LECTURE 1: INTRODUCTION

Contents:

Key words: steel industry, steel plants, mini steel plants, integrated steel plants, steel production and consumption

Attributes:

Steel belongs to iron carbon system. This system has a unique feature to alloy with several elements of the periodic table to produce materials for diversified applications.

Iron-Carbon system is capable of creating any desired property by altering the microstructure through surface hardening, heat treatment and deformation processing.

Steel is recyclable and hence is a “green material”.

The above attributes make steel to be the most important engineering material. Around 2500 different grades are produced to cater the need of several industries ranging from structural to aero-space.

Types of steels: Below are given some applications. Details can be looked into references given at the end of the lecture.

Broadly we have either plain carbon (carbon is the principle alloying element) or alloy (in addition to carbon there are other alloying elements like Nb, V, W, Cr, Ni etc) steel. Plain carbon steels are the following types:

Properties	Low carbon	Medium carbon	High carbon
Carbon	Lower than 0.25 weight Percent	In between 0.25 and 0.6 weight percent	In between 0.6 and 1.4 weight percent
Some properties	Excellent ductility and toughness. Weldable and machinable Not amenable to Martensite transformation	Low hardenabilty. These steel grades can be heat treated	Hardest, strongest and Least ductile
Some applications	Common products like Nuts, bolts, sheets etc.	For higher strength such as in machinery, Automobiles and agric-cultural parts (gears, axels, connecting rods) etc.	Used where strength, hardness and wear resistance is required. Cutting tools, cable, Musical wires etc.

The alloy steels are classified as low (less than 5 weight% alloying elements), medium (in between 5 to 10 weight percent alloying elements) and high alloy steels (more than 10 weight percent alloying elements).

Note: Whether plain carbon or alloyed ones, all steels contain impurities like sulphur, phosphorus, hydrogen, nitrogen, oxygen, silicon and manganese, tramp elements like copper, tin, antimony, and non-metallic inclusions. These impurities are to be controlled during steelmaking

Effect of impurity elements on steel properties (some effects are given; details can be seen in the references given at the end of this lecture)

Carbon imparts strength to iron. It reduces ductility and impact strength. But presence of carbon allows heat treatment procedures.

Sulphur segregates during solidification (segregation coefficient is 0.02). Sulphur causes hot shortness due to formation of FeS formed during solidification of steel. Sulphide inclusions lower weldability and corrosion resistance. Presence of sulphur may also lead to development of tear and cracks on reheating the steel.

Phosphorus segregates during solidification (segregation coefficient is 0.02). Presence of phosphorus impairs plastic properties.

Silicon and manganese: Silicon reduces the drawing capacity of steel. Manganese is beneficial; it increases strength without affecting ductility and sharply reduces hot shortness.

Gases: Nitrogen impairs plastic properties and increases embrittlement at lower temperatures. Hydrogen causes defects such as flakes, fish-scale fracture.

Inclusions: Presence of inclusions at the grain boundary weakens intra-granular bonds. Inclusions also act as stress concentrators. Some type of inclusions is brittle.

Tramp elements: Tramp elements like copper, zinc, tin, antimony etc create problems during reheating of steels because their melting points are much lower than steel reheat temperature.

Historical Perspectives:

Year	**Developments**
1856	Henry Bessemer developed a process for bulk steel production. He blew air in an acid lined pear shaped vessel. The process is termed Acid Bessemer Process. No heat was supplied from outside. It did not become possible for him to remove S and P. Moreover oxygen content of steel was high. Hot shortness was a problem during rolling.
1878	S.G.Thomas and Gilchrist developed basic Bessemer process. They lined the vessel with basic refractory. High nitrogen content of steel, no usage of scrap and plugging of bottom blown tuyeres were the problems.
1868	Siemens's and Martins developed Open Hearth Process. In this process thermal energy was supplied through combustion of gaseous and liquid fuels thus enabling them to use steel scrap in addition to other charge materials. Open Hearth Process for steelmaking has dominated the steel production for over approximately a century.
1900	Paul Heroult showed use of electricity for steel production. The quality of steel was better than open hearth process. The process was mainly used to produce alloy and special steels from scrap.
1928	Bulk oxygen production technology was developed.
1950	Oxygen was used to produce steel at Linz and Donawitz and process was termed LD Converter steelmaking. Oxygen was supplied through a consumable single hole lance from top of a pear shaped vessel.

1960	Continuous casting was developed. Today most of the steel plants use continuous casting to produce billet/bloom/slab
1950 and till date	Major developments took place in the following areas • Multi-hole lances for blowing of oxygen in LD Converter • Hot metal pre-treatment to control S and P • Simultaneous blowing of oxygen from top and inert gas/oxygen through the bottom. Industrially the process is known as combined blown steelmaking or hybrid blowing • Refractory lining materials and refractory maintenance and repairing procedures • Usage of ladles to perform refining, degassing, deoxidation and inclusion engineering • Process control and automation

Present Status of Steel Industry:

Plain carbon steels are produced principally by the following routes:

1) Blast furnace→ Basic oxygen furnace →Ladle treatments→continuous casting→Rolling →flat or long products. **Adopted by Integrated Steel Plants**

2) Electric Arc Furnace→ Ladle treatments→Continuous casting→Rolling →Mostly long products but occasionally flat products. **Adopted by Mini Steel Plants**

Alloy and special steels are produced by route 2. Some plants employ Argon-Oxygen-decarburization process instead of Electric Arc Furnace

Top steel producers in the world in the year 2010-2011

Rank	Plant	Production (Million (million tons)
1	ArcelorMittal, Luxembourg	103.3
2	Nippon Steel, Japan	37.5
3	Baosteel Group china	35.4
4	Posco, South Korea	34.7
8	Tata Steel India	24.4
10	United States Steel Corporation	23.2
20	Sumitomo Steel Industries, Japan	14.1
21	SAIL, India	13.7

Steelmaking in India

The first attempt to revive steel industry in India was made in 1874 when Bengal Iron Works cam into being at Kulti near Asansol in west Bengal. In 1907 Tata Iron and Steel Company was formed and produced steel in 1908-1909. In 1953 an integrated steel plant in public sector in Rourkela was signed with German Company. Then more integrated steel plants were added.

Indian steel industry is organised in three sectors as shown in the following:

Sectors

Integrated steel plants		**Mini steel plants**	**Induction furnaces.**
Public sector	**Private sector**		
• Rourkela • Bhilai • Durgapur • Bokaro • Salem • Alloy steel plant Durgapur • Indian iron and steel company • Visvesyary a iron and steel • RINKL, Vishakhapatnam	• TISCO • ESSAR • ISPAT • JSW	Uttam steels Kalyani steels Lloyd steel Usha martin Tata Metalics Mukand ltd. (Reader may add more).	Dispersed In various Parts of the country

A. Ghosh and A chatterjee: Ironmaking and steelmaking

B. List of steel producers, wilkepedia

C. www.steelads.com /…/ largeststeel/TOP30-Worlds- Largest- steel- Companies.html