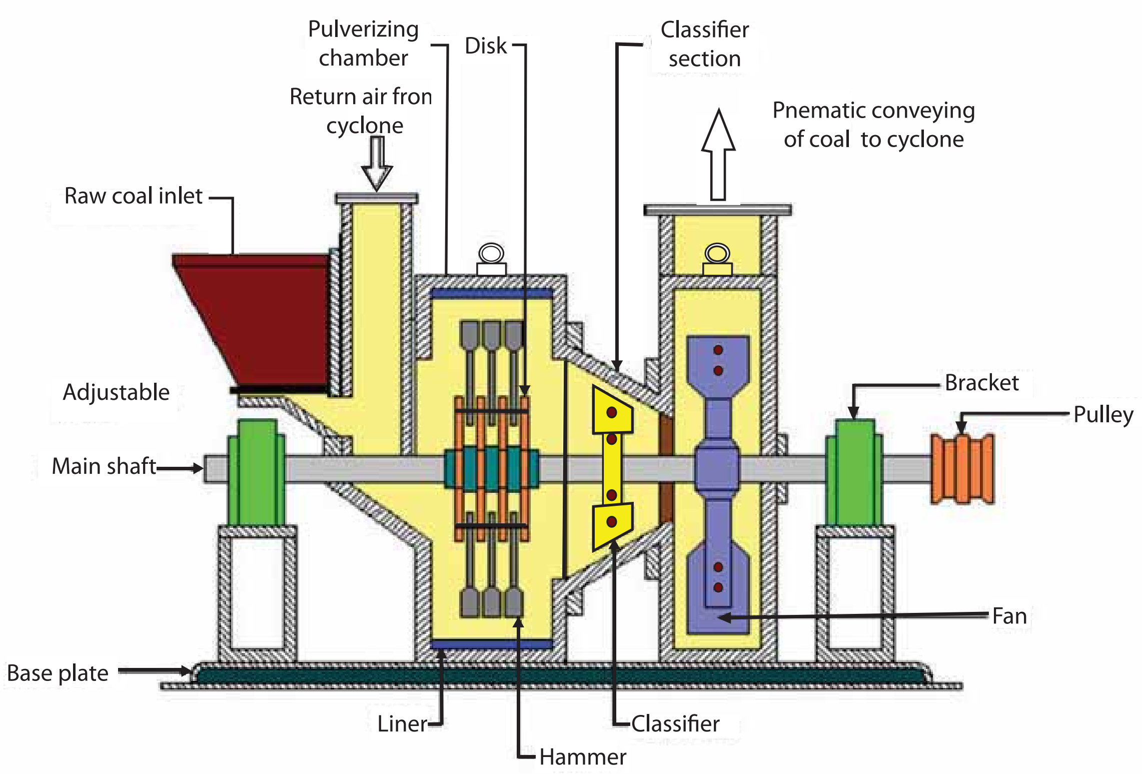
It is an established fact that fine pulverized coal releases maximum heat energy with lesser air requirement, which means the fineness of coal particles is the most critical parameter for reducing the scale loss and fuel consumption. In the SRRM sector, coal is being pulverized in hammer mills manufactured by local fabricators. The critical components of a pulverizer are a hammer, a mild steel liner, a classifier, and an inbuilt blower. The liner is a thick plate fixed inside the casing of pulverizer by screws. It is generally 12–16 mm thick mild steel with a number of 8–10 mm square mild steel bars welded on it. Due to a very high abrasion factor, these liners need to be repaired at least once every three months. Hammers are made of mild steel with the head welded with thick mild steel flats. Again, due to a very high abrasion factor, these hammers need to be replaced twice a week. Classifiers are an important component that resists the maximum abrasion action and, due to high wear and tear, this component needs repair even more often than the liner. The figure page 10 illustrates the various components of a pulverizer.

In order to achieve pulverized coal to the desired fineness in a consistent manner, the following modifications to existing pulverizers are suggested.

Hammer: Improve metallurgy with the addition of manganese (13%), carbon (1.13%), silicon (0.4%), sulphur (0.003%), and phosphorus (less than 0.2%) to increase its resistance to wear and tear.

Liner: Use grooved EN-31 hardened steel plates or casted high manganese.

Classifier: Ensure proper dimensions and thickness (gap between the classifier tip and casing to be less than 1 mm) to classify the pulverized coal to achieve 65%–80% of desired (–)200 mesh size. The classifier should be high chrome, high nickel alloy.



Section-view of pulverizer

General and suggested practice

General practice

Practice	Current practice	Impact
No measurement of fineness of pulverized coal coming out of pulverizer	It has been observed that the percentage of (–)200 mesh ranges between 10% and 30% in conventional units, depending on the level of maintenance of the pulverzer.	• Improper combustion • More ash deposition • Increase in specific fuel consumption • Increase in scale loss
Improper design and metallurgy of pulverizer	Various critical components of pulverizer such as hammer, liner, and classifier in most units are of poor metallurgy. Also, inadequate attention is given towards proper maintenance of those components.	• If pulverizing to the desired fineness and consistency cannot be achieved, the result will be improper combustion, ash deposition, high fuel consumption, and high scale loss.

Suggested practice

Recommended measure	Proposed practice	Impact
Measurement of pulverized coal size by (–)200 mesh or 75 microns analytical sieve at regular intervals	Coal output from a pulverizer is measured for its fineness and uniformity by passing it through analytical sieves. Material coming out of (–)200 mesh is weighed and the percentage calculated. Ideally, the percentage of pulverized coal passing through (–)200 mesh should be 65%–80%.	• Increase in pulverizer efficiency • Ascertaining the metallurgy and life of critical components of pulverizer
Use of energy-efficient pulverizer	To achieve pulverized coal in desired fineness in a consistent manner, the following modifications to existing pulverizers are suggested: *Hammer:* Improve metallurgy with the addition of manganese, carbon, and silicon to increase its resistance to wear and tear. *Liner:* Use grooved EN-31 hardened steel plate or casted high manganese. *Classifier:* Ensure proper dimensions and thickness to classify the pulverized coal to achieve 65%–80% of desired (–)200 mesh size.	• Increase in combustion efficiency with a significant decrease in percentage of unburnt coal • Reduction in specific fuel consumption and burning loss • Increase in furnace life

Energy savings calculation and payback

Table 2 summarizes the benefits envisaged in terms of reduction in specific fuel consumption (SFC), estimated investment and payback on investment, by using energy-efficient pulverizer, considering a typical 10 tonnes per hour (tph) furnace:

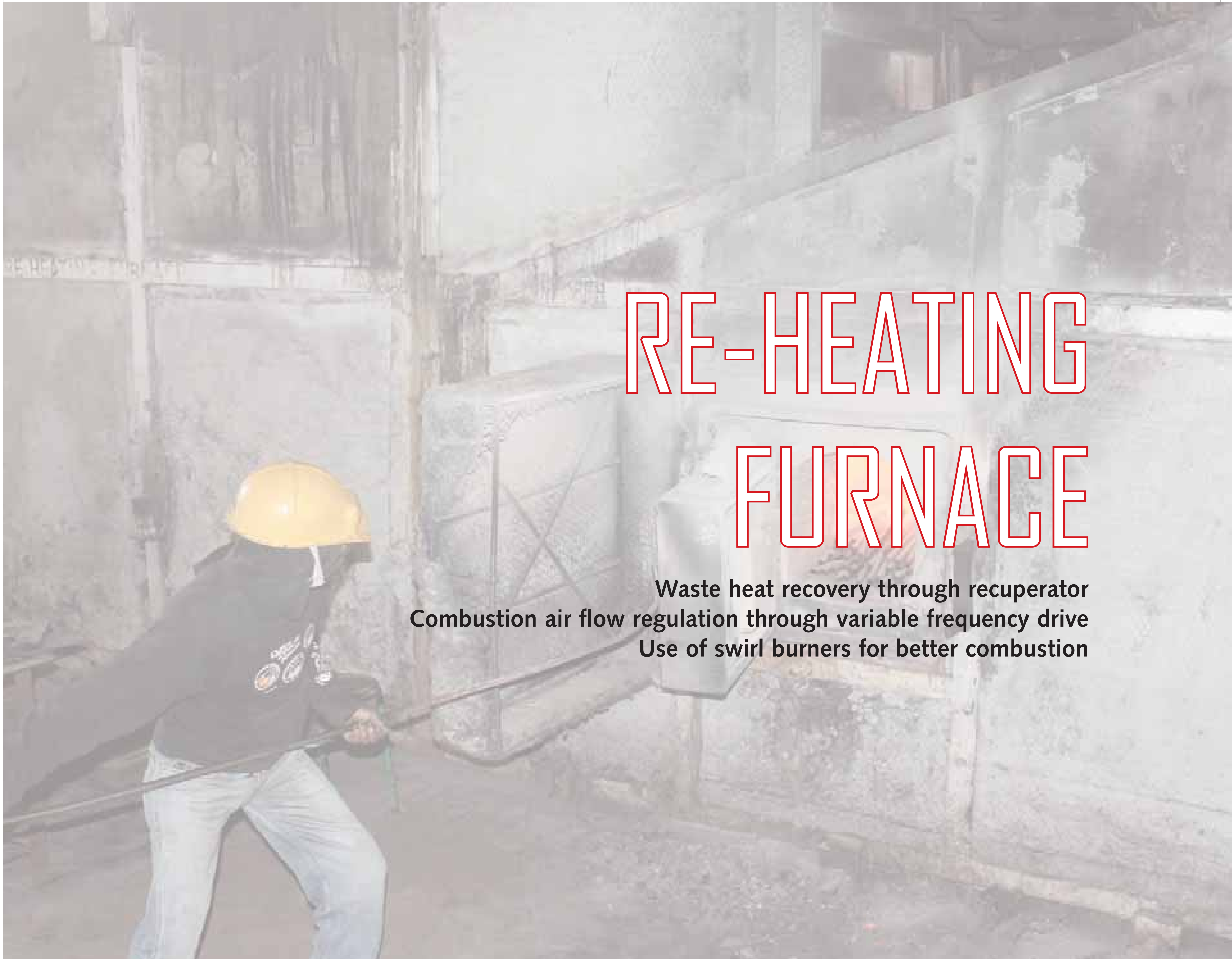
Table 2 Energy savings and payback by using energy-efficient pulverizer

Parameter	Unit	Value
Baseline		
Productivity	tph	10
No. of operating hours	h/d	12
No. of working days	d/y	300
Specific fuel consumption	kg/t	75
Annual production	t/y	36,000
Annual fuel consumption	t/y	2,700
Cost of fuel	Rs/t	12,000
Annual fuel cost	Rs (in lakh)	324
Post implementation		
Fuel saving	%	5
Fuel savings achieved	t/y	2,700 × 0.05 = 135
Annual cost savings achieved	Rs (lakh)	16.2
Estimated investment (including recurring cost of critical components for a period of 6 months)	Rs (lakh)	7
Simple payback period	month	less than 5 months

Note: Alternatively, depending on its condition, the existing pulverizer can be modified with Mn-alloy hammer, EN-31 hardened steel plate liner and classifier designed to suit (–)200 mesh pulverization at an investment of Rs 50,000–70,000 with a payback period of less than one month. However, to ensure proper performance of the pulverizer, it should be mechanically balanced. Mechanical balancing can be done by reputed manufacturers equipped with requisite facilities.

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	Panesar Machine Tools	G T Road, Khanna Side, Opp. Power House, Mandi Gobindgarh – 147 301, Punjab	01765-241304	098150 88982	panesarmachinetools@hotmail.com
2	Prithvi Steel Rolling Machine	B-230, Road No. 9 Vishwakarma Industrial Area, Jaipur – 302 013, Rajasthan	0141-2330478	093144 66666	info@prithvisteel.com
3	R K Industrial Enterprises	Plot No. 82, Parvatiya Colony, Sohna Road, Near Peer Baba, NIT Faridabad – 121 005, Haryana	—	093505 43850	rkindenterprises@yahoo.co.in
4	BS Mechanical Works	Near Punjab Forging Mills, Khanna Side, Mandi Gobindgarh – 147 301, Punjab	—	098150 93290	rajinder_bsmw@yahoo.com
5	Khalsa Engineering Works	Plot No 4, Sector 21-A, Near Bank of India, G T Road, P O Box 73, Mandi Gobindgarh – 147 301, Punjab	—	098152 46408	surindraengg@rediffmail.com
6	Bharat Heavy Machines	Plot No. G-20, Bajrang Bali Industrial Estate, Panki Site-4, Kanpur – 208 020, Uttar Pradesh	0512-2692577	099354 24256	bhmgroup@gmail.com
7	FAB-TECH Engineers	9, Pushkar Estate, Opp. National Rifle Factory, Phase-1, GIDC Vatva, Ahmedabad – 382 445, Gujarat	—	092275 59241	fteng.ahd@gmail.com
8	Refined Structures & Heat Control Unit	A-227, Nehru Nagar, Jaipur – 302 016, Rajasthan	—	098290 60615	refinefurnace@gmail.com



RE-HEATING FURNACE

Waste heat recovery through recuperator
Combustion air flow regulation through variable frequency drive
Use of swirl burners for better combustion

Re-heating Furnace

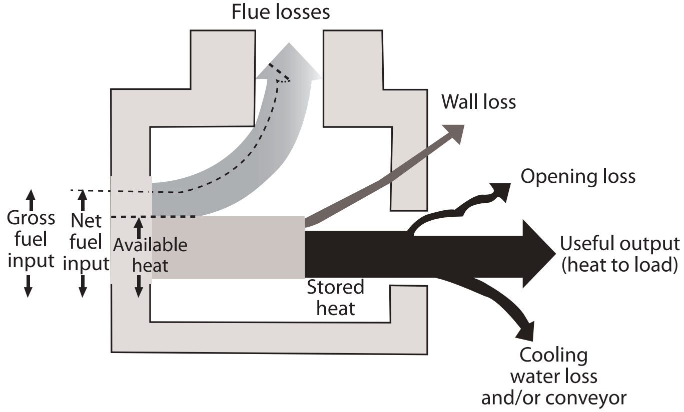
RE-HEATING FURNACE

Waste heat recovery through recuperator

Description

The steel re-rolling process involves heating of raw material such as ingot or billets or scrap to the re-crystallization temperature of steel. For the purpose of heating, a re-heating furnace is used. Most of the steel re-rolling mill (SRRM) units use top-fired pusher-type re-heating furnaces with solid, liquid or gaseous fuel. The heating process in a furnace involves certain energy losses in different areas and forms as shown in the sankey diagram below.

In most of the re-heating furnaces, a large amount of the heat supplied is wasted in the form of exhaust flue gases. These flue gases are at a temperature of 400–700 °C, which can be recovered to a certain extent and can be used for pre-heating the combustion air. As a thumb-rule, every 20 °C rise in the combustion pre-heat temperature leads to a fuel saving of 1%. The heat from the flue gas is recovered through the recuperator, generally a heat exchanger that uses the energy in hot waste flue gases to pre-heat combustion air.



Sankey diagram representing the various losses in a re-heating furnace

In India, most of the SRRM units using pulverized coal firing systems operate without a recuperator. Some of the key reasons why SRRM units face problems in installing recuperators are as listed below.

- Existing recuperator designs are specific to oil-fired or gas-fired furnaces.
- The tubes of underground installation, which are not otherwise accessible for routine maintenance and cleaning, generally get choked with deposits of ash present in the flue gas.

However, the increasing use of pulverized coal in the SRRM sector led to the modification and design of appropriate recuperators to overcome the above problems. Recuperators that can be used in pulverized coal-firing systems are shell-in-shell type recuperators or shell-and-tube type recuperators with regular cleaning arrangement for ash deposits.

Recuperator efficiency depends on the quantity of heat recovered from the flue gas. An efficient recuperator will be able to recover about 50% of the heat from the flue gas. To ensure maximum combustion pre-heat temperature in the burner tip, all combustion air pipelines should be insulated appropriately. Two important parameters on which a recuperator efficiency depends include surface area available at heat exchange and recuperator material. Waste heat recovery up to 250 °C can be realised if pulverized coal is to be pneumatically conveyed along with combustion air. However, in the case of separate firing of coal and air through a modified pulverized coal system, waste heat recovery of around 400 °C is suggested.

In the case of modified pulverized coal-firing system, independent hoppers with bag filters and silo are placed above the burner in the soaking/heating zone front wall. The hoppers are equipped with screw feeder controlled with DC motor, which enables controlled feeding of coal into the burner. The burner is equipped with separate entry points for coal, primary air, and secondary air. Coal is pneumatically transferred from the pulverizer unit to the overhead storage hopper (through cold air) and the cold air is transferred back to the pulverizer or emitted in the atmosphere. With this provision, 100% hot air from the recuperator can be fed directly into the burner. As the mixing of coal and air takes place in the burner tip, this facility can ensure a higher combustion pre-heat temperature.

General and suggested practice

General practice

Practice	Current practice	Impact
No recuperator	Flue gases from the re-heating furnace are let out into the atmosphere through the chimney.	• Significant heat of flue gas is wasted. • High fuel consumption.

Suggested practice

Recommended measure	Proposed practice	Impact
Installation of high-efficiency recuperator	Recuperator heat flows steadily through the wall from the heat source (hot flue gas) to the heat receiver (cold combustion air).	• Waste heat recovery up to 250 °C (for pneumatic conveying of pulverized coal) • Waste heat recovery up to 400 °C (in case of separate transfer of coal and air) • Savings in specific fuel combustion by 1% with every 20 °C rise in combustion pre-heat temperature

Energy savings calculation and payback

Table 1 summarizes the benefits envisaged in terms of reduction in SFC, estimated investment and payback on investment, by using a recuperator, considering a typical 10 tonnes per hour (tph) furnace.

Table 1 Energy savings and payback by using a recuperator

Parameter	Unit	Value
Baseline		
Flue gas temperature range	^{0}C	400–700
Productivity	tph	10
No. of operating hours	h/d	12
No. of working days	d/y	300
Specific fuel consumption	kg/t	75
Annual production	t/y	36,000
Annual fuel consumption	t/y	2,700
Cost of fuel	Rs/t	12,000
Annual fuel cost	Rs (lakh)	324
Post implementation		
Combustion pre-heated temperature after recuperator	^{0}C	230
Ambient temperature *(Every 20 ^{0}C rise in combustion air temperature will reduce 1% of specific fuel consumption)*	^{0}C	30
Fuel savings achieved	%	(200 – 30)/20 =10
Fuel savings achieved	t/y	2,700 × 0.10 = 270
Annual cost savings achieved	Rs (lakh)	32.4
Estimated investment	Rs (lakh)	6
Simple payback period	month	less than 3 months

Note: Cost of recuperator varies depending of the material used, surface area available for recuperation and efficiency of recuperator. For the above calculation, a recuperator efficiency of around 50% has been considered. Recuperator with as high as 80% recovery is also available in market with an appropriately higher initial investment. However, recuperator of all types will have payback period within 900–1500 hours of operation of rolling mill.

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	R K Industrial Enterprises	Plot No. 82, Parvatiya Colony, Sohna Road, Near Peer Baba, NIT Faridabad – 121 005, Haryana	—	093505 43850	rkindenterprises@ yahoo.co.in
2	Refined Structures & Heat Control Unit	A-227, Nehru Nagar, Jaipur – 302 016, Rajasthan	—	098290 60615	refinefurnace@ gmail.com
3	Eastern Equipment & Engineers Pvt. Ltd	12, Pretoria Street, Kolkata – 700 071, West Bengal	033-2290 0187/88	098310 48994	vka@recuperators.in
4	G R Plants & Equipments Co.	C-11, Focal Point Khanna –141 401, Ludhiana, Punjab	—	099140 24138	grplants@yahoo. com
5	THERM-PROCESS Engineering Pvt. Ltd	O2 Building, B Wing, Office No. 1203, Minerva Industrial Estate, Near Sai Dham, Opposite Asha Nagar, Mulund West, Thane – 400 080, Maharashtra	022-2544 7906/2540 4518	098200 77976	thermprocess@ yahoo.com

Combustion air flow regulation through variable frequency drive

Description

In the SRRM sector, centrifugal fans are used as forced draft (FD) fans in re-heating furnaces with the main aim of supplying ambient air for the combustion of fuel. Performance of centrifugal fans depends on various factors like type of fan, proper sizing of the fan, and the specification and design of ducting for the fan. In this section, we will discuss the effective mode of regulation for air flow.

Generally, air flow to a re-heating furnace is kept constant irrespective of temperature, draft and excess air in the re-heating furnace. It has been observed that due to inadequate draft and supply of excess air, the flame continuously gushes out of various openings of the re-heating furnace, which poses a threat to the safety of the men and machines working near the re-heating furnace. The most general practices of the flow regulation mechanisms in FD fans currently employed in the SRRM sector are listed in Table 2.

Table 2 General practice of the flow regulation mechanisms in FD fans

Regulation mechanism	Working principle	Disadvantages
Damper control at FD fan	Dampers are regulating valves located either at the outlet of FD fans. Damper closing or opening increases or decreases the flow by increasing or decreasing resistance to air flow (system resistance).	• Dampers provide limited amount of adjustment. • The fan speed is constant and hence, this method of air flow control is not energy efficient.
Suction control	Air flow in an FD fan is regulated by controlling the suction of the blower by placing a barrier in the suction side of the blower. The amount of barrier placed regulates the air suction thereby controlling the outlet air flow from the blower.	• The process involves manual intervention and hence control of air flow in a precise manner is not possible.
Pulley change	One of the ways to regulate the flow of FD fan is to change the diameter of the drive pulley. As the diameter of the drive pulley is reduced, the speed of the fan reduces and flow reduces proportionately.	• Pulley change requires intervention to continuous operation and can be done only in idle time or by interrupting the plant operation.

All of the above methods for controlling the air flow requires manual interventions. Also, monitoring of the parameters required for controlled air flow is not carried out. Therefore, it is recommended to regulate the air flow by variable frequency drives (VFDs). VFDs reduce the speed of the fan for reduced air flow demand, and this speed reduction is achieved by altering the frequency of input power. Hence, power consumption of FD fans will be proportional to the air flow being delivered to the re-heating furnace. The feedback for VFDs can be taken from an oxygen analyzer installed in the flue gas line. This analyzer will measure the excess air content in the flue gas. Along with stoichiometric air required for combustion, a certain amount of excess air needs to be supplied and this excess air varies based on the type of fuel used in the re-heating furnace. For a pulverized coal-fired re-heating furnace, excess air should be limited to 15%–25%, with oxygen in the range of 3%–4%. An oxygen analyzer is used to monitor the oxygen percentage in the flue gas. It is pertinent to highlight that a 10% reduction in excess air would result in 1% fuel saving.

General and suggested practice

General practice

Practice	Current practice	Impact
Air flow regulation by conventional techniques	Air flow is kept constant or regulated by conventional techniques like damper control, suction control or by changing the pulley.	Keeping air flow constant, irrespective of fuel firing rate, or by regulating air flow through conventional techniques, leads to the following disadvantages: • Uncontrolled supply of air resulting in flame coming out of furnace openings, causing damage to furnace structure. • Excess air takes away substantial heat from the combustion as waste heat through the chimney. • Flow regulation by conventional techniques are not energy efficient.

Suggested practice

Recommended measure	Proposed practice	Impact
Installation of VFDs for FD fan along with oxygen analyzer	It is recommended to regulate air flow through VFDs. VFDs take feedback from the oxygen analyzer installed in the flue gas line and based on the percentage of oxygen in the re-heating furnace, it regulates the speed of the FD fan by varying the frequency of input power to the FD fan.	Following are the advantages of installing VFDs for FD fans: • Flow is regulated by reducing or increasing the speed of the FD fan. This speed regulation is achieved by varying the frequency of input power to the fan. Hence, power consumption will be directly proportional to the required volume of air being delivered to the re-heating furnace. • Regulation of air flow by taking feedback on the percentage of oxygen present in the flue gas can be done in a controlled manner, thereby avoiding the heat taken away by excess air. This, in turn, ensures improvement in combustion efficiency and also the burning loss in the re-heating furnace.

Energy saving and payback

Table 3 summarizes the benefits envisaged in terms of reduction in specific fuel consumption, estimated investment and payback on investment, for combustion air flow using VFD and online oxygen analyzer, considering a typical 10 tonnes per hour (tph) furnace.

Table 3 Energy saving and payback through optimum combustion airflow regulation

Parameter	Unit	Value
Baseline		
Productivity	tph	10
No. of operating hours	h/d	12
No. of working days	d/y	300
Specific fuel consumption	kg/t	75
Annual production	t/y	36,000
Annual fuel consumption	t/y	2,700
Cost of fuel	Rs/t	12,000
Annual fuel cost	Rs (lakh)	324
Post implementation		
Percentage of fuel saving	%	5
Fuel savings achieved	t/y	2,700 × 0.05 = 135
Annual cost savings achieved	Rs (lakh)	16.2
Estimated investment	Rs (lakh)	9
Simple payback period	month	7

Note: In addition to savings in specific fuel consumption, the installation can yield significant savings in burning loss to the tune of 0.3%–0.5% which can yield a saving of 108–180 tonnes of finished steel giving a monetary value of Rs 43–72 lakh annually.

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	Masibus Automation and Instrumentation Pvt. Ltd	B-30, GIDC Electronic Estate, Sector - 25, Gandhinagar – 382 044, Gujarat	079-23287275/79	098980 38836	sales@masibus.comrupesh@masibus.com
2	Pyramid Automation	214/215, Gauri Commercial Complex, Navghar, Vasai Road (E), Dist. Thane – 401 210, Maharashtra	0250-3297106/3209008	099677 55779	info@pyramidautomation.co.in
3	Delta Energy Nature	F-187, Indl. Area, Phase-VIII-Bm Mohali – 160 059, Punjab	0172-4004213	093165 23651 098140 14144	dengjss@yahoo.com den8353@yahoo.com
4	C R Automation Products	C-29, Focal Point, Urban Estate Phase II, Jamalpur Colony, Ludhiana – 141 010, Punjab	0161-5091404	093566 01400 093577 01400	info@crautomation.in
5	Ecolibrium Energy (P) Ltd	I-4, CIIE, IIM New Campus, Vastrapur, Ahmedabad – 380 015, Gujarat	079- 66324219	098715 82246	himanshu.nagpal@ecolibriumenergy.com

Use of swirl burners for better combustion

Description

In most of the SRRM units, a 4-inch pipe is used as a burner for pulverized coal. This 4-inch pipe is inserted into the front and side walls of the re-heating furnace. Only primary air in ambient temperature is used for combustion in such conventional burners and the air-fuel ratio is neither monitored nor controlled. This crude practice of using 4-inch pipe as a burner leads to incomplete combustion, inefficient heat transfer to ingot/billet/scrap, and higher fuel consumption.

In order to have proper control of the air-fuel mixture in a re-heating furnace and also to ensure optimum combustion of coal, swirl burners for pulverized coal-fired re-heating furnaces can be used. The purpose of using a swirl burner is to achieve a stable flame and to ensure proper mixing of air and fuel. In a swirl burner, secondary air is supplied along with primary air in annular arrangement. Both primary air and secondary air are hot air drawn from the recuperator. Primary air is used for carrying coal, and hot secondary air is utilized for complete combustion of powder coal. This burner works on the basis of three *T*s of combustion.

- Time : Sufficient time for burning
- Temperature : Ignition temperature must be achieved
- Turbulence : Proper mixing of fuel and air, which is achieved by swirlers

The turbulence caused due to the rotation of air-fuel mixture being generated by a vane swirl generator results in proper air-fuel mixing and better combustion of fuel.

General and suggested practice

General practice

Practice	Current practice	Impact
Use of 4-inch pipe as burner without any regulation valve for either fuel or air	Conventional burner is a simple 4-inch pipe inserted into re-heating furnace. These burners do not have provision for secondary air. Air and fuel ratio is neither regulated nor monitored.	Higher fuel consumption and inefficient heat transfer due to: • Improper air-fuel ratio • High excess air • Incomplete combustion

Suggested practice

Recommended measure	Proposed practice	Impact
Swirl burners with regulating valves	Swirl burners use primary air and secondary air in annular arrangement for improved combustion of coal particles. While primary air is used to carry coal particles, secondary air is used to create required turbulence in the air-fuel mixture by swirling action.	Due to proper mixing and combustion, excess air is minimal and hence, heat loss through excess air is eliminated. Due to improved combustion, fuel consumption is optimized.

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Mobile	E-mail
1	R K Industrial Enterprises	Plot No. 82, Parvatiya Colony, Sohna Road, Near Peer Baba, NIT Faridabad – 121 005, Haryana	093505 43850	rkindenterprises@yahoo.co.in
2	Refined Structures & Heat Control Unit	A-227, Nehru Nagar, Jaipur – 302 016, Rajasthan	098290 60615	refinefurnace@gmail.com

ROLLING MILL

Use of anti-friction roller bearings
Universal spindles or cardan shaft for rolling mills
Implementation of guides, rest-bars, and roll cooling

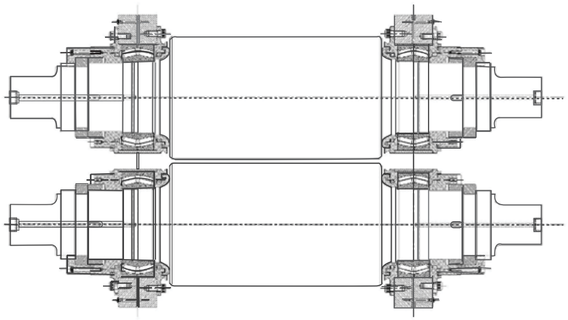
ROLLING MILL

Use of anti-friction roller bearings

Description

Bearing is a friction-reducing device that allows a moving part to rotate over another and it operates on the principle of rolling. The basic purpose of installing the roller bearings in a rolling mill is to provide frictionless support and to roll the stock effectively, with minimum mechanical energy losses. Rolling mill bearings are designed to withstand extreme rolling load, including heavy shocks, varying speeds, and extreme temperature. Apart from this, bearings are designed to tolerate ingress of scale, dirt, and water.

Anti-friction roller bearings



Typical bearing arrangement for an intermediate/finishing stand of a re-bar mill

Rolling mill bearings play an important role in reducing the power consumption and improving the working pattern of a mill. Roller bearings are preferred in cross-country mills as well as in continuous mills. Compared to fibre bearings and gun metal bushes, the coefficient of friction in the case of roller bearing is much lower, resulting in minimal power consumption. Table 1 shows the different types of bearing assemblies preferred for rolling different profiles.

Table 1 Types of preferred bearing assemblies for different profiles

	Type of rolling mill			
			Sectional mill	
Type of bearing	***Bar mill***	***Flat rolling***	***Light***	***Heavy***
Spherical roller bearing	√	√	√	X
Tapper roller bearing	X	√	√	√
Cylindrical roller bearing	X	√	X	√
Spherical/cylindrical along with axial locking bearings	Roughing mills and heavy sectional mills			

Majority of the rolling mill industry can easily switch over to roller bearings by checking the feasibility of technological requirements as given below.

1. Space availability in housing stands to incorporate the bearing assemblies.
2. Size of the roller with respect to the proposed bearing size.

Prompt lubrication of roll-neck bearing and other equipment therein enhances the overall energy efficiency. Lubrication should be carried out periodically not only to increase the bearing life but also to reduce frictional and energy losses.

General and suggested practice

General practice

Practice	Current practice	Impact
Plain bearing (fibre/gun metal)	In most of the rolling mills, fibre bearings or gun metal bushings are used in the rolling mill stands.	• Relatively high starting and running torque due to high friction • Higher power consumption • Size and shape variation • Less hot hours due to more wear and tear/ breakage in the mill

Suggested practice

Recommended measure	Proposed practice	Impact
Use of anti-friction roller bearings	Use of anti-friction bearings allows the rolling mill to withstand much higher loads than conventional mills with fibre bearings or gun metal bushings.	• Less friction due to lower contact area • Better tolerance of products • Longer life and can be fitted in an existing mill with slight modification • Improves the yield significantly by increasing hot hours and reduction in miss-rolls/breakdowns

Table 2 Energy savings calculation and payback by using anti-friction roller bearings.

Parameters	Unit	Value
Baseline		
Productivity	tph	10
No. of operating hours	h/d	12
No. of available hot hours	h/d	10
No. of working days	d/y	300
Electrical power required to roll 1 tonne of steel in rolling mill (for TMT)	kWh/t	105
Annual production	t/y	30,000
Annual power consumption	kWh/y	3,150,000
Unit cost of electricity	Rs/kWh	7
Annual power cost	Rs (lakh)	221
Post implementation		
Expected power saving	%	5
Power savings achieved	kWh/y	157,500
Annual cost savings achieved	Rs (lakh)	11
Investment	Rs (lakh)	5
Simple payback period	month	5

Suppliers and/or manufacturers for reference

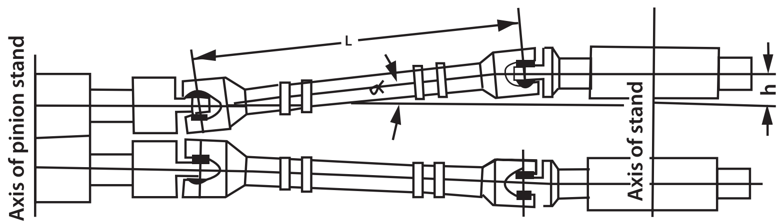
S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	A R Engineering Works	22, Okhla Industrial Estate, Phase-III, New Delhi – 110 020	011-41612339	098110 18176	info@argroup.net
2	P P Rolling Mill Mfg Pvt. Ltd	D-820, New Friends Colony, New Delhi – 110 065	011-26836340	098100 35999	ppeng@vsnl.com
3	Kathuria Roll Mill Pvt. Ltd	A-7/56–58, SSGT Road Industrial Area, Ghaziabad – 201 009, Uttar Pradesh	0120-4179800/ 2841851/52	—	kathuriarollmill@gmail.com info@kathuriarollmill.com
4	Rana Udyog (P) Ltd	18D Everest House, 46C, Jawaharlal Nehru Road, Kolkata – 700 071, West Bengal	033-30521116	098310 18989	birinder@ranaudyog.com amardeep@ranaudyog.com sales@ranaudyog.com
5	Jatindra Engineering Corporation	A - 10/11, Jhilmil Industrial Estate, New Delhi – 110 095	011-22110211/ 22582321/ 22572321	098114 64694	jatindraengg@gmail.com

Universal spindles or cardan shaft for rolling mills

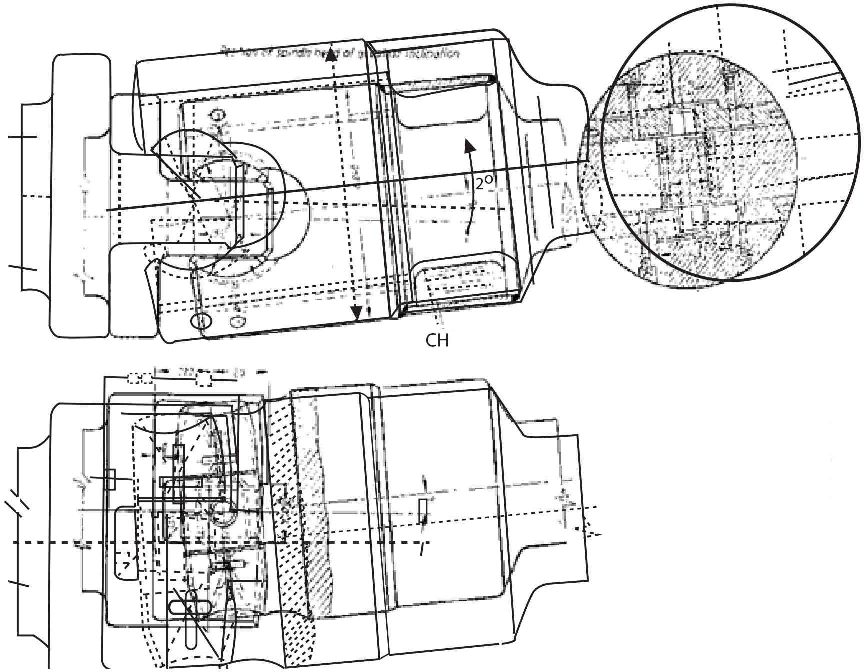
Description

Wobblers are the most commonly used couplers in steel re-rolling mill (SRRM) units to drive rolling mill rolls. These wobbler couplings are of cast iron and used in un-machined condition. The roughness and improper mating due to non-machining of the wobbler coupling gives rise to low metal-to-metal contact, which, in turn, phenomenally increases wear and tear as well as noise levels.

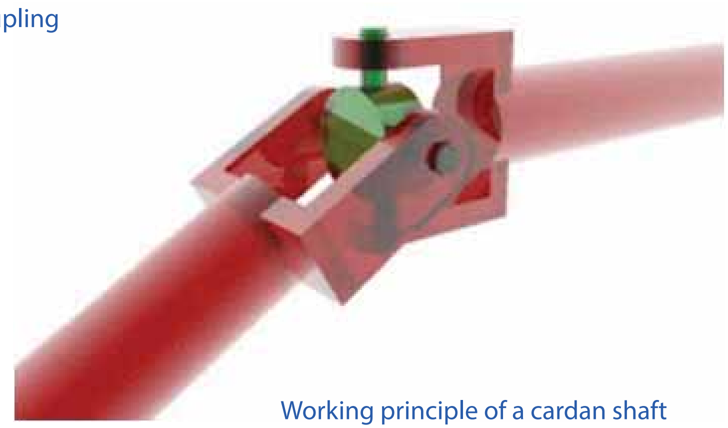
As an alternative to wobbler couplings, the use of universal couplings/cardan shafts has significantly increased in SRRM units. The most unique feature of universal couplings/cardan shafts is their high misalignment capacity that ranges from 3° to 10°. This is many folds higher than the misalignment capacity of wobbler couplings, which is restricted to a range of 1° to 2°. The design of universal couplings/cardan shafts allows them to resist lubrication loss and contamination due to the harsh environment. This unique feature reduces the friction and makes them suitable choice even for high speed mills. Simplicity and ease of maintenance further reduce the down-time. Universal couplings/cardan shafts have negligible backlash and radial clearance, thus improving the surface finish and overall product quality.



General arrangement of universal couplings in a hot rolling mill



Working principle of a universal coupling



Working principle of a cardan shaft

Table 3 compares the various parameters of wobbler coupling, universal spindle, and cardan shaft.

Table 3 Comparison of various parameters of wobbler coupling, universal spindle, and cardan shaft

Parameter	Wobbler coupling	Universal spindle	Cardan shaft
Operating characteristics	Wobbler couplings have a high percentage of wear and tear because of large abrasive force and they transmit relatively lower torque.	• High torque transmission capacity • Low wear and tear • High operational life • Low operational costs • Rigid, carries much higher rolling loads • Low cost compared to cardan shafts	• High torque transmission capacity • Low wear and tear • High operational life • Low operational costs • Rigid, carries much higher rolling loads Higher misalignment capacity compared to universal coupling • Requires more preventive maintenance compared to universal couplings
Torque transmission	The torque transmission capacity decreases as misalignment or deflection angle of rolls increases.	Universal coupling delivers high torque even at large misalignment angles ranging from 3^0 to 8^0.	Universal coupling delivers high torque even at large misalignment angles ranging from 3^0 to 10^0.

Continued

Table 3 *Continued*

Parameter	Wobbler coupling	Universal spindle	Cardan shaft
Backlash	Due to non-machining, wobbler couplings usually have a high degree of backlash, which increases as the spindle wears.	In universal couplings, backlash is far less compared to wobbler coupling. Higher contact ratio of mating parts further reduces wear and tear thereby increasing the hot hours.	In cardan shafts, backlash is even lesser compared to universal coupling.
Maintenance	Wobbler couplings undergo frequent failures and require high frequency of maintenance.	Universal couplings are rigid, therefore failure rate is often low and simplicity of their design makes them easy to maintain.	Cardan shafts are also rigid having low failure rate but requires frequent lubrication.

General and suggested practice

General practice

Practice	Current practice	Impact
Use of wobbler couplings in rolling mill	Despite the drawbacks as mentioned above, wobbler couplings are used in most of the SRRM units to transmit torque from prime mover to rolls.	• Chance of breakage is higher, leading to more down-time • Reduction in productivity • Misalignment capacity or angle deflection of roll is limited to 1^0–2^0. • High noise • Significantly lower torque transmitting capacity

Suggested practice

Recommended measure	Proposed practice	Impact
Use of universal coupling/cardan shaft	Universal coupling transmits higher torque through hinge pin along with slipper pad assembly housed in forged and well-machined universal drums. These drums are connected to machined spindles that carries the load. In the case of cardan shafts, the required power is transmitted through anti-friction roller bearings housed in cast yokes and a forged cross member.	• High misalignment capability ranging from 3° to 8° • Efficient torque transmission capacity • Low wear and tear • Enhanced life and easy to maintain • Increase in productivity • High payback time • Significantly improves the surface quality and dimensional accuracy of rolled product • Very low energy losses resulting in low operating cost

Energy savings calculation and payback

Table 4 summarizes the benefits envisaged in terms of reduction in SEC, estimated investment and payback on investment, for converting from wobbler couplings to universal couplings in a typical 10 tph rolling mill.

Table 4 Energy savings and payback on investment by installing universal spindles (based on single-shift basis for 10-inch mill)

Parameters	Unit	Value
Baseline		
Productivity	tph	10
No. of operating hours	h/d	12
No. of available hot hours	h/d	10
No. of working days	d/y	300
Electrical power required to roll 1 tonne of steel in rolling mill (for TMT)	kWh/t	105
Annual production	t/y	30,000
Annual power consumption	kWh/y	3,150,000
Unit cost of electricity	Rs/kWh	7
Annual power cost	Rs (lakh)	221
Post implementation		
Expected power saving	%	5
Power savings achieved	kWh/y	157,500
Annual cost savings achieved	Rs (lakh)	11
Investment	Rs (lakh)	5
Simple payback period	month	5

Note: Although, the simple payback period for the above installation is on a higher side, the installation will also result in additional benefits in terms of lesser mill down-time, lower breakdown, better utilization of rolls, improved product quality, and reduction in jerk loads.

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	Voith Turbo Pvt. Ltd	AB-06, Sector-1, Salt Lake City, Kolkata – 700 064, West Bengal	033-23592356/ 23587641	099039 94204	soumen.kar@voith.com
2	Cardan India	GT Road,Panagarh Bazar Durgapur – 713 148, West Bengal	0343-2524728	098000 46890	sales@cardanindia.com cardanindia@gmail.com
3	Dullabh Commercials	386, Ahmmed Chambers, Opp. Swastik Cinema, Lamington Rd, Near Opera House, Mumbai – 400 004, Maharashtra	022-23876633	098209 67337	kathuriarollmill@gmail.com info@kathuriarollmill.com
4	Cardan Shaft India	Plot No. 308, Sector -3, Block - C, Loha Bazar, Mandi Gobindgarh – 147 301, Punjab	01765-255199	081466 22027	info@cardanshaftsindia.com rsingh@cardanshaftsindia.com
5	A R Engineering Works	22, Okhla Industrial Estate, Phase-III, New Delhi – 110 020	011-41612339	098110 18176	info@argroup.net
6	P P Rolling Mill Mfg. Pvt. Ltd	D-820, New Friends Colony, New Delhi – 110 065	011-26836340	098100 35999	ppeng@vsnl.com
7	Kathuria Roll Mill Pvt. Ltd	A-7/56-58, SSGT Road Industrial Area, Ghaziabad – 201 009, Uttar Pradesh	0120-4179800/ 2841851/52		kathuriarollmill@gmail.com info@kathuriarollmill.com
8	Rana Udyog (P) Ltd	18D Everest House, 46C, Jawaharlal Nehru Road, Kolkata – 700 071, West Bengal	033-30521116	098310 18989	birinder@ranaudyog.com amardeep@ranaudyog.com sales@ranaudyog.com
9	Jatindra Engineering Corporation	A-10/11, Jhilmil Industrial Estate, New Delhi – 110 095	011-22110211/ 22582321/ 22572321	098114 64694	jatindraengg@gmail.com

Implementation of guides, rest-bars, and roll cooling

Guides and flexible rest-bar

Guides

Guides, as the name implies, assist the stock while entering and leaving the rolls of a rolling mill. They are further classified as entry and delivery guides according to their location and position secured on a rest-bar. The guides are fixed on a rest-bar by means of a clamping device, mounted along the axis of material flow, with the objective of feeding or drawing the material at right angle.

Classification of guides

- Static friction guides (for feeding and drawing of stock at entry and delivery ends of roughing mill stands)
- Roller guides (for feeding of stock at the entry end of intermediate and finishing mill stands)
- Twist guides (for twisting of stock at the entry end of intermediate and finishing mill stands)
- Delivery guides (commonly used for discharging of stock at the delivery end of intermediate and finishing mill stands)

Application of roller guides

Rollers guides are used in bar mills, flat mills, and profile mills.

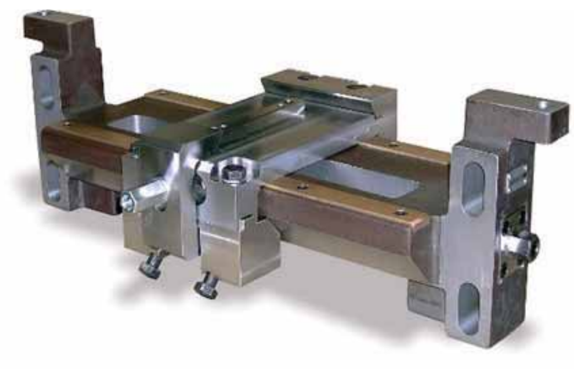
Type of rest-bars

There are commonly two types of rest-bars.

- Conventional-type fixed rest-bar
- Swedish-type adjustable rest-bar

Conventional-type fixed rest bars are generally fixed on the inner face of the housing stands. Due to fixing, they cannot be vertically adjusted to accommodate guide with respect to pass line.

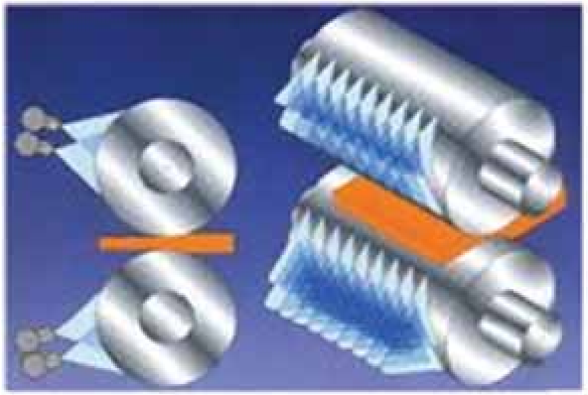
Swedish-type rest-bar is a mechanical device mounted on entry and delivery faces of the housing stands with a purpose to mount guides. The tractable-type rest-bars are kept vertically adjustable in order to maintain the pass line of the roll groove whenever roll change takes place.



Typical arrangement of Swedish-type rest-bar with guide

Roll cooling

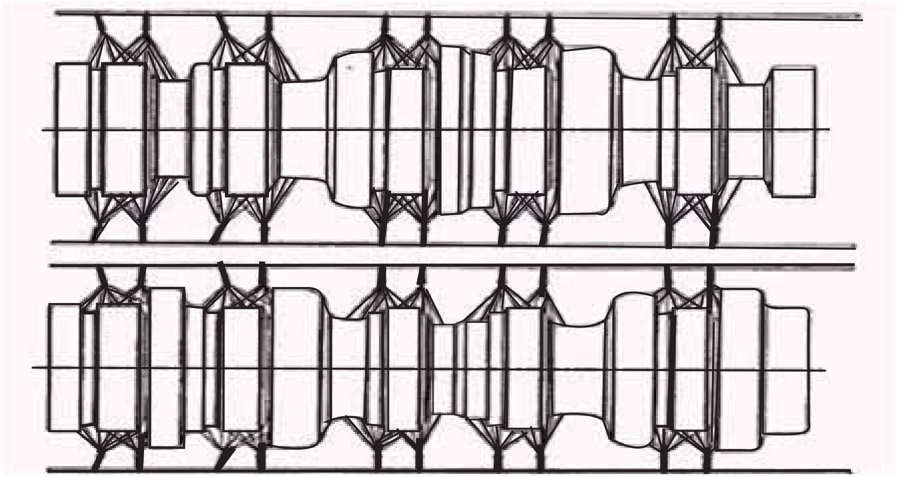
In a rolling mill, the roll absorbs heat when it bites the rolled stock, which is generally at higher temperature. The heating of the rolls decreases their hardness, which shortens their life span. Further rise in temperature of the rolls leads to growth of fire cracks. This severely hampers surface quality of the finished product.



Roll cooling

General and suggested practice

In three hi-mills, water is poured from the top of the rolls, which does not exactly cool the rolls, instead causes many problems (e.g., crack generation, reduction in hardness, increase in downtime due to frequent change of passes and roll breakage).



Current practice in conventional rolling mill

General practice

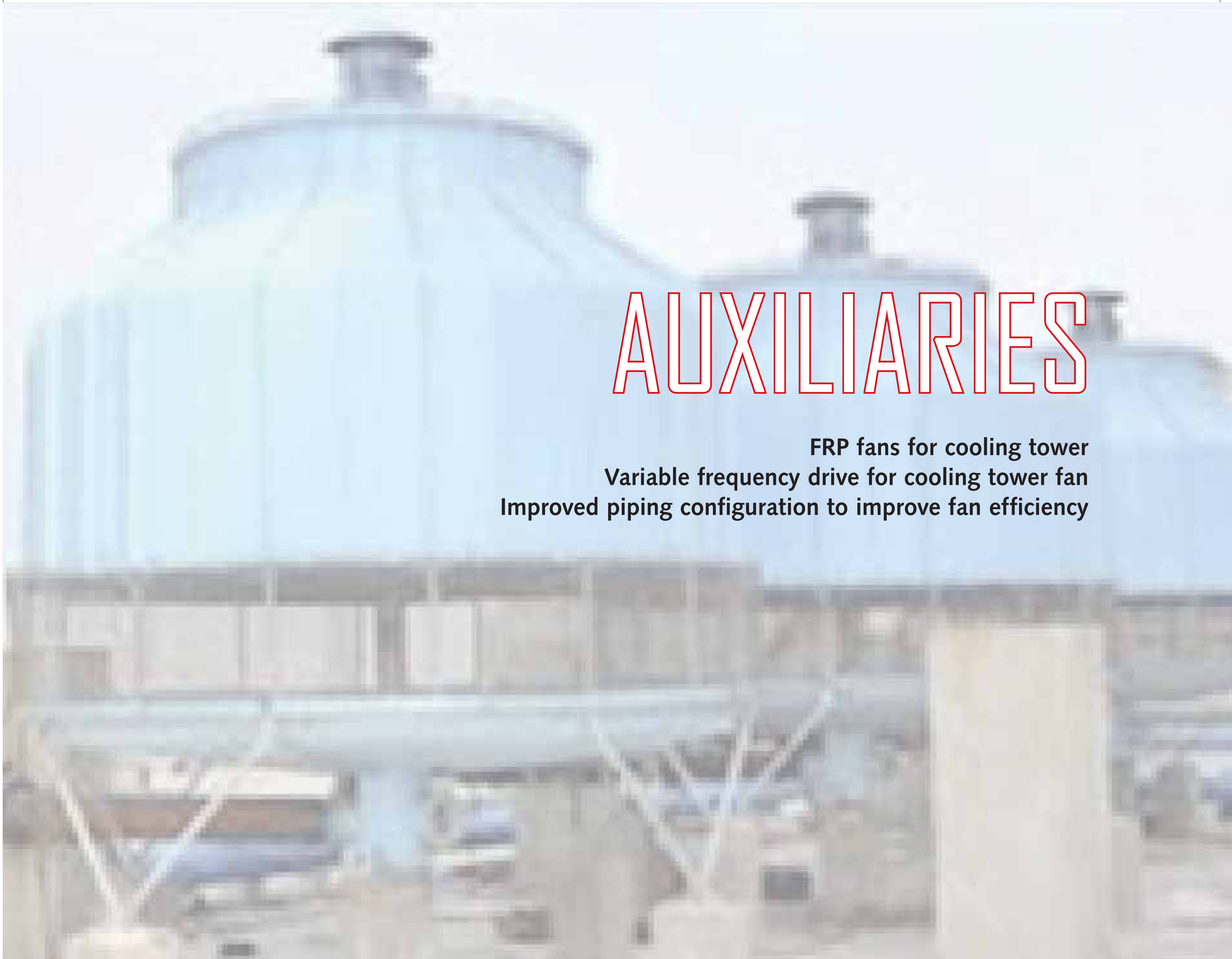
Practice	Current practice	Impact
Spray of water on rolls through hose	In most SRRM units, water is poured on rolls by means of a simple hose mechanism without controlling the flow of water. In some of the units, water is poured on the rolls with the help of a funnel or even bucket.	Such improper cooling of rolls leads to the following problems: • Development of fire cracks • Reduction in hardness of the rolls • Roll breakage due to deepening of surface cracks • Escalation of down-time further reduces productivity and pass life.

Suggested practice

Recommended measure	Proposed practice	Impact
Adaption of cyclic cooling	In a more efficient practice, the coolant should be sprayed at the discharge end of pass when material leaves the periphery of the rolls. It is recommended to install a loop-type spray bar having holes to strategically mount spray nozzles for effective and instant cooling of rolls.	Down-time will reduce due to reduction in breakage of rolls resulting from surface crack formation • Improvement in pass life subsequently increases productivity • Roll consumption per tonne of steel production would further decrease

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	A R Engineering Works	22, Okhla Industrial Estate, Phase-III, New Delhi – 110 020	011-41612339	098110 18176	info@argroup.net
2	P P Rolling Mill Mfg Pvt. Ltd	D-820, New Friends Colony, New Delhi – 110 065	011-26836340	098100 35999	ppeng@vsnl.com
3	Kathuria Roll Mill Pvt. Ltd	A-7/56-58, SSGT Road Industrial Area, Ghaziabad – 201 009, Uttar Pradesh	0120-4179800/ 2841851/52	—	kathuriarollmill@gmail.com info@kathuriarollmill.com
4	Rana Udyog (P) Ltd	18D Everest House, 46C, Jawaharlal Nehru Road, Kolkata – 700 071, West Bengal	033-30521116	098310 18989	birinder@ranaudyog.com amardeep@ranaudyog.com sales@ranaudyog.com
5	Jatindra Engineering Corporation	A-10/11, Jhilmil Industrial Estate, New Delhi – 110 095	011-22110211/ 22582321/ 22572321	098114 64694	jatindraengg@gmail.com



AUXILIARIES

FRP fans for cooling tower

Variable frequency drive for cooling tower fan

Improved piping configuration to improve fan efficiency

AUXILIARIES

FRP fans for cooling tower

Description

In the SRRM sector, cooling towers are used extensively in thermo mechanically treated (TMT) manufacturing units for cooling the water used for quenching in TMT machines. Cooling is achieved through heat exchange between the water and the ambient air, which is drawn to the cooling tower by a fan. The performance of the cooling tower depends on factors such as heat load, the fill media, ambient air conditions, and the fan design. In this section, the design and construction materials of cooling tower fans will be discussed.

The purpose of the fan in a cooling tower is to move a specific quantity of air through the cooling tower system. While doing so, the fan has to overcome resistance in the cooling tower (system resistance), which is also defined as pressure loss. Hence, the work done by the fan is the product of air flow and pressure loss. The fan's efficiency is the ratio of the work done by the fan to the power consumed by the fan (kWh). Fan efficiency depends on the profile of the fan blades and the material of construction of the fan. Lighter fan blades with aerodynamic profiles consume less energy. Conventional cooling towers are equipped with metallic fan blades (typically aluminum). These metallic fan blades are heavy, and also they are manufactured either by casting or by an extrusion process, so it is difficult to achieve an aerodynamic profile. It is recommended that aerodynamic fibre reinforced plastic (FRP) fans be used for cooling towers.

FRP fan used in cooling tower

The advantages of using FRP fans in cooling towers are listed below.

- The aerodynamic shape of blades provide higher efficiency for any specific application.
- Due to reduced weight, FRP fans require a lower capacity drive motor, which results in lower power consumption compared to metallic fans.
- As the overall weight of fan is reduced due to use of lighter material, the life of the mechanical drive system is extended along with ease of handling and maintenance.
- Because FRP fans are manufactured by a composite fabrication process such as compression moulding, they have uniform dimensions and consistent quality.
- The aerodynamic design of the fan blades leads to reduced noise levels.

Overall, FRP fans consume less energy compared to conventional metallic fans due to less weight and the aerodynamic profile of the fan blades.

General and suggested practice

General practice

Practice	Current practice	Impact
Use of metallic fans for cooling towers	Conventional cooling towers are equipped with metallic fans (usually aluminum) that are heavy. As metallic blades are manufactured either by casting or extrusion process, an aerodynamic profile is difficult to achieve so they have flat profiles.	As metallic blades are heavy and have a flat profile, they consume high energy for moving specific amounts of air through cooling towers. Due to heavy weight, installation and maintenance of these fans require more effort and labour.

Suggested practice

Recommended measure	Proposed practice	Impact
Use of FRP (fibre reinforced plastic) fans for cooling towers	FRP fans are light in weight and their blades are aerodynamic in profile. Due to their manufacturing process, FRP fans are uniform in shape and consistent in quality.	Due to their light weight compared to metallic fans, and due to the aerodynamic profile of their blades, FRP fans consume less power for moving specific amounts of air through cooling towers. They are also associated with other benefits like reduced noise levels, ease of maintenance, and longer life of equipment.

Table 1 gives an estimate of the cost savings on account of reduced power consumption by using FRP fans for cooling. On an estimated investment of Rs 75,000, the simple payback period has been worked out to be about 27 months.

Table 1 Energy savings and payback by using FRP fans for cooling tower

Parameter	Unit	Value
Power consumption of cooling tower with conventional blade	kW	15
Annual operating hours	h/y	12 × 300 = 3,600
Annual power consumption of cooling tower with conventional blade	kWh/y	54,000
Power consumption of cooling tower with FRP blade	kWh	13.5
Annual power consumption of cooling tower with FRP blade	kWh/y	48,600
Unit cost of electricity	Rs/kWh	6
Power savings achieved	kWh/h	5,400
Cost savings achieved	Rs/y	32,400
Estimated investment	Rs	75,000
Simple payback period	month	27

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	Mobile	E-mail
1	Parag' Fans & Cooling Systems Ltd	Plot no. 1/2B & 1B/3A, Industrial Area no. 1, AB Road, Dewas – 455 001, Madhya Pradesh	07272-425100/ 01/02/03/04	099930 27026	info@impactgroupindia.com
2	Dew-Pond Engineers Pvt. Ltd	Plot No. A - 478, Road 26, Wagle Ind. Estate, Thane – 400 604, Maharashtra	022-25829208		dewpond@gmail.com sunil@dewpondcoolingtowers.com
3	Paharpur Cooling Towers Ltd	Paharpur House, 8/1/B Diamond Harbour Road, Kolkata – 700 027, West Bengal	033-40133000		pctccu@paharpur.com

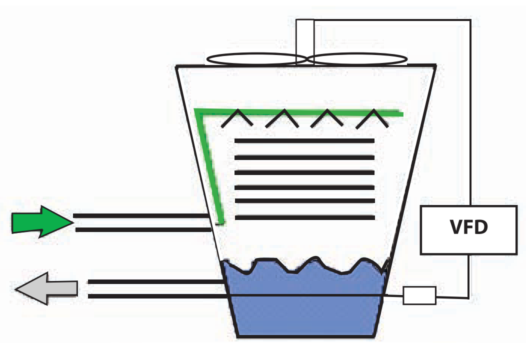
Variable frequency drive for cooling tower fan

Description

In the SRRM sector, cooling towers are used extensively in TMT steel manufacturing units for cooling the water used for quenching in TMT machines. The cooling effect is achieved by heat exchange between water and ambient air, which is drawn to the cooling tower by a fan. It has been observed that cooling tower fans are run continuously and at a constant speed, irrespective of heat load on the cooling tower. The heat load on the cooling tower (the amount of heat required to be removed from the water) may vary based on the size of the TMT being produced and the rate of production. However, cooling tower fans are run at a constant speed and the same amount of air is moved through the cooling tower resulting in an additional cooling effect, which is not required.

It is recommended that variable frequency drives (VFDs) be installed for cooling tower fans along with temperature measurement of the return water. The temperature of the water returning from process is measured and the feedback is given to the VFD for increasing/decreasing the fan speed. For example, if the temperature of the water returning from the process is below the set point, the fan will be run at minimum or zero speed as there is no requirement for heat to be removed from the water. As the temperature of the water goes up above the set point, the fan speed will be increased proportionately by the VFD.

VFDs increase or decrease the fan speed by altering the frequency of input power to the fan motor. Hence, the power consumed by the fan motor is made directly proportional to the heat load on the cooling tower.



Fan speed controlled by VFD

General and suggested practice

General practice

Practice	Current practice	Impact
Running the cooling tower fan at a constant speed	In TMT steel manufacturing units, cooling towers are used for removing heat from water used for quenching. The heat load on the cooling tower varies based on the size of the TMT being produced and the production rate. However, the cooling tower fan is run at a constant speed irrespective of the heat load on cooling towers.	The practice of running cooling tower fans at a constant speed, irrespective of load on the cooling tower, is not energy efficient. This will result in additional cooling of process water (which is not required) and excess power consumption.

Suggested practice

Recommended measure	Proposed practice	Impact
Use of VFDs for cooling tower fans, along with temperature measurement of return water from process	Temperature of return water is measured and feedback is given to the VFD of cooling tower fan to increase/decrease the fan speed. For example, if the return water temperature is below the set point, the fan will run at reduced or zero speed as there is no requirement of heat to be removed from the water.	As the fan speed is increased or decreased based on the temperature of the return water, the power consumed by the cooling tower fan is made directly proportional to the heat load on the cooling tower. Hence, the fan is more energy efficient.

Table 2 gives an estimate of the cost savings on account of reduced power consumption by using VFD for cooling tower fan. On an estimated investment of Rs 40,000, the simple payback period has been worked out to be about 15 months.

Table 2 Energy savings and payback by using VFD for cooling tower fan

Parameter	Unit	Value
Power consumption of conventional cooling tower without flow regulating mechanism	kW	15
Annual operating hour	h/y	12 × 300 = 3,600
Annual power consumption of conventional system	kWh/y	54,000
Power savings achieved by installing VFD	kWh	13.5
Annual power consumption after the installation of VFD	kWh/y	48,600
Unit cost of electricity	Rs/kWh	6
Power savings achieved	kWh/h	5,400
Cost savings achieved	Rs/y	32,400
Estimated investment	Rs	40,000
Simple payback period	month	15

Suppliers and/or manufacturers for reference

S. no.	Supplier/ Manufacturer	Contact address	Phone	E-mail
1	ABB Ltd	No. 4A, 5 & 6, 2nd Phase, Bangalore – 560 058, Karnataka	080-67143000	contact.center@in.abb.com
2	ALSTOM India Ltd	IHDP Building, Plot no.7, Sector 127, Noida – 201 301, Uttar Pradesh	0120-4731100	in.corporatecommunications@ power.alstom.com
3	Danfoss Industries Pvt. Ltd	A-19/2, SIPCOT Industrial Growth Center, Oragadam V – 602 105, Tamil Nadu	044-67151000	danfoss.india@danfoss.com
4	Kirloskar Electric Company Ltd	PB No. 5555, Malleswaram West, Bangalore – 560 055, Karnataka	080-23374865	keshav.prasad@kirloskar-electric. com
5	Schneider Electric India Pvt. Ltd	9th Floor, DLF Building No. 10, Tower C, DLF Cyber City, Phase II, Gurgaon – 122 002, Haryana	0124-3940400	customercare.IN@schneider-electric.com
6	General Automation	D-7, Devashray Industrial Park, Nr. Express Highway, Opp. NKR Engineers Pvt. Ltd, Phase 4, Vatva, GIDC, Ahmedabad – 382 445, Gujarat	079-65447654	response@acdrivesindia.com

Improved piping configuration to improve fan efficiency

Description

In the SRRM sector, centrifugal fans are used as forced draft (FD) fans in re-heating furnaces with the main aim of supplying ambient air for combustion of fuel. Centrifugal fans use a rotating impeller to move air radially outwards by centrifugal action, and then tangentially away from the blade tips. Centrifugal fans are capable of generating relatively high pressures. Performance of centrifugal fans depend on various factors such as type of fan, fan size, mode of air flow regulation, proper installation of fan, and design of fan ducting. In this section, we will discuss the effect of duct orientation on the performance and efficiency of the fan system.

Flow patterns have a substantial impact on fan output and system resistance. Fans and system components are sensitive to the profile of air entering and leaving the fan. Non-uniform air patterns can cause the pressure to drop across the fan system leading to higher energy consumption. Many fan performance problems can be avoided by properly designing the ducting at the inlet and outlet of fan. The ducting should be as straight as possible within the physical constraints of available space. Inadequate attention to the ducting of the fan during installation increases the operating cost of fan system. Many industries increase the fan size to compensate for the pressure loss due to improper ducting, which will lead to higher energy consumption for the required flow and pressure characteristics.

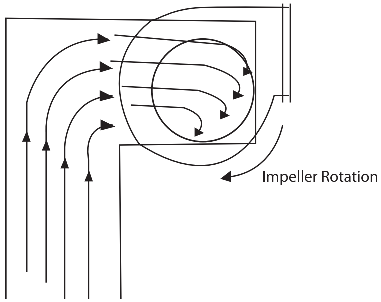
Fan inlet: Poor air flow conditions at the inlet of a fan decreases the effectiveness and efficiency with which a fan imparts energy to an airstream. A pre-rotational swirl and non-uniform flow are two examples of improper inlet duct design. A pre-rotational swirl is caused by an elbow that is located very close to the fan inlet. If possible, the fan should be configured so that there is enough distance from the closest bend for the air flow to straighten out. Because space constraints often do not allow ideal configuration, an air flow straightener, such as turning vanes, can improve fan performance.

Another inlet condition that can interfere with fan performance is highly non-uniform flow. Placing a bend too close to a fan inlet can cause the air flow to enter the fan unevenly, which leads to inefficient energy transfer and fan vibrations. One general guideline is to provide a straight duct length of at least three times the duct diameter just prior to the fan inlet.

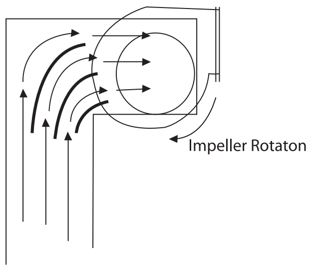
Fan outlet: Poor outlet conditions also contribute to under-performance in fan systems. Swirls and vortices increase the pressure drops of elbows and other duct fittings. Tees and other fittings should be placed far enough downstream of a fan for the air flow to become more uniform. Similarly, where possible, fans should be oriented so that the air flow profile of a fan matches the air flow behaviour created by fittings such as an elbow.

General and suggested practice for fan inlet condition

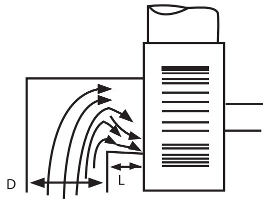
General practice

Practice	Pictorial representation	Current practice	Impact
Installing the fan very close to a bend or elbow		When a fan is installed very close to a bend or elbow at the inlet side, a pre-rotational swirl is created.	A pre-rotational swirl decreases the efficiency of the fan system and more energy is required to deliver a given air flow at the desired pressure.

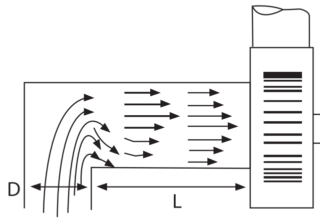
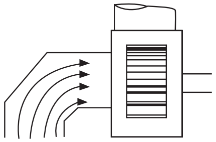
Suggested practice

Recommended measure	Pictorial representation	Proposed practice	Impact
Provide sufficient straight duct at the inlet of fan, or provide turning vanes at the inlet of fan		The fan system should be configured so that there is enough distance from the closest bend to the fan inlet for air flow to straighten out. If space is a constraint to provide a straight duct, turning vanes (as shown in the diagram) can be provided at fan inlet.	Due to straightening the air flow, energy transfer to the air flow will be efficient and power consumption will be reduced.

General practice

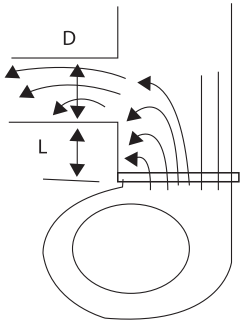
Practice	Pictorial representation	Current practice	Impact
Installing fan very close to a bend or elbow		When a fan is installed very close to a bend or elbow at the inlet side, air will enter the fan unevenly.	Uneven entry of air flow will lead to inefficient energy transfer to air and high fan vibration.

Suggested practice

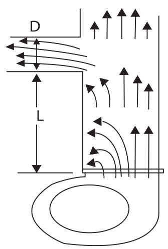
Recommended measure	Pictorial representation	Proposed practice	Impact
A general guideline is to provide straight duct length of at least three times the duct diameter prior to the fan inlet (L > 3D), or provide flow straighteners at the inlet	 	Fan installation should be carried out in such a way that the length of straight duct at the fan inlet (without any bends or elbows) is greater than 3 times the diameter of the inlet duct. If space is a constraint, installing flow straighteners (profiled bends) can be considered.	Due to straightening of air flow, energy transfer to air flow will be efficient and power consumption will be reduced.

General and suggested practice for fan outlet condition

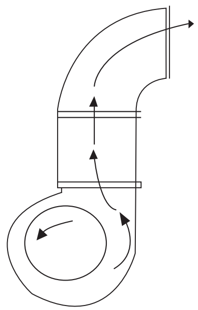
General practice

Practice	Pictorial representation	Current practice	Impact
Installing an elbow or tee joint very close to the fan outlet		Elbow or tee is placed very close to the fan outlet.	When an elbow or tee is placed very close to the fan outlet, the pressure drop increases across the system components and it needs to be compensated for by consuming additional energy.

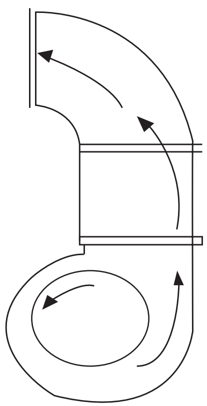
Suggested practice

Recommended measure	Pictorial representation	Proposed practice	Impact
The general guideline is to provide straight duct length of at least three times the duct diameter after the fan outlet (L > 3D)		Fan installation should be carried out in such a way that the length of the straight duct at the fan outlet (without any elbows or tees) is greater than three times the diameter of the outlet duct.	Due to uniform air flow at the outlet of the fan, pressure drop at the fan outlet is minimal, leading to energy efficiency.

General practice

Practice	Pictorial representation	Current practice	Impact
Placing fan and downstream elbow such that the airstream reverses direction		Elbow or bend is placed at the outlet in such a way that the air flow reverses its direction immediately after the fan outlet.	A sudden disruption in the direction of air flow will lead to huge pressure loss and hence, high energy will need to be consumed to create the required pressure and flow characteristics.

Suggested practice

Recommended measure	Pictorial representation	Proposed practice	Impact
Orientation of fan and fittings in such a way that air flow profile coming out of fan matches with the air flow profile created by the fittings		Fan installation should be carried out in such a way that the air flow profile of the fan and fittings are matched. For example, the outer radius of the elbow requires higher air velocity than the inside radius because air has to travel further at the outer radius. The air flow will become consistent with fan flow characteristics when installation is similar to the one shown in the diagram.	Pressure drop across the delivery line is minimal, so energy conservation is achieved.

The steel re-rolling mill sector faces tremendous challenges in terms of high costs of raw materials, low market demand, growing labour costs, and rising prices for fuel and power. In a typical unit, around 30%–40% of the conversion cost (cost of converting ingots/billets/ scraps into finished products) is for energy (fuel and power) and thus energy plays a significant role in deciding the profitability and sustainability of the steel making units.

Pulverized coal has been the most widespread and emerging fuel for the sector during the past couple of years. However, a substantial number of units are still running on obsolete technologies, combined with inefficient operating practices. All this leads to incredibly high energy consumption and higher costs. Thus, there is great potential for transforming the overall energy consumption patterns.

The manual, Efficient practices for profitable rolling, identifies three important areas where good practices and new technologies can bring about far-reaching benefits to the mill owners. The three areas are as listed below.

- Fuel preparation
- Re-heating furnace
- Rolling mill

This manual discusses not only the technologies and practices in the above areas but also provides information on estimated investments, key benefits envisaged, and payback for a set of technology packages/measures. For the benefit of the stakeholders, it also provides lists of technology providers with their contact details. Floor-level engineers, foremen, and mill owners would find the manual useful.

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