

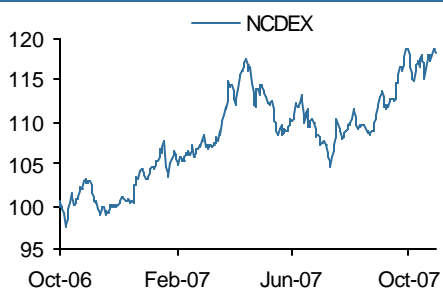
November 01, 2007

Steel prices: Room for upside

Commodity Data

Commodity: Steel	
Recommendation: BUY	
Exchange	NCDEX (Rs/ton)
CMP	22,160
Target price	24,200
Upside (%)	93
52 week H/L	22,239/15,811
Code	STLINGGZB

Commodity price trend



- Global steel demand expected to grow by 6.8%, led by intense infrastructure activity in the BRIC nations.
- Chinese government curbs on export of primary metals to reduce over supply situation in the global market.
- Raw material costs, which are generally pass through, are expected to swell resulting into higher metal prices.
- We recommend BUY with a price target of Rs24,200 on the NCDEX, an upside of 9.3%.

Steel demand to be driven by BRIC nations over the next two years

BRIC countries, accounting for 41% of global steel demand, will continue to see 12.8% and 11.1% growth in demand in CY07 and CY08 respectively. Intense construction activity in the BRIC nations will keep demand for the metal strong over the next two years. The BRIC nations are expected to account for 77% and 71% of growth in global consumption in CY07 and in CY08 respectively.

Government curbs to reduce supply from China

In order to curb inflow of funds, the Chinese government levied duties on exports of primary metals. This will lead to lower exports of the metal, as costs will rise, and bring about parity in demand supply situation in the global market. We expect this move will result into global steel prices moving northwards.

Soaring raw material prices to push steel prices up

The increase in raw material prices is expected to push production costs higher by ~US\$55-65 in CY08. This rise in manufacturing costs will lead to rise in steel prices by manufacturers during the period. Although we do not expect manufacturers to fully pass on raw material price rise, we believe the hike in steel prices will be to the tune of ~7-8%.

Steel prices: room for upside

Strong demand momentum driven by the infrastructure sector is expected to continue in the near term. The higher steel consumption globally will allow steel manufacturers to pass through the rise in raw material costs, which are expected to jump by ~US\$55-65 per ton in CY08. We expect steel prices to rise from current levels in the near term and remain around there. We expect, average CIS hot rolled coil prices to be US\$590 in Q4CY07 and US\$610 in CY08. On the NCDEX (National Commodity & Derivatives Exchange Ltd.), investors can buy with a price target of Rs24,200 per ton, an upside of 9.3%.

Global steel demand-supply

(mn tons)	2004	2005	2006	2007E	2008E
Production	1,069.1	1,142.3	1,244.7	1,352.6	1,446.1
% yoy growth	10.2	6.8	9.0	8.7	6.9
Consumption	974.3	1,026.0	1,113.0	1,197.7	1,278.6
% yoy growth	8.9	5.3	8.5	7.6	6.8
Balance	94.8	116.3	131.7	154.9	167.5
CIS HRC (US\$/ton)	516.0	449.3	499.3	572.5	610.0
% yoy growth	84.0	(12.9)	11.1	14.7	6.6

Source: India Infoline Research, International Iron and Steel Institute (IISI)

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Investment rationale

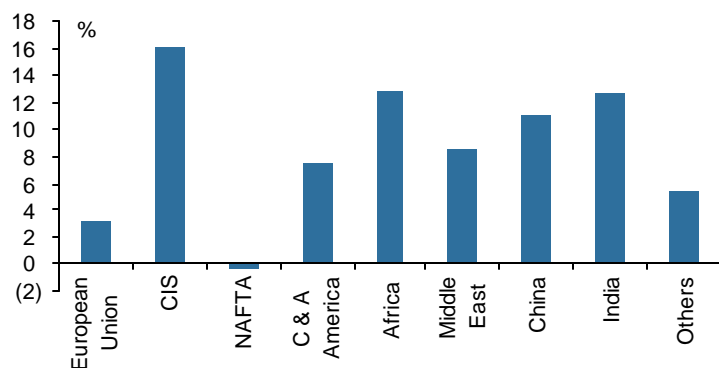
Steel demand upbeat, led by BRIC nations

Steel consumption in the BRIC nations increased at a steady pace during the decade. China, followed by India, have witnessed their steel consumption rise by a CAGR of 18.4% and 9.54% respectively in the last five years. Compared to these two countries, the demand growth in the other two has been slower. Brazil and Russia have witnessed their consumption increase by a CAGR of around 5% in the last five years.

But in the next five years, we expect Chinese consumption to moderate from its five year CAGR of 18.4% to 11.1% in the next two years. Consumption from India is expected to rise by a CAGR of 12.7% in the next two years as construction spending in the economy is set to increase. In the next two years, Russia is expected to outpace India and China and lead the overall BRIC nation's consumption. Russian steel consumption is expected to increase by a CAGR of 16% in the next two years, while Brazil is expected to witness its consumption grow around 10% in the next two years.

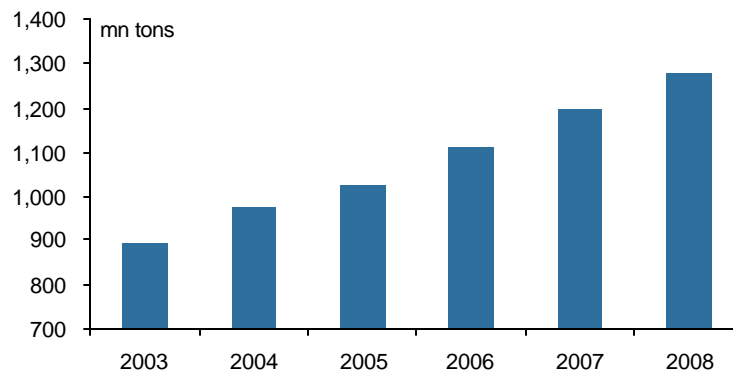
The BRIC countries, which accounted for about 41% of global steel demand in 2006, will again be leading the growth with an expected increase of 12.8% for CY07 and 11.1% for CY08. Overall, 77% of world consumption growth in CY07 and 71% in CY08 will be seen in the BRIC countries.

Change in steel consumption over CY06-08



Source: IISI, USGS, India Infoline Research

World steel consumption estimates



Source: IISI, USGS, India Infoline Research

China's steel use is expected to grow by 11.4% in CY07 and 11.5% in CY08, accounting for 35% of the world total. For India, forecasts for apparent steel use, point to an increase of 13.7% in CY07 and 11.8% in CY08.

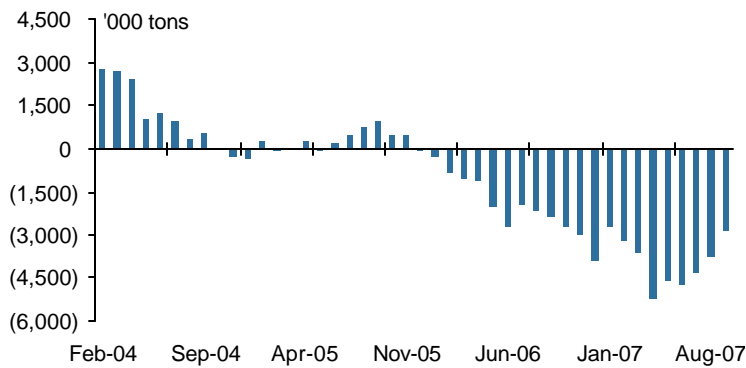
The Russian market is expected to grow by 25% for CY07 and 9.5% for CY08. The rise is mainly led by the energy and construction sectors. Also, steel consumption in Brazil is expected to increase by 15.7% for CY07 and 5.1% for CY08, with strong fixed capital formation partly driven by public investment programs.

The International Iron and Steel Institute (IISI) forecasts in October show that CY07 will be another strong year for the steel industry with apparent steel use rising from 1,120.9mn tons in CY06 to 1,197.6mn tons in CY07, an increase of 6.8%. It also expects consumption to rise further by 6.8% in CY08. These figures were revised upwards by 0.9% for 2007 and 0.7% in CY08 over its March forecast.

Government curbs to reduce supply from China

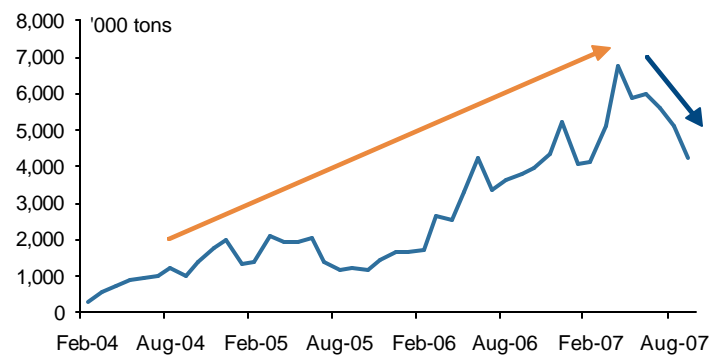
With one-third share of global production and consumption in CY06, China maintained its position as the largest producer and consumer of steel in the world. China, in the last five years has been the major force behind the two cycles witnessed in steel. In the first half of this decade, China led the markets in consumption, accounting for a major portion of world import markets. The huge domestic consumption led to local producers adding on huge capacities. The huge increase in production capacities in China transformed China into a net steel exporter in CY05. The surge in Chinese exports acted as a dampener in CY06 and led to steel prices falling to around US\$400 levels. Chinese exports increased month on month at a fast pace leading to an oversupply situation around the world.

Chinese net imports/ (exports)



Source: Bloomberg

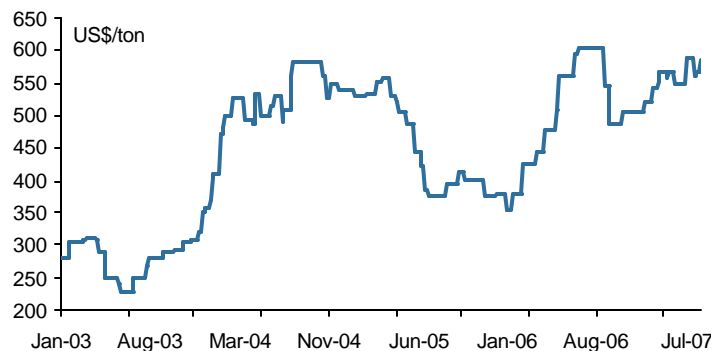
Chinese monthly exports



Source: Bloomberg

However in the last three months, the Chinese government has tried to maintain a check on exports. It witnessed a scenario of excess liquidity in its domestic markets and during the current year has levied steps to curb the flow of money into the economy. One of the measures it adopted during this period was to curb exports of primary metals. It levied extra taxes and removed the rebates received by manufacturers on exports. The government in July removed all the rebates received by the steel manufacturers on exports of 553 products. It has also increased its export tax on 83 products in June this year besides increasing the export duty on steel slabs from 10% to 15%.

CIS HR coil price chart



Source: Bloomberg

Chinese Government tax resolutions

Date	Chinese Government actions
September 15, 2006	Export rebates on major steel products reduced to 8% from 11%
November 01, 2006	Levy of export tax of 10% on steel semi products and pig iron
April 15, 2007	Removal of rebates on 83 steel products
May 20, 2007	Introduction of export licensing on 83 steel products
June 01, 2007	Levy of export taxes on most of the steel products
July 01, 2007	Removal of rebates on export of 553 products

Source: IISI

Chinese steel exports rose to its all time high of 6.7mn tons in April, a 268% rise year on year. The massive growth in exports led to the Chinese Government levying export duties with effect from July, 2007. Following the implementation of duties, exports fell sharply in the next two months. After rising to a high of 6.7mn tons in April, exports fell by 37.7% to 4.2mn tons in September. The export cut from China led to a deficit market, as supplies were not able to match demand. The fall in supply pushed steel prices higher from the lows of last year created by the oversupply scenario in CY06.

We expect that the supply from China to be curbed in the near term, pushing steel prices higher. Steel exports are expected to be around the current levels leading to a balanced steel market in the near term.

Soaring iron ore costs to push steel prices up

Iron ore prices, over the last one year have doubled led by a surge in the demand from China. Iron ore prices have been debated largely as markets expect that the surge in iron ore prices have not ended and it will continue to rise in the next calendar year. China has been hungry for raw materials in the last five years and the demand is not expected to slowdown in the near term. China has seen its steel production triple in the last five years. The raw material for the production rise largely has been supported by iron ore imports in the last two years. China imports a major portion of its iron ore consumed as the local production accounts for only 40-45% of total demand.

Steel manufacturing capacities in China as well as in the rest of the world are rising at a rate of 10% in the next two years. New steel manufacturing capacities are built in areas where the iron ore is easily available. The new capacities in the iron ore producing areas of India, Brazil and Australia will lead to lower exports from these countries to China. Global steel production has grown 46.4% in the last five years from 850mn tons in CY01 to 1,244mn tons in CY06, led by 197% steel production growth in China from 142mn tons to 423mn tons in CY06.

The strong growth in the steel demand is expected to continue and the International Iron and Steel Institute (IISI) forecasts 2007 will be another strong year for the steel industry with apparent steel use rising from 1,120.9mn tons in CY06 to 1,197.6mn tons in CY07, an increase of 6.8%. BRIC nations, which accounted for about 41% of global steel demand in 2006, will again be leading the growth in the next two years. China's apparent steel use is expected to grow by 11.4% in 2007 and 11.5% in 2008. For India, steel consumption will increase by 13.7% in CY07 and 11.8% in CY08.

Chinese iron ore demand estimates

	2004	2005	2006	2007E	2008E
Crude steel production	274	353	423	482	597
Pig iron production	257	337	404	461	566
Consumption (Mt iron ore, @63%Fe)	416	547	655	747	917
% change in iron ore consumption		31.5	19.7	14	22.8

Source: IISI, USGS, India Infoline Research

The growth in steel manufacturing will lead to higher demand for iron ore. We believe the shortage has been caused by booming Chinese and world steel production, a major shortfall in seaborne iron ore exports this year and a slowdown in the rate of growth of domestic iron ore production in China. The small price hike of 9.5% in iron ore contracts at the start of the year was low and we expect the prices to go higher as the year spans out. We expect iron ore contracts will be settled at 50-60% incremental rates from that of CY07. The shortage of iron ore availability is expected to continue and the rise may continue till CY09.

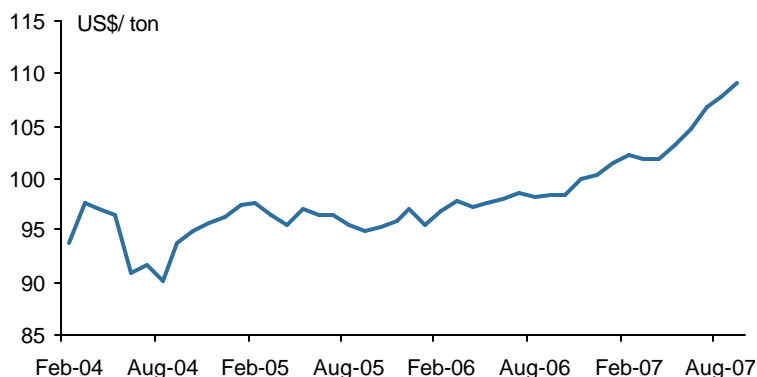
We expect iron ore contracts to rise by 50% in CY08 and 15-20% further in CY09. The phenomenal surge in the Chinese market in recent months amid a growing shortage of iron ore is one of the major reasons for the jump in iron ore prices.

Manufacturing costs to swell in CY08

Raw material costs account for more than 50% of total manufacturing costs. Iron ore and coal are the major raw materials used for steel manufacturing. As mentioned above we expect iron ore costs to increase by 50-60% in CY08. This increase in iron ore costs is expected to push the per ton cost of manufacturing by US\$30-35.

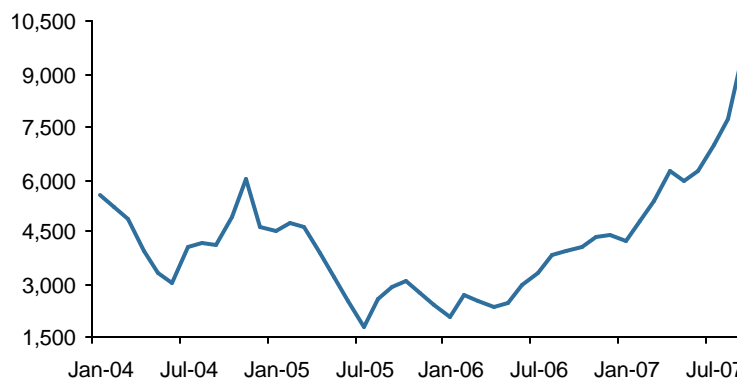
Along with iron ore, coking coal the other raw material used for steel manufacturing is also expected to witness a price rise. The strong demand from the steel sector and the lower growth in coal mining over the next two years will push coking prices higher from the current levels. Coking coal prices are expected to rise by 25-30% in CY08, leading to a steel manufacturing cost rise by US\$10-15.

Coking coal price chart



Source: Bloomberg

Baltic Dry Index (BRI)



Source: Bloomberg

Adding to the incremental raw material costs, freight costs have been on the rise during the year. The trend is expected to continue for the next year. Major deposits of iron ore and coking coal are located in Latin America nations, in Asian countries like China and India and in Australia. One third of global steel production comes from China, but the domestic iron ore production is not able to meet the increasing demand in the country. As a result, it has to import half its raw material requirement. The transport facilities around the world are not able to match the high flow of materials across the countries. The mismatch has pushed freight costs higher across countries adding to rising raw material costs. We expect freight costs to increase by 10% in the next one year, pushing raw material costs by US\$10-15.

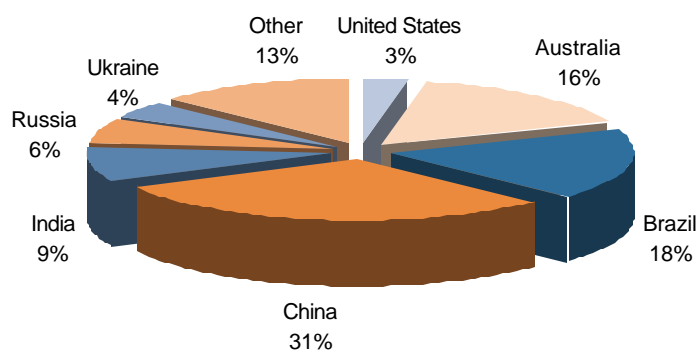
Thus, the raw material costs will increase production costs higher by US\$55-65 in CY08. The rise in manufacturing costs will lead to steel manufacturers hiking prices in CY08. Manufacturers may not be able to pass on the full raw material cost rise. We expect steel prices will increase by US\$35-50 in CY08 led by the high raw material costs.

Iron ore production

Iron ore industry has witnessed vast mergers and acquisitions in the last couple of years. Iron ore supplies in the recent past have been a major factor looked at when major mergers or acquisition have taken place. Steel making Greenfield projects have been started in areas where iron supply has been abundant.

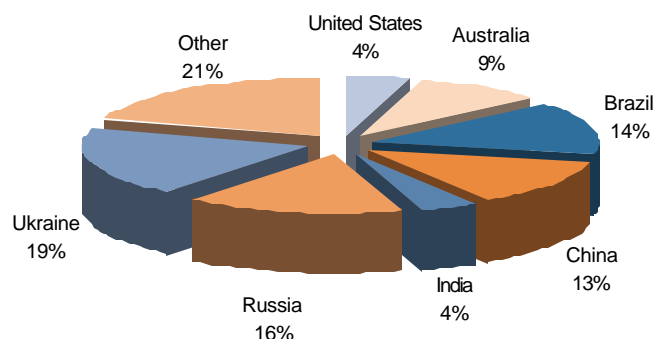
Iron-rich rocks are common worldwide, but ore-grade commercial mining operations are dominated by the countries like China, Brazil, Australia and India. These four countries contributed to around three quarters of the total iron ore supply in CY06. The major constraint to economics for iron ore deposits in other countries has been the position of the iron ore relative to market, the cost of rail infrastructure to get it to market and the energy cost required to do so.

Iron ore production in CY06



Source: USGS, IISI

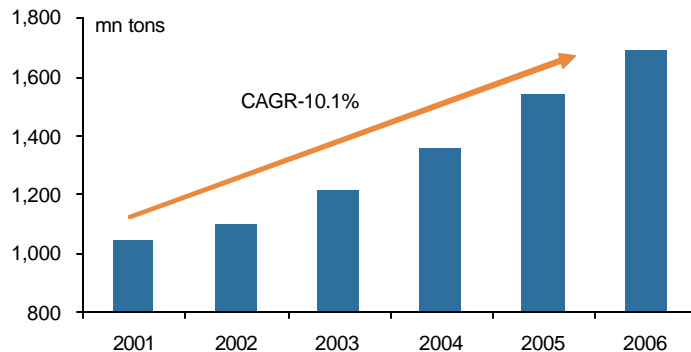
Iron ore reserves



Source: USGS, IISI

China is the largest producer of iron ore, contributing around 31% of global iron ore supply in CY06. China has been the largest producer of iron ore in the last five years. China has been the major contributor for the growth in global iron ore production in the last five years. China is followed by Brazil and Australia, contributing around 18% and 16% respectively of the global production. India contributes around 9% of total supply, maintaining its share of 8-9%.

Iron ore production



Source: USGS, IISI

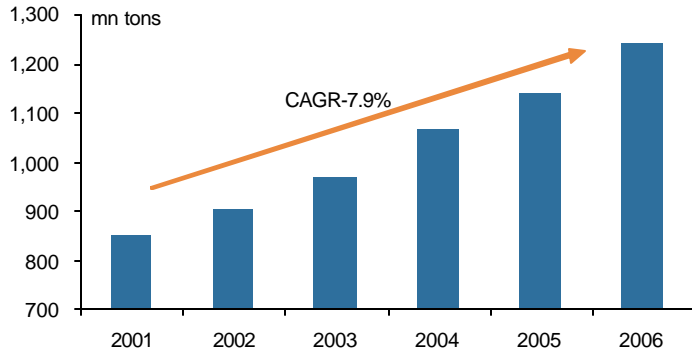
Global iron ore production has increased to 1,690mn tons in CY06, an increase of 9.7% over 1,540mn tons achieved in CY05. In the last five years, iron ore production has witnessed a CAGR of 10.1% higher than the demand for steel over the same period. The easy availability of iron ore led to iron ore prices remaining subdued in before CY06. China accounted for 47% of the total increase in global iron ore production in the last five years. Doubling of Chinese output has led China increasing its share to 31% in CY06 from 21.5% in CY05.

In the last five years, iron ore supply has increased in areas where the iron content is higher. Though Ukraine has around 19% of the total iron ore reserves, it accounts only 4% of global supply in CY06. The iron content in Ukraine is lower as it accounts for only 11.2% of total iron content in global iron ore reserves against an 18.7% share in global iron ore reserves. Brazil has around 20.3% of total iron ore content against a 14.4% share of total iron ore content.

Crude steel production

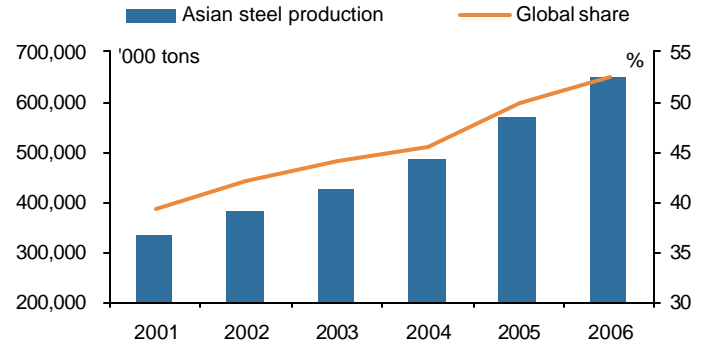
World crude steel output in CY06 reached 1,239.5mn tons as per International Iron and Steel Institute (IISI). This was an increase of 8.8% over CY05 and also represents the highest level of crude steel output in history. 2006 was also the third consecutive year in which crude steel output has been above 1 billion tons.

Global production



Source: USGS, IISI

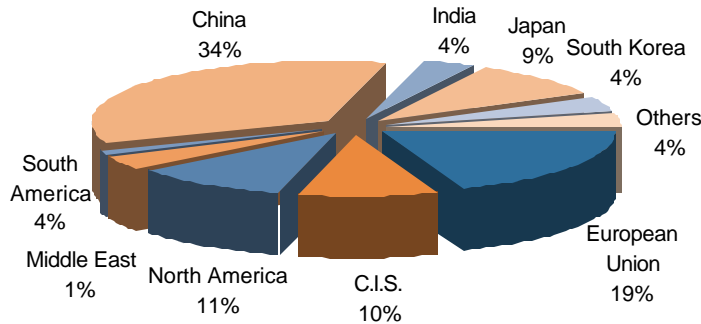
Asian steel production and global share



Source: USGS, IISI

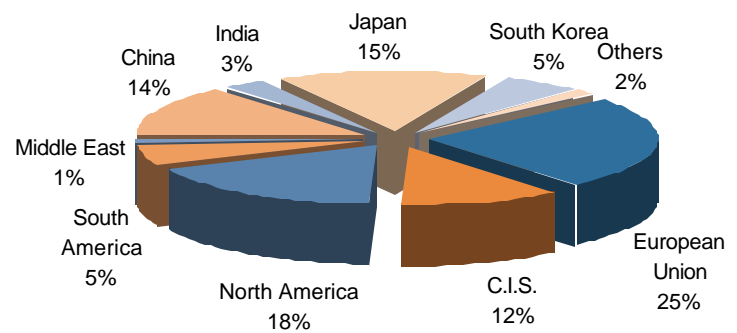
Crude steel production in CY06 was 65.3% above the total production for the world ten years ago. It is also 45.7% above the total production achieved five years ago. Global crude steel production has increased by a CAGR of 7.9% in the last five years. The supply growth rate was slightly higher than the 7.6% demand growth in the last five years.

Country-wise contribution in CY06



Source: USGS, IISI

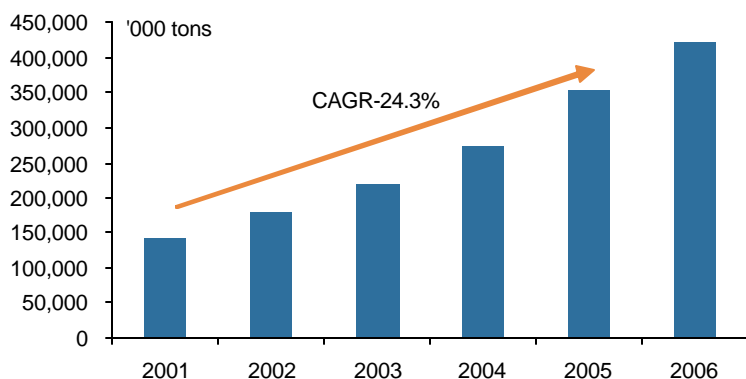
Country-wise contribution in CY95



Source: USGS, IISI

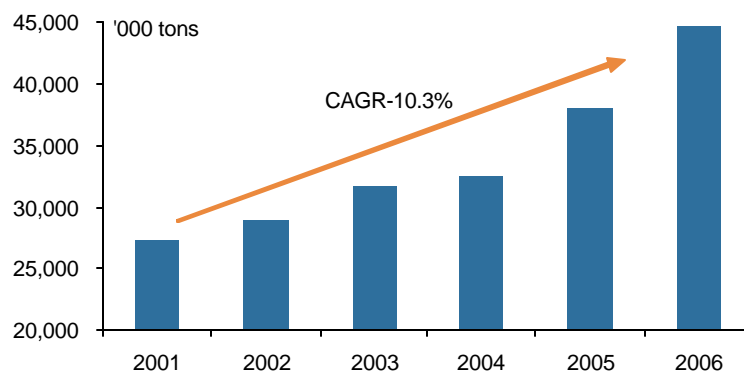
However, over the past ten years the most remarkable growth has been in China and the Asia region. In 1996, China produced 101.2mn tons of crude steel. By 2001 this had risen to 150.9mn tons, an increase of 49.1% and in 2006, China produced 418.8mn tons of crude steel, an increase of 313.8% in just ten years. China's share of world crude steel production has also increased exponentially. In 1996, China became the largest steel producing country in the world for the first time, accounting for just 13.5% of production. In 2006, this share had risen to 33.8%, just above one third of all crude steel produced in the world.

Chinese steel production



Source: USGS, IISI

Indian steel production



Source: USGS, IISI

Crude steel production

Rank 2006	Rank 2005	Country	2006	2005	% Change
1	1	China	418.8	355.8	17.7
2	2	Japan	116.2	112.5	3.3
3	3	USA	98.5	94.9	3.8
4	4	Russia	70.6	66.1	6.8
5	5	South Korea	48.4	47.8	1.3
6	6	Germany	47.2	44.5	6.1
7	7	India	44.0	40.9	7.6
8	8	Ukraine	40.8	38.6	5.7
9	10	Italy	31.6	29.4	7.5
10	9	Brazil	30.9	31.6	(2.2)

Source: USGS, IISI

Ten years ago the Asia region accounted for 38.4% of all crude steel produced. By 2001, this percentage had risen to 41.6%. In 2006, the Asia region accounted for 53.7% of world crude steel production. In 2006, the top three steel producing countries were China (418.8mn tons), Japan (116.2mn tons) and the US (98.5mn tons). Brazil has slipped from ninth to tenth place in the list of the top ten steel producing countries. It is also the only country in the list to show negative production in 2006.

Crude steel consumption

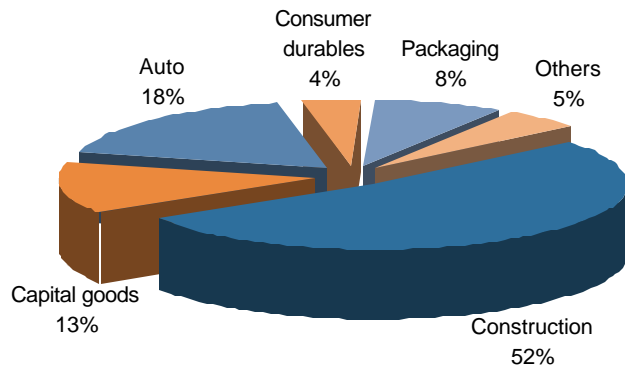
Steel probably has the widest applications. The wide range of alloy compositions, mechanical properties and product forms available make it a versatile material which is used in components and products that may be small or large, high-tech or low-tech, everyday or specialist. The pace of social and economic growth has been closely linked to the proficiency with which people have been able to use and shape various materials. Steel has played an important role in the development of mankind in the past century. Today, it is difficult to imagine a world without steel. We depend on steel for almost everything from our houses and buildings, the cars we drive, roads, bridges, agricultural equipment, machines, the list is endless.

Today, consumption of steel is also regarded as an indicator of development of a nation. Per capita steel consumption is now universally accepted as an index of economic development of a nation. Given its role, steel has established itself as the backbone of any economy. Here is just a small selection of its uses, of which many are found in our everyday life:

- **Home:** Domestic appliances such as refrigerators, washing machines, ovens and microwaves, sinks, radiators, cutlery, hi-fi equipment, food and beverage cans, razors, pins.
- **Travel and transport:** Car bodies, engine components, wheels, axles, trucks, transmissions, trains, rails, ships, anchor chains, aircraft undercarriages, jet engines components.
- **Construction:** Low and high rise buildings, housing, modular buildings, retail, industrial, education and hospital buildings, sports stadiums, stations, reinforcing bars for concrete, bridge deck plates, piers and suspension cables, harbours, cladding and roofing, office, tunnels, security, coastal and flood defenses.
- **Power and energy:** Oil and gas wells and platforms, pipelines, electricity power turbine components, electricity pylons, wind turbines.
- **Electrical and magnetic:** Electromagnets, transformer cores, electromagnetic shields.
- **Capital goods:** Earth-moving and quarrying equipment, cranes, fork-lift trucks.
- **Agriculture and industry:** Farm vehicles and machinery, storage tanks, tools, structures, walkways, protective equipment.

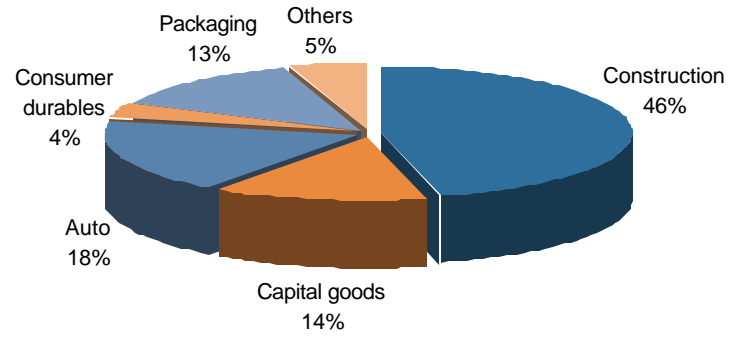
The construction sector accounts for more than half of the global steel consumption. The percentage share varies from country to country, as in the Asian countries the construction sector consumes more than 60% whereas the rest of the world account for a nearly 50% of total consumption. In the Asian countries automobiles consume less amount of steel as compared to Western countries. Packaging constitutes a higher share of total demand in the Western countries as compared to its Asian counterparts.

World consumption pattern



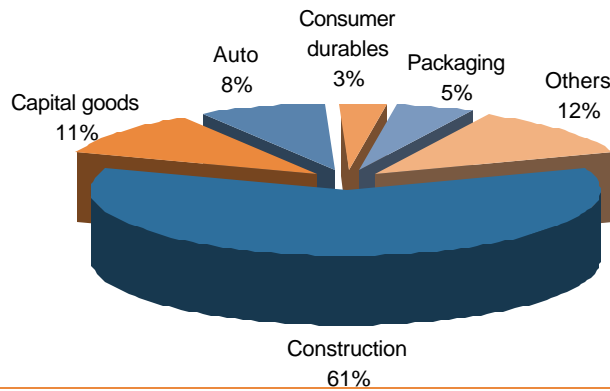
Source: USGS, IISI

EU consumption pattern



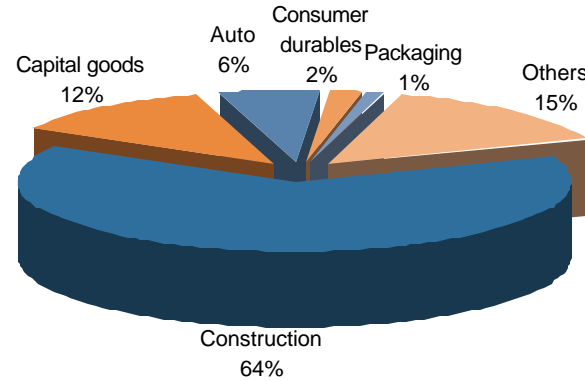
Source: USGS, IISI

Indian consumption pattern



Source: USGS, IISI

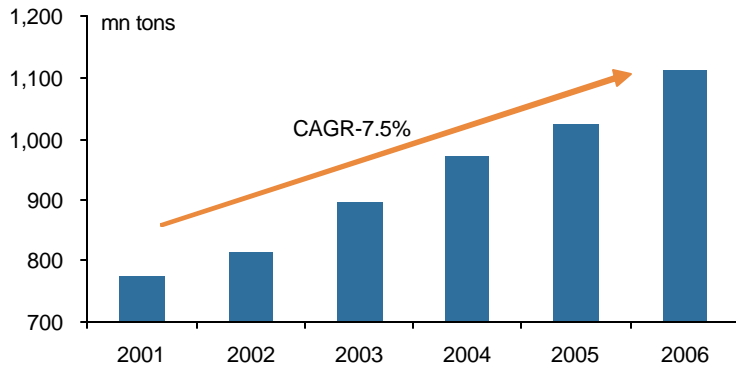
Chinese consumption pattern



Source: USGS, IISI

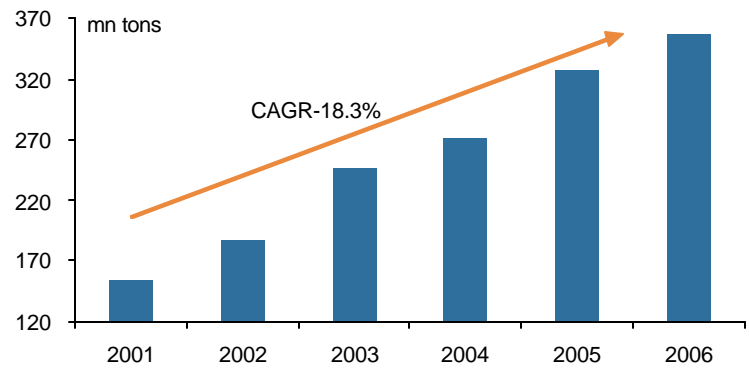
Steel demand globally has been buoyant in the last five years with major economies growing steadily, led by the emerging markets of India and China. The strong role played by steel in the growth of economies was indicated by the double digit CAGR witnessed in the BRIC countries. Global steel consumption witnessed a CAGR of 7.5% in the last five years led by CAGR of 18.3% for China. India and Middle East witness its consumption increase by a CAGR of 9.5% in the last five years. In the last 10 years, steel consumption grew at a rate of 5.3%. The European Union witnessed a CAGR of 3.4% in the last five years. India, the other Asian emerging country saw its consumption increase by a CAGR of 9.5% from CY01.

Global consumption



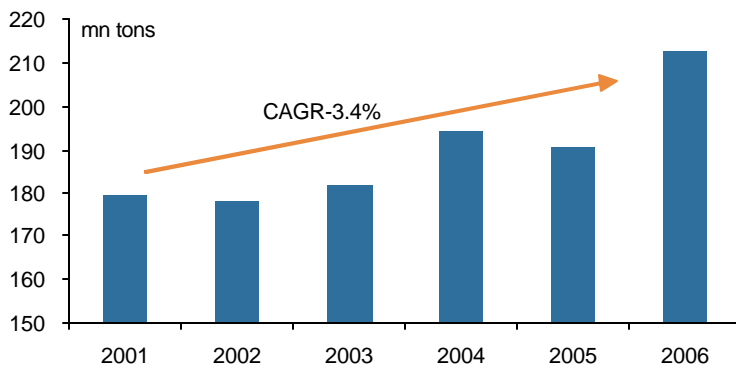
Source: USGS, IISI

Chinese consumption



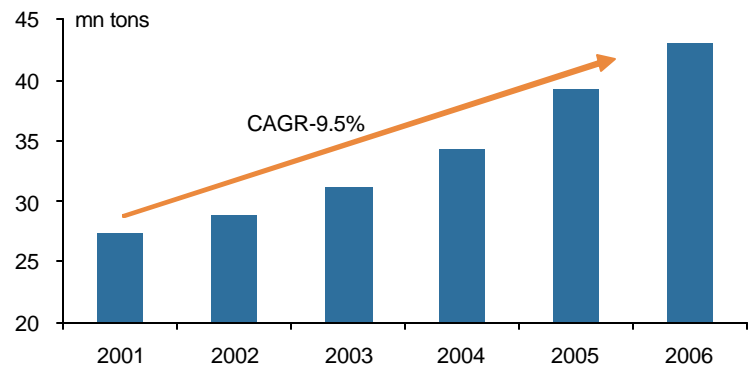
Source: USGS, IISI

European Union consumption



Source: USGS, IISI

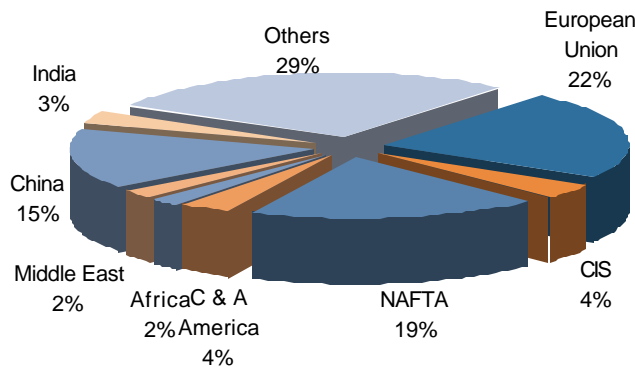
Indian consumption



Source: USGS, IISI

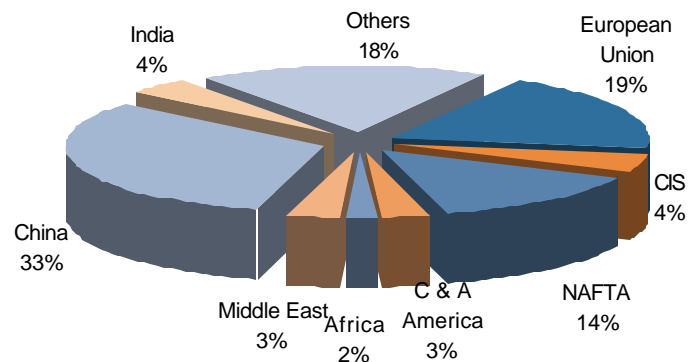
In CY06, global consumption increased by 8.5% to 1,113.2mn tons from 1,026.3mn tons consumed in CY05. In CY06, the European Union surprised the market as its consumption witnessed a growth of 11.6% against a CAGR of 3.6% in the last five years. Demand from CIS and NAFTA nations also increased by 12.8% and 11.1% respectively in CY06, higher than the growth witnessed in the last five years. The Western countries consumption growth rate was higher than the growth rate witnessed in the Asian countries for the first time in the last five years.

Country wise steel consumption in 1995



Source: USGS, IISI

Country wise steel consumption in 2006



Source: USGS, IISI

China was the largest consumer of steel globally in CY06, for the tenth straight consecutive year. It consumed around one third of global steel consumption in CY06, followed by US and Japan. Chinese consumption in CY06 was 356.2mn tons, an increase of 18.3% CAGR in the last five years. Chinese steel consumption has risen three and a half times in the last ten years. During the last ten years, China increased its global share from 15% to 33%.

Introduction

Steel is an alloy of iron and carbon containing less than 2% carbon and 1% manganese and small amounts of silicon, phosphorus, sulphur and oxygen. Steel is the most important engineering and construction material in the world. It is used in every aspect of our lives, from automotive manufacture to construction products, from steel toecaps for protective footwear to refrigerators and washing machines and from cargo ships to the finest scalpel for hospital surgery.

Carbon and other elements act as a hardening agent, preventing dislocations in the iron atom crystal lattice from sliding past one another. Varying the amount of alloying elements and form of their presence in the steel controls qualities such as the hardness, ductility, and tensile strength of the resulting steel. Steel with increased carbon content can be made harder and stronger than iron, but is also more brittle.

The maximum solubility of carbon in iron (in austenite region) is 2.14% by weight, occurring at 1149 °C; higher concentrations of carbon or lower temperatures will produce cementite. Alloys with higher carbon content than this are known as cast iron because of their lower melting point. Steel is also to be distinguished from wrought iron containing only a very small amount of other elements, but containing 1–3% by weight of slag in the form of particles elongated in one direction, giving the iron a characteristic grain. It is more rust-resistant than steel and welds more easily.

Iron, like most metals, is not usually found in the Earth's crust in an elemental state. Iron can be found in the crust only in combination with oxygen or sulfur. Typical iron-containing minerals include Fe_2O_3 the form of iron oxide found as the mineral hematite and FeS_2 pyrite. Iron is extracted from ore by removing the oxygen by combining it with a preferred chemical partner such as carbon. This process, known as smelting, was first applied to metals with lower melting points. Cast iron, iron alloyed with greater than 1.7% carbon melts at around 1370 °C. All of these temperatures could be reached with ancient methods that have been used for at least 6000 years (since the Bronze Age). Since the oxidation rate itself increases rapidly beyond 800 °C, it is important that smelting take place in a low-oxygen environment.

Types of steel

All steel products are made from semi-finished steel that comes in the form of slabs, billets and blooms. Steel products can be broadly classified into two basic types according to their shape:

Flat products

Derived from slabs, this category includes plates and hot rolled (HR) steel such as coils/sheets. While plates are used for applications such as shipbuilding, etc., HR steel is the most widely used variety of steel and other downstream flat products such as cold rolled (CR) steel and galvanized steel are made from it.

HR steel has a variety of applications in the manufacturing sector. It is primarily used for making pipes and has many direct industrial and manufacturing applications, including the construction of tanks, railway cars, bicycle frames, ships, engineering and military equipment and automobile and truck wheels, frames and body parts. Cold rolled steel is used primarily for precision tubes, containers, bicycles, furniture and for use by the automobile industry to produce car body panels. Galvanized steel is used for making roofs in the housing and construction sector.

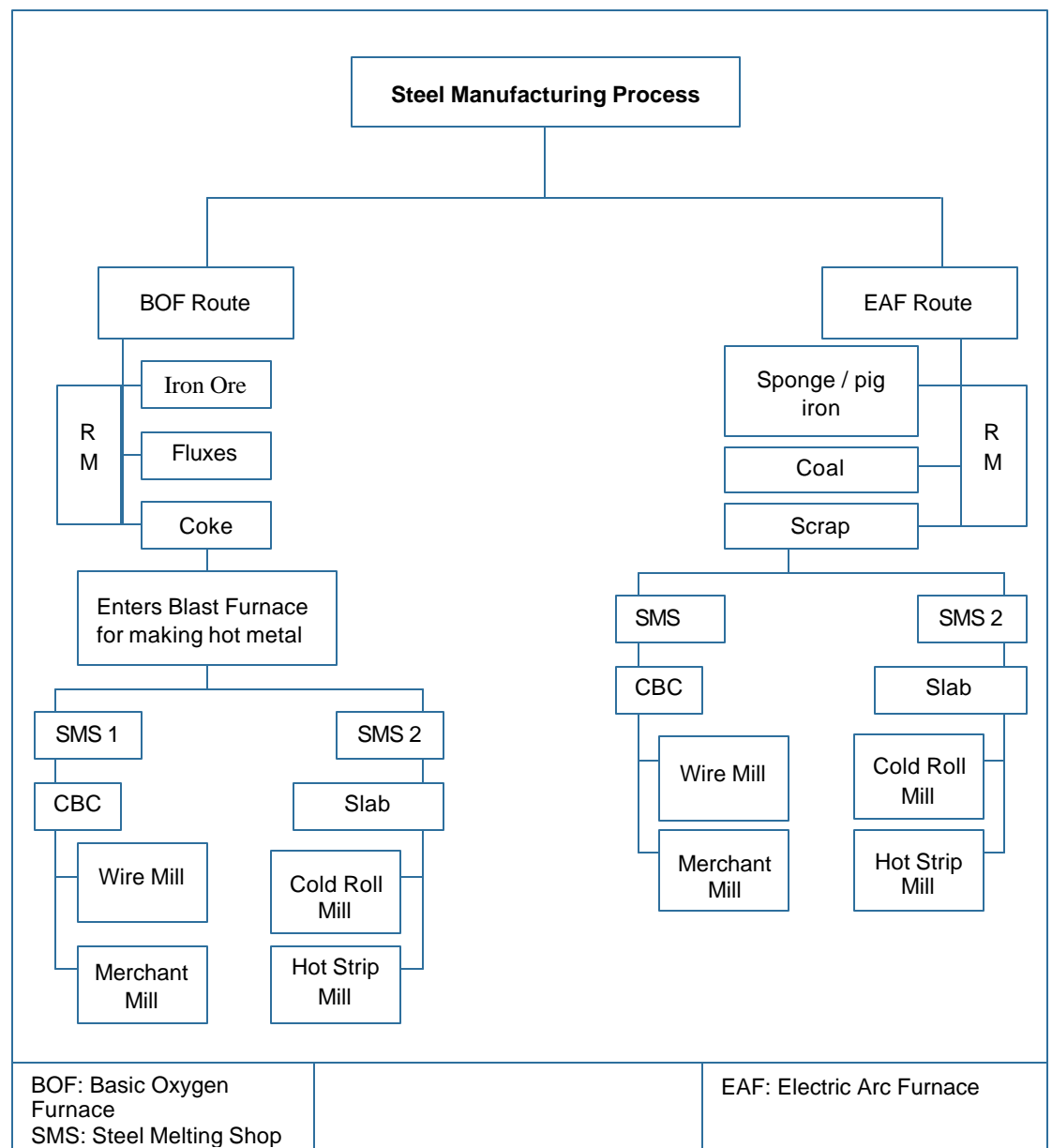
Long products

These products derive their name from their shape. They are made using billets and blooms and include rods, bars, pipes, ropes and wires, which are used largely by the housing/construction sector. There are also other products like rail tracks in the category.

Semi-finished steel is also used to produce other varieties of specialized steel such as alloy steel.

Manufacturing process of steel

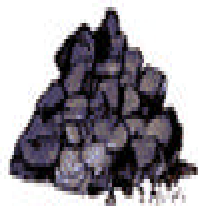
Steel can be manufactured through either Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF). Manufacturers who use the BOF route to produce steel are known as primary steel producers or Integrated Steel Plants, while those producing through EAF are called as Mini Steel Plants.



Source: India Infoline Research

Basic Oxygen Furnace (BOF)

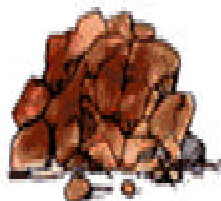
Basic oxygen furnace route of manufacturing steel is a commonly used method to produce steel. Major raw materials required for making steel through this route are: iron ore in fines or lumps, limestone or other fluxes and coke. Iron ore fines are not suitable to make steel therefore they are converted into lumps and used along with fluxes and coke to prepare a granular form in the Mixers.



Coal



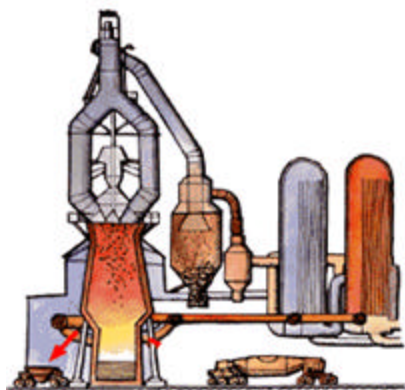
Limestone



Iron Ore



Coke Oven



Blast Furnace

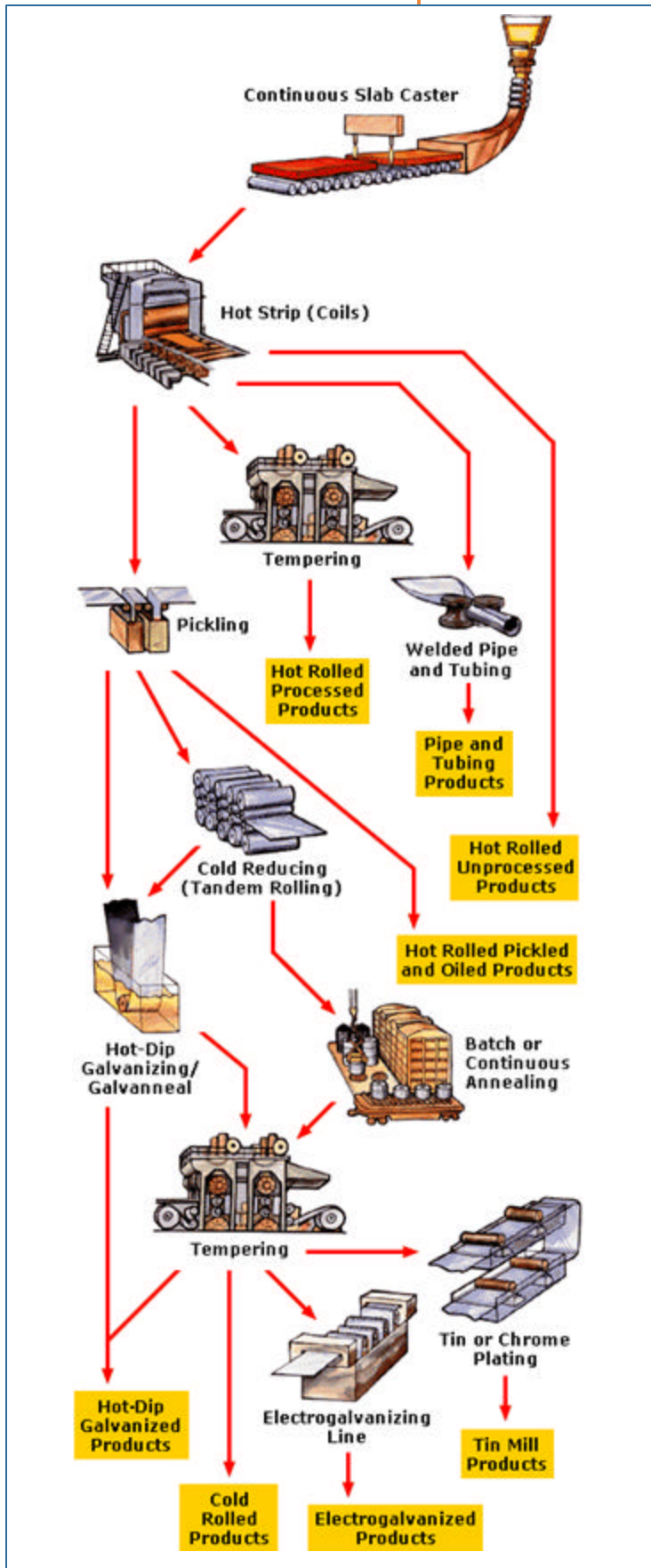
Limestone or other fluxes are used to remove acidic impurities from molten iron. These ingredients are put in a mixer to make iron ore lumps. Heat generated through combustion during the mixing process itself creates lumps of hot sinter. This is then cooled and stored in smaller sizes to be used in the blast furnace. This is used to make hot metal of desired quality in the blast furnace.

Naturally obtained coal cannot be used for steel making as it contains fixed carbon, ash, moisture and other impurities. Therefore, to improve its crushing strength and reduce volatile matter, it is converted into coke in the coke oven. Coal is graded as premium, medium and blendable based on its properties. Blending of different grades of coal is necessary for achieving the required properties of coke.

All ingredients i.e. iron lumps along with coke are put into the blast furnace where hot metal is produced. A blast furnace is a type of furnace for smelting whereby the combustion material and ore are introduced along with air from the bottom of the chamber such that the chemical reaction takes place all rounds. Coke is added to the furnace as it is used to attain high temperatures required for reduction of iron oxide into molten iron. Fluxes are added to create a low melting slag and control the quality of hot metal.

Hot metal and slag are collected in the heart of the furnace and tapped regularly. The process upto here is known as iron making. From hereon, hot metal is taken to produce steel in the steel melting shop. Hot metal is converted into steel after removing carbon, silicon, sulphur and phosphorous contents from it. Liquid steel is then converted into billets in the continuous casting machine. A portion of steel is converted into ingots using cast iron moulds. Special grade steel are cast as ingots after degassing and refining.

Source: IISI



Steel is either sent to merchant mill or wire mill or is further processed and sent to make HR coils or CR coils. In the merchant mill steel billet/ingot is passed through reheating furnace where it is heated to make it softer so as to cut it into smaller sizes and roll into desired width. The metal is rolled into the specified width and then passed through water boxes and then cut into desired sizes. Similar is the process for wire mill too where steel ingot/billet is passed through furnace and then through rolling mills to flatten the commodity and passed through water box. It is then passed through another set of rolling mills and water boxes before it is spiraled to form wires.

Steel ingot/billet is used to make HR coils and CR coils. For making HR coils it is sent to HR mill where the slab is reheated to soften the slab and then rolled to make it flat. This flat steel is then coiled in the coil box and flattened again before it is sent to the finishing mills. At the finishing mills the commodity is made of the desired thickness and sent ahead to laminar cooling. Post this flat is recoiled to make HR coils.

HR coil is passed through hydrogen batch annealing and then the skin pass mill from where it is sent to the packaging line after rolling and inspection. HR coils can also be passed through continuous galvanizing line for making auto, appliance, engineering or construction grade steel.

Electric Arc Furnace (EAF)

This is the second route to manufacture steel. Steel is manufactured via this process uses scrap or sponge iron, i.e. Direct Reduced Iron (DRI) as the basic raw material.

An electric arc furnace used for steelmaking consists of a refractory-lined vessel, usually water-cooled in larger sizes, covered with a retractable roof, and through which one or more graphite electrodes enter the furnace. For a typical AC furnace three electrodes are used.

The regulating system maintains an approximately constant power input during the melting of the charge. The mast arms holding the electrodes carry heavy bus bars, which may be hollow water-cooled copper pipes, used to convey current to the electrode holders.

To produce a ton of steel in an electric arc furnace requires close to 400 kilowatt-hours per short ton or about 440 kW·h per metric ton (1.5 kJ/g). Electric arc furnace steelmaking is economical where there is a plentiful supply of electric power, with a well-developed electrical grid.

Unlike the basic oxygen route, EAF does not use hot metal. It is charged with "cold" material, this is normally steel scrap. Other forms of raw materials are however available which have been produced from iron ore. These include direct reduced iron (DRI) and iron carbide, as well as pig iron, which are iron from a blast furnace, which has been cast and allowed to go cold, instead of being charged straight into a basic oxygen vessel.

Steel scrap (or other ferrous material) is first tipped into the EAF from an overhead crane. A lid is then swung into position over the furnace. This lid contains electrodes, which are lowered into the furnace. An electric current is passed through the electrodes to form an arc. The heat generated by this arc melts the scrap.



Adding steel scrap



Adding molten iron



Molten steel is removed



Slag is removed

Source: IISI

During the melting process, other metals (ferro-alloys) are added to steel to give it the required chemical composition. As with the basic oxygen process, oxygen is blown in to the furnace to purify the steel and lime and fluorspar are added to combine with impurities and form slag.

After samples have been taken to check the chemical composition of steel, the furnace is tilted to allow the slag, which is floating on the surface of molten steel, to be poured off. The furnace is then tilted in the other direction and molten steel poured (tapped) into a ladle, where it either undergoes secondary steelmaking or is transported to the caster.

The modern electric arc furnace typically makes 150 tons in each melt, which takes around 90 minutes.

Integrated Steel Plants

The major raw materials in an integrated steel plant are iron ore lumps, coke, limestone and dolomite. Iron ore in the form of pellets and sinters are also used sometimes, to improve furnace productivity. The raw material is charged in a blast furnace where hot air is blown at around 1600^oC. The molten metal formed is devoid of carbon impurities and when solidified is called pig iron. Slag is separated from molten metal and can be used as an input to make cement.

Pig iron is further reduced in a steel melting shop. This reduced pig iron that has more Iron content is called steel. Molten steel can be further processed to make alloys such as steel etc. Otherwise, the molten steel is passed through a continuous casting process to make billets blooms, slabs etc. Steel, at this stage is known as semi finished steel. This steel can be further processed in a rolling mill and rolled out as flat and long products.

The semi steel is reheated further and rolled into long products like structurals, bar and angles or rolled into flat products like HR plates or coils. HR coils can be further treated to make CR coils, which have reduced thickness. CR plates are further treated in a galvanized plant with zinc to make plates or corrugated sheets (GP/GC).

Mini Steel Plant

In a Mini Steel Plant, the raw materials used are scrap or sponge iron in the form of Direct Reduced Iron (DRI) or Hot Briquette Iron (HBI). Scrap/sponge iron is passed through an electric arc and the metal is melted. Molten metal is reduced to get steel. At this stage, steel can be converted into stainless steel by addition of chromium and nickel or cooled to make semi-finished steel. Semi finished steel is further rolled in the same manner as in an integrated steel plant.

Consuming industries of steel

Agricultural	Automotive Parts	Containers	Pressure Tube and Pipe
Farm Machinery	Air Filters	Aerosol Cans	Air Heater Tubes
Grain Bins	Axles	Food Cans	Boiler Tubes
	Bumper Shocks	Jar Lids	Heat Exchange/ Condenser Tubes
Appliances	Engine Cradles	Steel Drums	
Air Conditioners	Exhaust Systems	Insecticide Cans	Rack and Pinion Systems
Dishwashers	Frames	Paint Cans	Rims and Wheels
Furnaces			Steering Columns
Gas and Electric Ranges	Construction	Miscellaneous	Truck Clutches
Microwave Ovens	Building Panels	Bathtubs	
Refrigerators	Conduit Elbows	Bleachers	Recreational
Toasters	Culvert Pipe	Computer Cabinets	Bicycles
Vacuum Cleaners	Electrical Conduit	Copy Machines	Camping Equipment
Washers and Dryers	Scaffolding	Curtain Rods	Exercise Equipment
	Standard Pipe	File Cabinets	Swimming Pools
Automotive	Steel Studs	Garage Doors	
Buses		Light Poles	
Cars	Hardware	Oxygen Tanks	
Trucks	Ladders	Venetian Blinds	
Vans	Lawn Mowers		
	Tools		

Types and uses

Iron and steel are used widely in the construction of roads, railways, infrastructure and buildings. Most large modern structures, such as stadiums and skyscrapers, are supported by a steel skeleton. Even those with a concrete structure will employ steel for reinforcing. In addition to widespread use, in electrical appliances and motor vehicles steel is used in a variety of other construction-related applications, such as bolts, nails, and screws. Other common applications include shipbuilding, oil and gas pipelines, mining, aerospace, office furniture, steel wool, tools, and armour in the form of personal vests or vehicle armour.

- Steel is often classified by its carbon content:
 - a high-carbon steel is serviceable for dies and cutting tools because of its great hardness and brittleness;
 - Low- or medium-carbon steel is used for sheeting and structural forms because of its amenability to welding and tooling.
- Alloy steels, now most widely used, contain one or more other elements to give them specific qualities.
 - Aluminum steel is smooth and has a high tensile strength.
 - Chromium steel finds wide use in automobile and airplane parts on account of its hardness, strength, and elasticity, as does the chromium-vanadium variety.
 - Nickel steel is the most widely used of the alloys; it is nonmagnetic and has the tensile properties of high-carbon steel without the brittleness.
 - Nickel-chromium steel possesses a shock resistant quality that makes it suitable for armor plate.
 - Wolfram (tungsten), molybdenum, and high-manganese steel are other alloys.
 - Stainless steel, has a high tensile strength and resists abrasion and corrosion because of its high chromium content

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