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What's Inside

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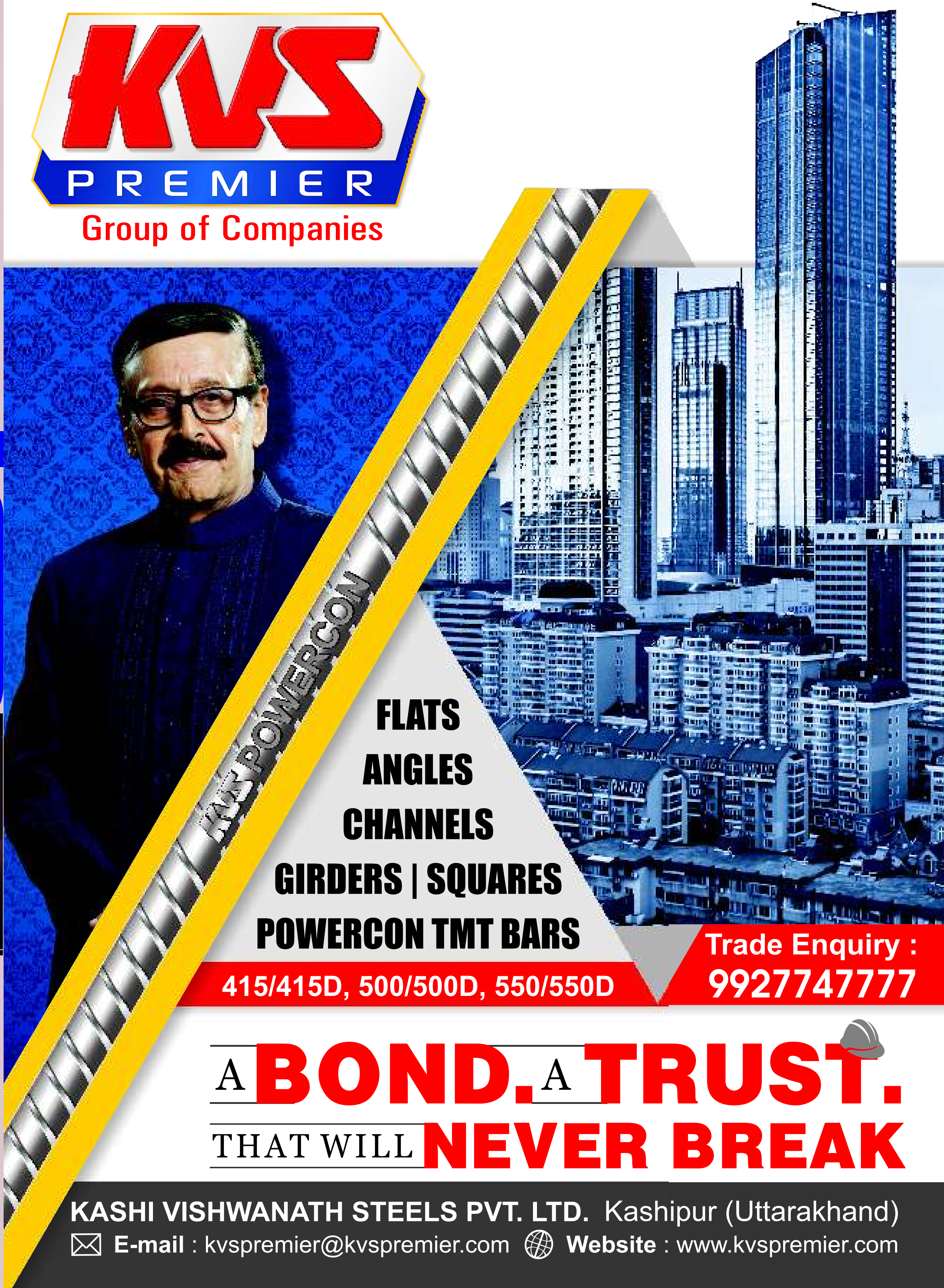


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Shaping of Steel by Hot Rolling in Indian Re-Rolling Mills

Kamal Aggarwal
Hon. Sec. General, AIIFA

Introduction - After independence, Govt. of India placed great emphasis on the development of Indian steel industry. Further, In financial Year 1991, the six major plants, five in the public sector, produced 10 million tons. The rest of India steel production, 4.7 million tons, came from 180 small plants, almost all of which were in the private sector. India's Steel production more than doubled during the 1980s but still did not meet the demand in the mid-1990s, the Govt. was seeking private-sector investment in new green-field steel plants. Since 1880, crude steel production increased suddenly and Japan started in a big way steel production from 1940 though till 1945, Japan's steel production was at low level but it increased suddenly after the Korea War broke out in June of 1950. Movement of computer control began in the 1960s in the Western countries which was systematized on a base of the past experiences gained in the Western countries.

It was felt that with the growth of steel production in India, proportionately shaping of steel must increase using input from steel plants for rolling and rerolling. Steel re-rolling is one of the most important segments of the steel industry, as it constitutes an unavoidable link in the total supply chain of iron and steel. It becomes apparent that the domestic re-rolling industries started playing critical role in the growth of the steel sector using semi-finished products from up-stream units in the production of varied items of 'long or non-flat steel products', the Indian Re-rolling industry has steadily supplied material to and thereby supported, the country's rapid infrastructure development. That the relationship is mutually beneficial is evident in the fact that such development has, in turn, favored

Manufacturing has always a significant impact on global development and growth and it is going to continue due to increasing demand for goods and increasing population. Overall manufacturing plays an important role in today's socioeconomic system as a valuable contributor to wealth generation and job creation most likely in developing countries. On the other side, manufacturing activities are also a burden to the environment. Rolling and Re-Rolling is the process of plastically deforming the metal by passing it between a set of rolls revolving in opposite direction, employed to convert metal ingots to products like blooms, billets, sheets, plates, strips etc.

Indian Steel Scenario: Growth of the Indian steel industry in general and the Re-rolling industry in particular developed at very fast rate which is the oldest and biggest metal working process by volume after forging and today is the most commonly used method of deforming as-cast metals like steel ingot or cast bloom/ billet/slab into shapes suitable for fabricating into a wide range of products. Although still primarily thought of as •a shaping process, hot rolling has recently become more sophisticated because of the possibility ot improving the mechanical properties of the product by controlling the quality parameters. The advent of controlled rolling has therefore been largely dependent on a fuller understanding of the structural changes that occur during hot working and although controlled rolling will not be considered per se, the applicability of the principles derived from studies on a wide range of alloys will be apparent. .

Post-Independence India has seen a magnificent growth in the Steel industry. From the year 1950 to 1951 India produced an estimate of 16.9 lakh tons of pig iron. During the first plan, Iron and Steel in India, TISCO and IISCO were the three main players in the private sector and Mysore State Iron and Steel Works were in the Public sector. The Steel Authority of India (SAIL) was launched in the year 1973. It is a government organization which manages all the major steel plants in India like Bhilai, Bokara, Rourkela and Burnpur. This organization started managing the Iron and Steel in 1976. The **iron and steel industry in India** is among the most important industries within the country. India surpassed Japan as the second top steel producer in the world next to China. Policy for the sector is governed by the Indian Ministry of Steel, which concerns itself with coordinating and planning the growth and development of the iron and steel industry, both in the public and private sectors; formulation of policies concerning production, pricing, distribution, import and export of iron and steel, ferro-alloys and refractory; and the development of input industries.

Statistics of last 8 years indicates the status of India's steel production.										
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	Down by
Prod.	77.3	81.2	87.3	89.6	95.5	101.4	109.3	111.2	99.6	10.6%
Global Ranking	**4th**	**4th**	**3rd**	**3rd**	**3rd**	**3rd**	**3rd**	**2nd**	**2nd**	

The finished steel production in India has grown from a mere 1.1 million tonnes in 1951 to 31.63 million tonnes in 2001-2002. During the first two decades of planned economic development, i.e. 1950-60 and 1960-70, the average annual growth rate of steel production exceeded 8%. However, this growth rate could not be maintained in the following decades. During 1970- 80, the growth rate in steel production came down to 5.7% per annum and picked up marginally to 6.4% per annum during 1980-90, which further increased to 6.65% per annum during 1990-2000.

The growth in the steel sector in the early decades after Independence was mainly in the public sector units set up during this period. The situation has changed dramatically in the decade 1990-2000 with most of the growth originating in the private sector. The share of public sector and private sector in the production of steel during 1990-91 was 46% and 54% respectively, while during 2001-02 the same was 32% and 68% respectively. This change was brought about by deregulation and decontrol of the Indian iron & steel sector in 1991.

A number of policy measures have been taken since 1991 for the growth and development of the Indian iron & steel sector. Some of the important steps are (a) removal of iron & steel industry from the list of industries reserved for the public sector and also exempting it from the provisions of compulsory licensing under the Industries (Development & Regulation) Act, 1951, (b) deregulation of price and distribution of iron & steel, (c) inclusion of iron and steel industry in the list of high priority industries for automatic approval for foreign equity investments upto 51%. This limit has been since increased upto 100%, (d) lowering of import duty on capital goods and raw materials etc.

Hot Working by Re-Rolling: It is not exaggeration even if it is said that the quality became stable and pushed up market competitiveness to the first place in the world, because the system was well able to follow new steel grade or totally new rolling condition, which became a flexible computer control system. A rolling technology is not only a rolling technology, and it goes without saying that it consists as synthesis technology such as hardware techniques of rolling mills or rolling rolls, measurement techniques to observe the rolling state, metallurgy-based software techniques to elaborate materials, control techniques to get highly precise thickness and shape even of rolled strips, and lubrication techniques to realize extension of roll life and reduce rolling load.

The most widely used metal forming process employed to shape steel ingots at temperature 1250-1300˚C to shape products like blooms, billets, sheets, plates, strips etc. is known as rolling. On the other hand, in re-rolling process, the shaping operation after heating in re-heating furnace the stock like bloom/ billet/ slab etc. from rolling at hot working temperature in rolling mill is termed as re-rolling.

Rolling mill is a much larger unit compared to a re rolling mill in terms of variety of products like structural products lie channel ,rail track& rods sections) & product volume. 'ingots'(a large cross section steel casting about 600x600mm) are rolled into' blooms' (150x150 to 400x400).blooms are rolled to billets(40x40 to150x150).these billets, normally, are input for re rolling mills which usually produce the mild steel rods from the billets mainly for civil construction work and also alloy steel in engineering / various manufacturing industries. The process of rolling however remains the same for rolling & re rolling. Some re rolling units, however, use the induction furnaces to prepare their own small ingots termed as pensil ingot to be rolled into rods, square etc. here the size of the unit is very small compared to rolling mills.

Hot re-rolling process of steel is shaping stock by roll pressed at very high temperature over 1,700˚F i.e. 900/ 950˚C finishing temperature (varying from 1200 to 950˚C) depending on steel grades), which is above the re-crystallization temperature for most steels making the products easier to form, and resulting in products that are easier to work with. In case of alloy steels, the re-rolling temperature is 1180/1150 – 950/900˚C. To process hot rolled steel, re- rolling starts with a large, rectangular length of stock, called a billet or bloom which are heated and then sent for pre-processing, where it is flattened into a large roll. From there, it is kept at a high temperature and run through a series of rollers to achieve its finished dimensions. The white-hot strands of steel are pushed through the rollers at high speeds. For other forms, such as bars, flats or section products. Steel shrinks slightly as it cools. Since hot rolled steel is cooled after processing, there is less control over its final shape, making it less suitable for precision applications. Hot rolled steel is often used in applications where minutely specific dimensions aren't crucial. Railroad tracks and construction projects often use hot rolled steel. Hot rolled steel can often be identified by the following characteristics:

A scaled surface—a remnant of cooling from extreme temperatures. Slightly rounded edges and corners for bar and plate products (due to shrinkage and less precise finishing).Slight distortions, where cooling may result in slightly trapezoidal forms, as opposed to perfectly squared angles

Hot rolled steel typically requires much less processing than cold rolled steel, which makes it a lot cheaper. Because hot rolled steel is allowed to cool at room temperature, it's essentially normalized—meaning it's free from internal stresses that can arise from quenching or work-hardening processes.

as overall material strength, and where surface finish isn't a key Hot rolled steel is ideal where dimensional tolerances aren't as important concern. Where surface finish is a concern, scaling can be removed by grinding, sand blasting, or acid-bath pickling. Once scaling has been removed, various brush or mirror finishes can also be applied. Descaled steel also offers a better surface for painting and other surface coatings.

The best rolling technology in the world was not realized only with the rolling theory, but it was stimulated with advancement of the neighboring techniques and it was made up technically. The role of the rolling theory is introduced to decide a pass schedule (including a draft schedule and the pass number) to get the aimed thickness/ shape from a certain thickness of stock, the methods are to decide by looking for the pass schedules from the past data and another one is a method to decide by calculating a pass schedule with the rolling theory. The former is a Western method, and the latter is the method that our country adopted.

Re-rolling in different grades of carbon, alloy steel and stainless steel based on the percentage of carbon and other alloying elements and mainly classified as:.

- Low-carbon, or mild steel contains 0.3 % or less carbon by volume.
- Medium-carbon steel contains 0.3% to 0.6% carbon.

- High-carbon steels contain more than 0.6% carbon,
- High strength low alloy steels (HSLA)
- Stainless Steel in types Austenitic, Ferritic, Martensitic, Duplex stainless steel,
- Tool Steels of different grades.

Small amounts of other alloying materials such as Cr, Mo, Ni, Mn, W etc. are also added to produce many more grades of steel. These alloys modify the properties of the steel, such as tensile strength, ductility, malleability, durability, and thermal and electrical conductivity etc..

Hot rolling also involves forming and rolling the steel slabs into a long strip while heated above its optimum rolling temperature. The red-hot slab is fed through a series of roll mills to form and stretch it into a thin strip/ sheet. After forming is complete, the steel strip/ sheet is water cooled and then wound into a coil. Different water-cooling rates develop different metallurgical properties in the steel.

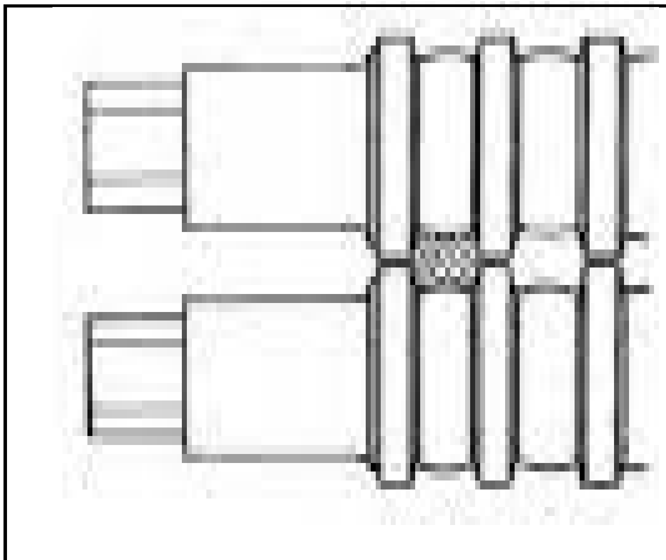
Normalizing hot rolled steel at room temperature allows for increased strength and ductility. Annealing of rolled product is also done byf heating rolled products to above the recrystallization temperature, soaking at that temperature and then cooling it in furnace. Heating of the steel during annealing facilitates the movement of iron items, resulting in the disappearance of dislocations and formation and growth of new grains of various sizes. For specific grade products where both hardness, strength and impact properties are required, hardening & tempering is done. Hot rolled steel is typically used for construction, railroad tracks, sheet metal, automobile and different engineering / manufacturing industries.

Steel Re-Rolling Units Often Face Problems → Mostly Operates with Old Equipments & Technology → Resource Shortage → Higher Cost of Input → Input Quality → Limited Product Range → Low Yield → High Energy Consumption → Products mostly Serve Local Market → Absence of Information Technology in the process → Lack of Standard Operating Practice → Inadequate Quality Control System → Low Profit

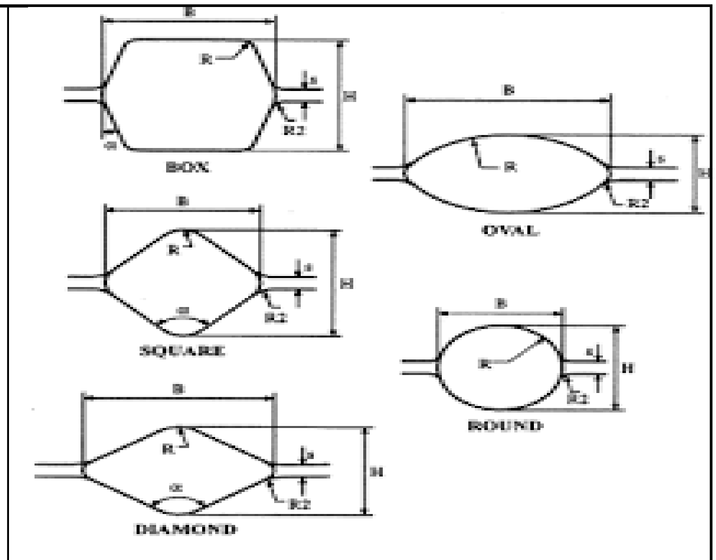
Roll Pass Design in Re-Rolling Mill: Stock movement in rolling mill in hot condition takes shape during path movement of steel products between the working rolls and rolling pass. The roll pass design generally means the cutting of grooves in the roll body through which steel to be rolled is made to pass sequentially to get the desired contour and size. Roll pass design is a set of methods for determining the dimensions, shape, number, and type of arrangement of rolling mill passes The quality and productivity of hot rolled bar steel products strongly depends on hot rolling parameters such as strain, strain rate, temperature, groove design and rolling sequence. It influences the metal deformation behavior within the pass and mill load requirement apart from roll wear.

A pass schedule is calculated near the capacity limit of a rolling mill by using rolling load and torque, and decided to adjust the calculated pass schedule so that the output does not worsen the flatness degree when it becomes thin near the last pass during flat/ strip rolling. Pass schedule shows a strength for the rolling condition in the range where it had a past experience at all, but it is not helpful in the case that a totally new steel grade and product are considerably different from the past experiences. However, it is a strength by the latter method that it can be done so without a problem in this case.

The metal flow behavior in a hot rolling process is a complex phenomenon, which is complicated due to tensorial stress distribution that is influenced by the material properties and deformation parameters. The knowledge of the in-process deformation and micro structural changes is critical for the optimization of the pass design, the pass schedule and ultimately, the properties of the as rolled product. Computer based FEM simulations incorporating deformation models can be used to develop optimum process sequences to obtain steels with sound quality, desirable microstructure and mechanical properties by controlling the hot rolling process parameters of bars, sections, flats etc. In the hot rolling of bars, the material characteristics, rolling load, angle of bite, the roll groove geometry and roll pass sequence etc influence metal deformation and properties.



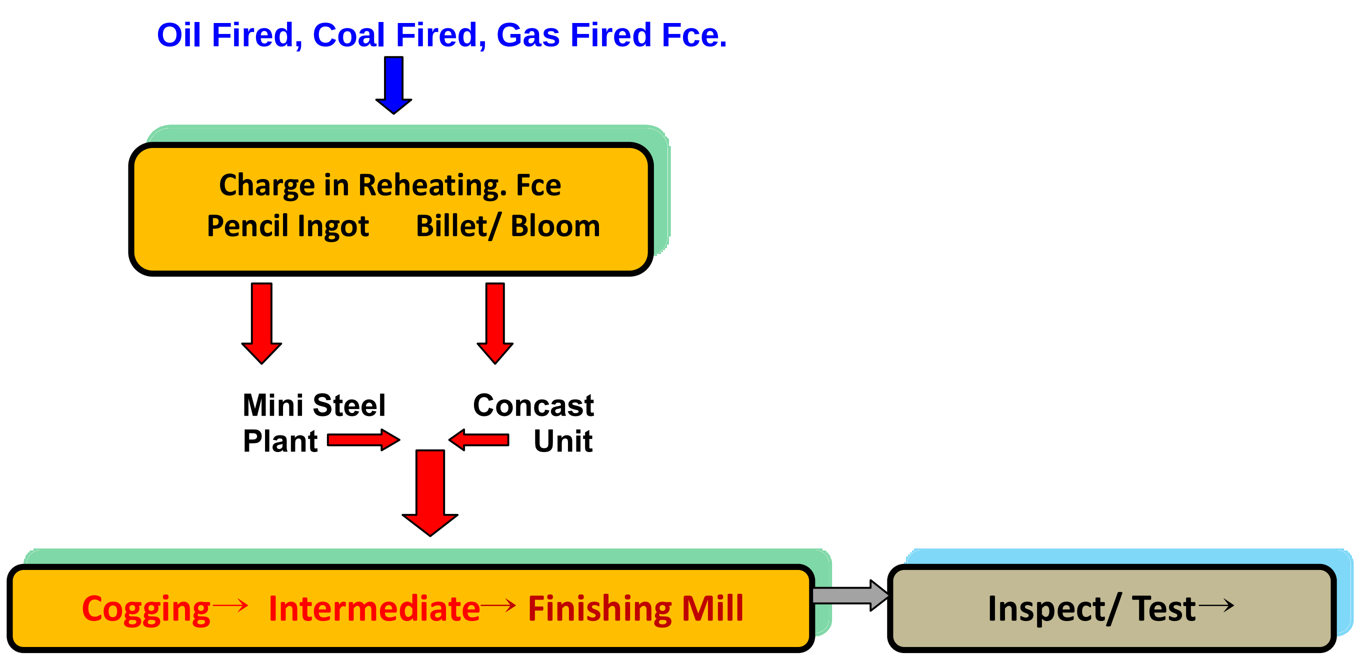
Open Pass Design



Shape Rolling of Round Bar

Status of Rolling at Different Periods (1990): Indian Steel re-rolling mills started production as low economic growth in the 1980s. It is seen that the remarkable environment change surrounded the Japanese society or steel industry in Japan in the middle of the 1990s and the international competitiveness was being lost so that the continuation of the company was asked which was not experienced conventionally. The technological innovation relating to production technology with cost competitiveness in India was felt to be urgently needed besides the appropriate response as the manufacturing industry came to be demanded for the environment change to surround the steel industry including the social need to the issues of earth environment, energy, and resources recycling .

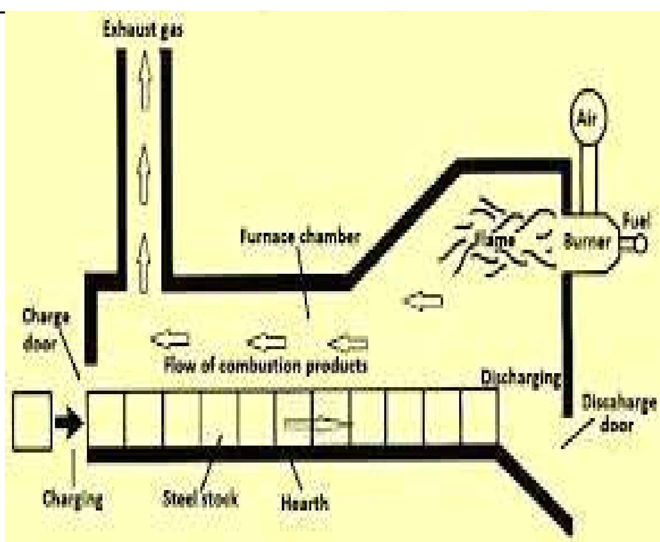
Material Flow in Re-Rolling Mill



Companies in the highly polluting steel-rerolling sector in India are introducing measures to improve energy efficiency as a result of a partnership between UNDP and the Ministry of Steel. In doing so, they are demonstrating that the industry can become more energy efficient, more environmentally conscious and more profitable. Mr. Haoliang Xu, Assistant Administrator and Regional Director, UNDP visited one such success story in Jaipur, Rajasthan and saw first-hand how the company has innovated to improve productivity and reduce specific fuel consumption.

Indian re-rolling units completed the crown-shape control technology in the 1980s. The concept for the crown-shape control is to make a strip crown into the target crown without strip shape disturbance simultaneously by predicting the strip shape with formulas to express the strip crown change and the shape change. As for the strip crown, the way to introduce the transcription rate and the heredity coefficient are well used in the hot strip rolling.) The transcription rate means how much the strip crown formed under the uniform rolling load transcribed into the strip crown after rolling, and the heredity coefficient means a constant to express how much the strip crown at the entry of the roll gap influences that after rolling. In the cold strip rolling, the strip crown at the entry of the roll gap is inherited approximately 100% except the edge-drop region of strip width. However, when there is non-uniformity in the width direction such that the length at some region of strips comes to be larger than that at other region after rolling, the longitudinal tensile stress of the former becomes smaller, and the rolling load per unit width grows bigger, and the roll deformation grows bigger too.

However, the economic slump after the 21st century started, but the development of steel rolling & re-rolling process with supper fine grain came in the country as development of high strength steel to save non-ferrous components of steel such as the rare metals which jump up in price of products. As the result, the production technologies of the high strength steel with supper fine grain by the ultra-speed multi-passes rolling were established) In addition, the endless hot strip rolling mills were operated newly, and as for joining technology of a rough bar which was a key technology, the friction welding technology using strong shear deformation was developed. Further, joining technology of material during rolling, assessment of internal structure have been developed .



Entry & Exit of Stock in Reheating Fce.

Typical Re-Heating Furnace

Re-Rolling Mill

Operation in Re-Rolling Mill

Inputs for Steel Re-Rolling Mills & Rolling Process: Smaller size Ingot (pencil ingot), Bloom or Billets produced from Continuous Casting Units come out as output after hot rolling as input in re-rolling mill converted as output in shapes as Round, Square, Flat, TMT Bar, Wire & Rod, sections like Angle, Channel , Joists etc. Few products mostly flats are Cold Rolled in shapes against requirements.

Currently, secondary steel producers have a cumulative share of more than 70% in the rolled long product market. The role of the re-rolling industry in the overall production of the secondary steel sector for the supply of finished products is thus very important for country's industrial development and economic growth. Presently there are nearly 2000 working steel re-rolling mills in India that are adding strong muscles to the Indian steel sector. Maximum SRRM in India are running as family businesses or MSMEs/ SMEs. In India, the re-rolling sector began in Kanpur in 1928, with no substantial technical development in most units. As a result, the re-rolling industry in India is not very energy efficient and also has high level of emissions. Re-rolling mills contribute more than 10% of the overall emissions from the steel industry.

The production volume of long steel products across **India was approximately 48 million metric tons** in the fiscal year of 2019, steadily improving continuously as 2016 – 42 MT, 2017 – 44, 2018 – 45MT, 2019 – 48 MT, but production affected due to COVID-19 in 2020 and also first few months in 2021. Out of total tonnage, 70-75% long products come from secondary steel sectors. In terms of value, the long product steel market size is estimated to be USD 527.0 billion in 2020 and projected to reach USD 636.7billion by 2025, at a CAGR of 3.9% from 2020 to 2025.Increasing construction and infrastructure activities, industrialization, and rising population levels are the major factors responsible for the growth of the long steel market

Steel re-rolling is the process to convert raw or unprocessed steel into the required finished product by rolling and re-rolling the raw material into required shapes. There are two common rolling processes (i) Hot rolling and (ii) Cold rolling. Broadly, rolling process comprises the application of mechanical forces to metal surfaces through a succession of rolls to produce particular shapes and sizes by plummeting widths and thicknesses. Normally the feed material is in the form of ingots or billets. Hot rolling involves reheating raw material near to soaking temperature and rolling them into desired shapes through a series of rollers. The raw material is heated up to 1150 °C to 1250 °C.

to be continue .....

Design Aspects of Different Types of Reheating Furnaces for Re-rolling Sector

P. Mishra
Sr. Exec. Director, AIIFA

Synopsis

The Article has explained the design aspects of various types of Reheating Furnaces for Rerolling Sector. While discussing about design aspects, the Article has also talked about different types of Reheating Furnaces.

Design aspects of Reheating Furnaces depend on various factors such as technical specifications; sizing of the furnace, which includes the length and width of the furnace; and the Refractory Lining of the furnace including ceramic fibre materials in different zones. These include Furnace Roof, Furnace Walls and Hearth. The design aspects also include Mild Steel Casing, which is provided as cladding for the Refractories; Combustion System like Fuel Oil Burners, Combustion Air Blower and Fuel Oil Heating & Pumping Station; Flue Exhaust System & Chimney; Charging/Discharging Equipment/Withdrawing Roller; Combustion Control System: Conventional/Programmatic Logic Controller; Air-Preheat System (Recuperator); and finally, Factors affecting Operating Efficiency. The Article has briefly discussed these design aspects of Reheating Furnaces.

Preamble

India is a unique country in the world where almost 60% steel is produced from the secondary steel sector which include Electric arc Furnace, Induction Furnace and Re-Rolling mills. There are **308 sponge iron producers** that use iron ore/ pellets and non-coking coal/gas providing feedstock for steel production; **47 electric arc furnaces & 1128 induction furnaces** that use sponge iron and/or melting scrap to produce semi-finished steel and around **1300 re-rollers** that rolls out semi-finished steel into finished steel products for consumer end use. Therefore, the secondary steel producers are equally important in Indian scenario. **(JPC AR 2018-19)**

Today Indian Steel Industry is rated as the 2ndlargest in the world with annual production of over 110 million tons(JPC Annual Statistics Report-**2018-19**)through **BF-BOF (45%), DRI-EAF (25%) & Scrap/DRI-EIF (30%) route**. In other words, **50 MT** of steel produced through oxygen route (**BF-BOF)** and remaining **60.92 MT** of steel produced through electric route (**DRI-EAF & Scrap/DRI-EIF).**

Re-rolling Sector may be divided in number of sub-sectors depending upon the Annual production of the Re-rolling Units as follows:

a) Re-rolling Units with annual production of 10000 tons (Reheat Furnace rated at 5 tph).

b) Re-rolling units with annual production of 25000 tons (Reheat Furnace rated at 10 tph)

c) Re-rolling units with annual production of 40000 tons (Reheat Furnace rated at 15 tph)

d) Re-rolling units with annual production of 50000 tons (Reheat Furnace rated at 20 tph) etc.

Secondary Steel Industry mainly caters to production of Rebars and similar types of steel used in construction work.

Different Types of Reheating Furnaces

Reheating Furnaces for Re-rolling Industry are of many types:

- Chamber Type
- Pusher Type
- Walking Hearth
- Walking Beam Type

Different types of Reheating furnaces are used for different types of feed stock: e.g., pencil ingots, Concast / rolled billets, blooms, ingots. Re-rolling Mills in the Secondary Steel Industry mainly use Pusher Type Reheating Furnaces. Pusher Type Furnace may be Top Fired or Top & Bottom Fired depending on the cross section of the feed stock. Feed stock up to 150 mm X 150 mm cross section is usually heated in top fired Reheat Furnace. Feed stock with cross section exceeding 200 mm X 200 mm cross section is usually heated in top and bottom fired Reheat Furnace. For our Workshop today, we shall take up design of a 20 TPH Pusher Type Reheat Furnace.

Design of 20 TPH Reheating Furnace forRe-rolling Mill

1 Technical Specifications:

Capacity:	20 tons / hour
Reference Billet Size:	100 mm X 100 mm x 6 000 mm (single row) 100 mm X 100 mm X 3 000 mm (double row)
Fuel:	Furnace Oil (IS-1593) C.V. = 10 000 kcal / kg.
Furnace Temperature:	1 250 Deg. C
Billet Temperature:	1 200 Deg. C
Billet Charging:	End
Billet Discharge:	Sideways

2. Sizing of the Furnace : Useful Dimensions of the Furnace and Useful Length of the Furnace:

Weight of one 100 mm X 100 mm X 6 000 mm billet: 470 kgs. 20 tons shall have 43 billets. Heating Time (up to 1200 deg C) for 100 mm cross section mild steel billet: ~ 140 minutes Nos. of billets in the furnace: 43 X (140 / 60 = 2.33) = 100 Hence useful Length of the Furnace = 100 billets X 100 mm = 10 000 mm. From the centre line of billet discharge, ~ 800 mm gap is provided up to inside of the end wall of the Furnace. Hence the Furnace length between inside of the entry and end wall = 10 800 mm

Width of the Furnace:

Pusher Type Furnace needs ~ 250 mm clearance on either side inside the width of the Furnace, so that while pushing the feed stock does not damage the inside walls of the Furnace. If it is 2-row charging, gap of ~ 200 mm is provided between 2 rows of the billets to ensure that each row of billets is pushed upto discharge end without fouling with the other row. Hence width of the Furnace would be: 250 mm + 3 000 mm + 200 mm + 3 000 mm + 250 mm = 6 700 mm

Arch type roof is provided for Reheating Furnace with inside width of up to ~ 3 500 mm.

Hanging Roof is provided for higher width.

3. Refractory Lining in Different Zones : The furnace is usually lined with conventional refractories and insulation materials including ceramic fiber materials broadly as follows:

Furnace Roof:

Soaking Zone: 250 mm thick special shaped bricks made of 60 % Alumina backed by 25 mm Insulating Castable.

Heating Zone: 250 mm thick special shaped bricks made of 38- 40% Alumina (IS-8) backed by 25 mm Insulating Castable.

Furnace Walls

Discharge End Wall: 230 mm 60 % Alumina bricks backed by 115 mm hot face insulation bricks, 115 mm Mica insulation bricks, 75 mm block insulation / ceramic fibre blanket

Sidewalls > 1000deg C: 230 mm 60 % Alumina bricks backed by 115 mm hot face insulation bricks, 115 mm Mica insulation bricks, 75 mm block insulation / ceramic fibre blanket

Sidewalls < 1000deg C: 230 mm IS-8 quality fire bricks ,115 mm Cold face insulation bricks,115 mm Mica insulation bricks, 75 mm block insulation / ceramic fibre blanket

Charging end wall: 175 mm ceramic fibre module

Top Flue: 50 mm ceramic fibre blanket which shall be held in position by heat resisting studs and washers

Hearth:

Soaking Zone: 150 mm 80 % Alumina Bricks (Fusion cast bricks preferred), 75 mm 45 % Al203 firebricks, 230 mm Cold face insulation

Heating Zone > 1000° C: 150mm 50 % Al203 firebricks, 115 mm Hot Face Insulation Brick, 115 mm Cold Face Insulation Brick, 230 mm Mica Insulation brick

Heating Zone < 1000° C: 150 mm 45 % Al203 fire bricks,115 mm Hot Face Insulation Brick, 115 mm Cold Face Insulation Brick, 230 mm Mica Insulation brick

Door at charging end: 175 mm RT Ceramic fibre Module, 25 mm ceramic fibre blanket RT128

Door at discharging end:	225 mm RT Ceramic fibre Module, 25 mm ceramic fibre blanket RT128
Over head flue upto}:	115 mm IS-6 quality fire bricks,115 mm mica insulating recuperator bricks, 50 mm calcium silicate block insulation
Lagging for Air Line:	75 mm thick rock / glass wool blanket covered with galvanised steel sheet cladding.

Refractory Lining is designed for outside wall temperature of ~ 60 degC over the ambient near the Burners, roof and the Soaking Zone and ~ 50 degC over the ambient in rest of the Furnace.

4. Steel Casing:

Mild Steel Casing (IS 2062) is provided as cladding for the Refractories. 10 / 12 mm Steel Casing is necessary for Furnace Zones operating at 800 to 1200 deg C. 6 / 8 mm Steel Casing is adequate for the pre-heating zones of the Reheat Furnace. Steel Casing is suitably reinforced by channels and beams. Typically, steel required is ~ 0.5 tons / m2 of Overall Furnace Area. Steel Casing is usually painted with heat resisting aluminium paint to reduce radiation loss from the walls of the Reheat Furnace.

5. Combustion System:

5.1 Fuel Oil Burners:

Theoretically 18 kgs of fuel oil are required to heat one ton of mild steel billets to 1 200 deg. C. In actual practice this may vary from 30 kgs to 55 kgs. Typically, Combustion Systems of new Reheat Furnaces are, however, designed on the basis of specific fuel consumption of 40 kgs / ton. 20 TPH Reheat Furnace will accordingly have Combustion System designed for 800 kgs. of oil / hour. Typically, 20 TPH Reheat Furnace will have 3 Zones:

Preheating Zone

Heating Zone and

End Soaking Zone.

Preheating Zone often is unfired to recover heat from the hot combustion gases leaving the Furnace. Heating Zone is rated at 65 % to 70 % of the Total Heat Requirement. In this case ~ 520 kgs. End Soaking Zone will be rated at ~ 280 kgs. Since the inside of the end wall is 6 700 mm wide, there is adequate room to provide 6 Burners each rated at ~ 45 kgs of oil per hour in Soaking Zone.

Heating Zone will have 13 Burners each rated at 40 kgs of oil per hour. Heating Zone Burners may be located on both side walls of the Reheat Furnace in staggered arrangement. Hence total of 19 Burners of same size will be required for the Combustion System Burners Rated Capacity is achieved when combustion air is supplied to them at 300 to 400 mm water gauge at the Burners. The Burners should be suitable for air-preheat of ~ 300 deg. C to save ~ 15 % of fuel consumption. (~ 5 % of energy is saved with each 100 deg C preheating of combustion air)

5.2 Combustion Air Blower:

Theoretically ~ 11 nm3 of air are required for full combustion of 1 kg. of oil. In practice excess air is required to ensure full combustion of fuel oil. ~ 15 % excess air has been found adequate for proper burning of fuel oil. (Only 8 to 10 % excess air is required when gas instead of oil is the heating medium)

The Combustion Air Blower will accordingly be rated for capacity of 800 X 11 X 1.15 = 10 120 nm3 per hour. Ambient air temperature in day time often is 35 to 40 deg. C, hence air sucked in by the Combustion Air Blower is at that temperature. Hence the Combustion Air Blower capacity is further increased by ~ 15 % to take care of higher ambient temperature. Combustion Air Blower to be ordered should have rating of 10 120 x 1.15 = 11 640 m3 / hour. Static Air Pressure of the Blower = ~ 400 mm required at the Burner + pressure loss through the recuperator (typically ~ 200 mm WG) + pressure loss in the Combustion Air Piping (typically 200 to 300 mm WG) = .800 to 900 mm WG. (Typically, ~ 10 % of line pressure is thepressure loss of Control Valve). Hence the Combustion Air Blower will be rated for 11 640 m3 / hour at 900 mm WG static pressure

5.3 Fuel Oil Heating & Pumping Station:

Furnace Oil delivered at works normally has high viscosity. It is heated to about ~ 85-90 deg. C to lower the viscosity to ~ 1.5 deg. Engler. Normally electric heaters are used to heat the oil from ambient temperature to ~ 85-90 deg. C. Furnace Oil is normally stored in Tanks. It is to be supplied to the Burners mounted on the Reheat Furnace at ~ 1.5 to 2.0 atmospheres pressure. Required pressure is achieved by Fuel Oil Pump. Fuel Oil Heating & Pumping Stations are readily available in the Market.

6. Flue Exhaust System & Chimney:

Properly designed Flue Exhaust System & Chimney are necessary to ensure economic operation of Reheat Furnace as well to conform to applicable Pollution Norms. Flue Channel routing depends on the Layout of the Reheat Furnace with respect to the entire Plant Layout. Flue Channel leaving the Reheat Furnace is often underground. However, in case of high-water table in the plant area flue channel may be taken out from the roof of the Reheat Furnace. Flue Channel is usually lined with 230 mm of IS-6 Bricks followed by Red Bricks. Indian Standards are available for appropriate design of the Chimney. Chimney is to be provided with suitable tapings to analyse flue exhaust gases before they are discharged into the atmosphere. The bell portion of the Chimney (about 1/3 height of the Chimney) is usually lined with insulation castable suitable for 900°C. Insulation Castable is held my mild steel anchors welded to the chimney. The thickness of lining shall be ~ 150 mm.

7. Charging / Discharging Equipment / Withdrawing Roller:

Billets are usually charged into a Reheat Furnace by Hydraulic / Mechanical Pusher. Hydraulic Pusher has the advantage that same Hydraulic System (Power Pack) can also be used for Discharge Pusher as well as Withdrawing Roller. Number of Billets in the Reheat Furnace: 100 Additional Billets on the Charging Table / Charging Grid: 10 Total weight of 110 Billets (100 mm X 100 mm X 6 000 mm) to be pushed by the Pusher = 470 kgs X 110 = 51 700 kgs. Pushing Force required = 30 tons As the Reheat Furnace is designed for double row charging, it will be provided with 2 Hydraulic Cylinders. Typically, Hydraulic Power Pack is designed for 100 atmosphere pressures with operating pressure of 70 atmospheres. Hence 2 cylinders with diameter of 200 mm would be adequate for the Charging Pusher. Hydraulic Motor will be provided for (a) Side Discharge Pusher and (b) Withdrawing Roller.

8. Combustion Control System: Conventional / PLC Conventional: Conventional Control System consists of Temperature Control of each Zone: Temperature is measured in each zone by a thermocouple. The measurement is "fed" toTemperature Controller. The Controller commands opening / closing of the Control Valve located in Combustion Air Piping of the corresponding Zone. This causes variation in the pressure of the Combustion Air. An impulse piping from Combustion Air Piping controls opening / closing of the valve in fuel oil piping. (Ratiotrol)

Pressure Control of the Reheat Furnace Safety Controls for:

a) Excess Zonal Temperature

b) Low Air Pressure

c) Low Oil Pressure

d) High Preheat Temperature

e) High Flue Exhaust Temperature before Recuperator etc

Record of Temperatures in each zone, Combustion Air Temperature after Recuperator, Flue Gas Temperature before Recuperator etc.

PLC based:

Now-a-days Programmable Logic Controller (PLC) based control system is provided for all above functions. In this case, however, it is necessary to have more elaborate and exact measurements of combustion air flow and fuel oil measurement in each zone. PLC also has built in Ratio Control System. With Ratio Control System, it is possible to vary atmosphere inside the Reheat Furnace. This is however not necessary for Rebars. In addition, PLC can also take care of automatic sequential operation of the charging and discharging equipment for the movement of billets in and out of the Reheat Furnace and further to the mill roller table with associated safety auxiliary interlocks and automatic tracking of batches of charged materials through the furnace

Data Monitoring & Protection:

Back up protection for the zonal temperature, recuperator protection and monitoring and recording of data is accomplished by providing a 16-channel data scanner/monitor with high and low alarm capability together with a 132-column line printer.

This shall have following functions:

Monitoring the Zonal temperatures, flue gas temperatures before and after recuperator, hot air temperature after the recuperator. Excess temperature alarm for all four control zones inside the furnace. On / Off control of bleed of butterfly valve for protection of recuperator in case of excess combustion air temperature. On / Off control of dilution air butterfly valve for protection of recuperator in case of excess flue gas temperature.

Auxiliary Safety Protection:

Auxiliary furnace protection and audio-visual indication is provided for Combustion air failure and Hydraulic system fault by means of suitable pressure switches / sensors and fuel solenoid shut-off valve.

Field Sensors and Actuators: Necessary field sensors, thermocouples transmitters / transducers and actuators are provided for making the instrumentation and control system complete and reliable. The panel mounted instruments are housed in a floor mounted dust and vermin proof instrument panel. The panel also has necessary alarm annunciator /s switches, push buttons indicating lamps etc.

Safety Features: For the safe operation and long life of the furnace, following safety features are provided. Excess temperature control: In case the furnace temperature exceeds beyond set point, the fuel supply is shut off. The fuel supply can be re-started only with manually operated safetyshut off valve. Dilution air blower to safeguard the recuperator tubes. Hot air bleed off valve in case of over temperature of combustion air. In case of low combustion air pressure, the fuel supply shall be shut off. In case of low fuel pressure, the fuel supply shall shut off.

9. Air-Preheat System (Recuperator):

Flue Exhaust Gases leave Reheat Furnace at temperature of 600 to 700 deg.C. For economic operation of Reheat Furnace it is necessary to recover from Flue Exhaust Gases as much heat as possible. Recuperators are used to recover heat from Flue Exhaust Gases and preheat Combustion Air before it is led to the Burners. With Flue Exhaust Temperature of 600 to 700 deg C, Combustion Air Preheat obtained in the Recuperator is ~ 300 to 350 deg c. Generally, Combustion Air Preheat is restricted to < 400 deg C to facilitate use of mild steel for the Combustion Air Piping.

Recuperator may be ceramics / metallic. In Re-rolling Industry Reheat Furnaces generally metallic recuperators are used. Recuperator may be of cross flow type or parallel flow type. For Re-rolling Industry Reheat Furnaces - often operating on one 12-hours shift a day - parallel flow recuperator is recommended.

It may be noted that ~ 5 % fuel is saved for every 100 deg C pre-heating of Combustion Air. Hence with 300 deg C pre-heated Combustion Air at the Burners, ~ 15 % fuel oil will be saved.

10. Factors affecting Operating Efficiency:

a) There should be no leakages from Furnace Casing, Hot Air Piping, Fuel Oil Piping and Hydraulic Piping.

b) Operating Doors should be kept open - only when necessary- to minimum extent.

c) Hot Combustion Air Piping as well as Fuel Oil Piping should be properly insulated.

d) Thermocouples should be re-cal liberated once a month.

e) Reheat Furnace should normally operate with positive furnace pressure.

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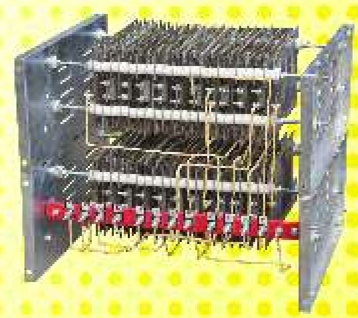

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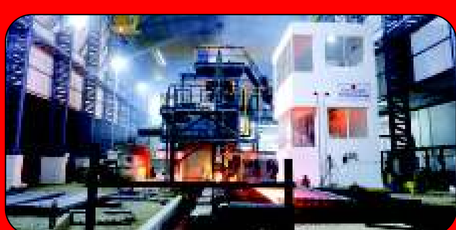

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