Unit 19 Energy for Metallurgical Industries

lecturer: Juan Yang

School of Metallurgy and Environment

nonrenewable energy sources	不可再生能源
renewable energy sources	可再生能源
tidal energy	潮汐能
nuclear energy	核能
biomass /ˈbaɪəʊmæs / n.	生物质
hydrogen /ˈhaɪdrədʒən / n.	氢
sponge iron	海绵铁
greenhouse gas	温室气体
glucose /ˈgluːkəʊs / n.	葡萄糖
forestation /ˌfɒrɪsˈteɪʃən / n.	造林

Introduction

- The metals have been in the service of mankind since long and their use has been increasing with time.
- The metals occur in nature mostly as minerals in the form of oxide, sulfide, carbonates, or hydrated oxide. The noble metals like gold occur in metallic form embedded in rocks.
- The process of metal extraction involves mining of minerals, mineral beneficiation, and metal production by pyrometallurgical, hydrometallurgical, or electrometallurgical techniques. The metal thus produced is given shape by rolling, forging, or casting methods for specific use and finally heat-treated to render the required mechanical and structural properties in the metal.
- In this process of converting a mineral to finished metal product, energy is required at every step.

What can we learn in this unit?

1. Energy sources

2. Energy demand in metallurgical industry

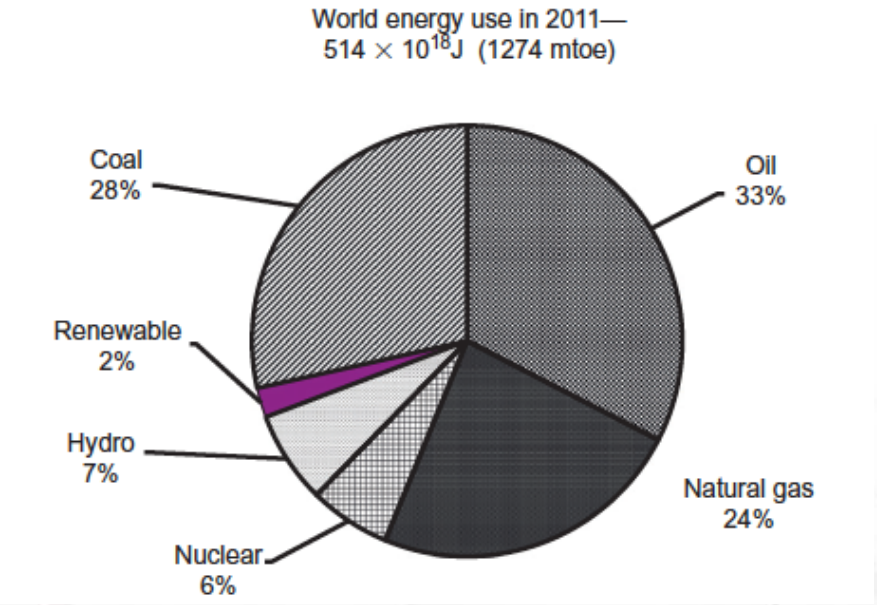
3. Possible solutions to the problems caused by energy use

4. Alternate energy sources for metallurgical use

Energy sources

- Nonrenewable energy sources: These energy sources take very long duration (millions of years) in their formation by nature and hence termed as “nonrenewable”.

- Renewable energy sources: The energy sources which are abundant in nature like solar or which can be regenerated in the nature during a short period (5–10 years) of time is termed “renewable”.



Pattern of world energy use. Source: BP Statistical Review of World Energy.

Energy demand in metallurgical industry

The process of metal extraction involves several steps and at every step the energy is needed to meet requirement for three basic functions:

- (1) Process functions: The functions like size reduction, mixing, conveying material, rolling, forging, etc., involving machine operations which are driven by electrical systems require electrical energy. The electrical energy is also needed to operate auto-control devices, lighting, cooling systems, etc.

- (2) Chemical functions: The extraction of metal from its oxide form is based on chemical reaction with some reducing agents like carbon or hydrogen. Carbon is the most common reducing agent used in metallurgical processes in the form of coke or coal. The hydrogen gas used by sponge iron-making industry derives it from natural gas.

Energy demand in metallurgical industry

The process of metal extraction involves several steps and at every step the energy is needed to meet requirement for three basic functions:

- (3)Thermal functions: The metallurgical reactions occur at elevated temperature and thermal energy is needed to sustain the process. The metal thus obtained needs to be separated from associated gangue minerals by melting to cause physical separation of metal and slag. This requires thermal energy for heating and melting. This thermal energy could be obtained by combustion of coal, oil, or natural gas. In some electro-metallurgical processes, the electrical energy provides the thermal energy.

Energy demand in metallurgical industry

- There are nearly 80 metals which are produced in quantities ranging from a few tons to millions of tons according to their usage. The present production of some common metals in the world is shown in Fig.19-1.

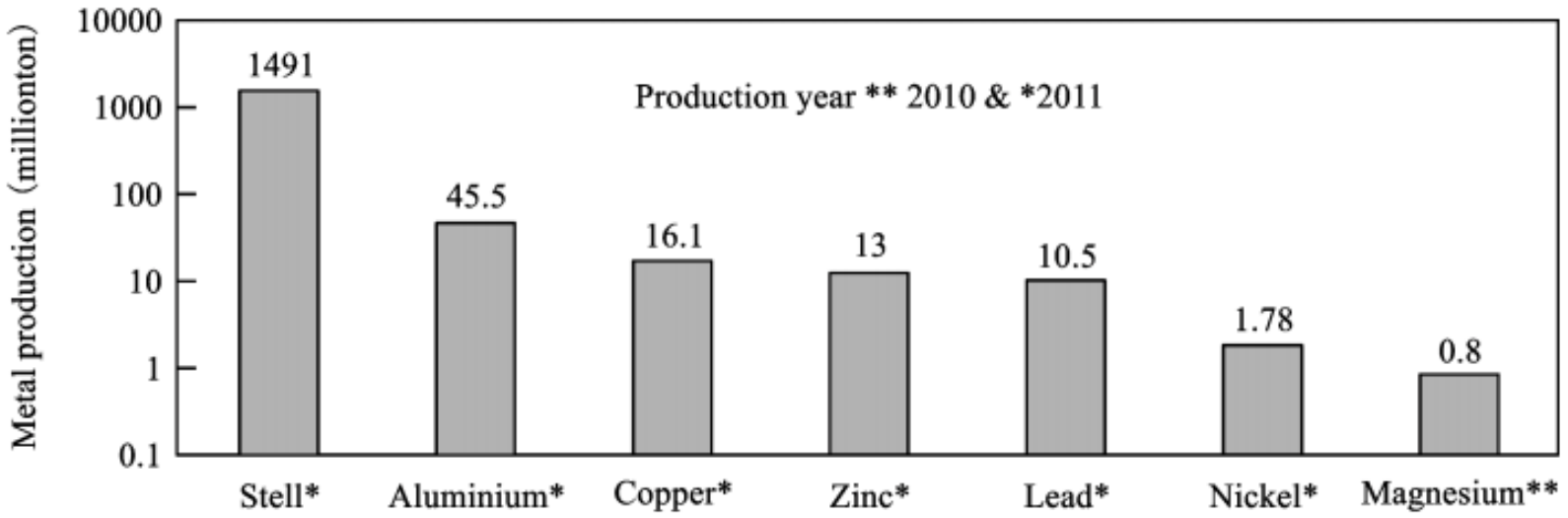


Fig. 19−1 Production of some common metals in the world (2011)

Energy demand in metallurgical industry

- The energy requirements for metal extraction starting from its ores depend on various factors which include the quality of raw materials, process route, and type of technology adopted.

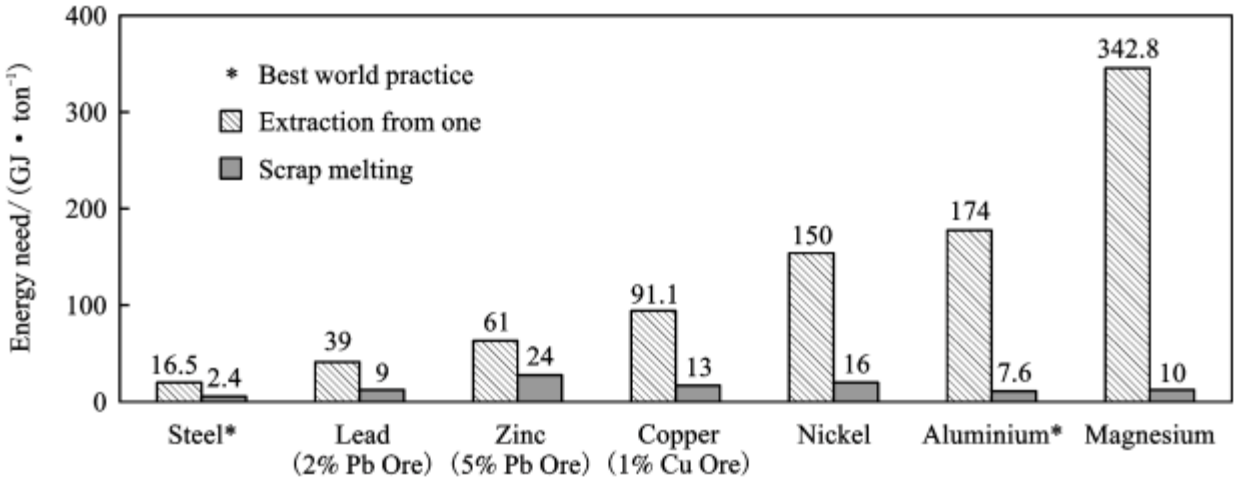


Fig. 19–2 Energy requirements for production of some common metals

- Fig. 19 - 2 illustrates energy requirements for some common metals. What can you learn from this figure?

Possible solutions to the problems caused by energy use

Metal industries use fossil fuel (mainly coal) as their energy source. The use of fossil fuels cause ——

- emission of toxic (CO, NO_X, SO_2) and greenhouse gases (CO_2, CH_4, VOC, etc.)
- discharge of water contaminated by harmful elements
- generate huge amount of fly ash from thermal power plants and slag from metal plants whose disposal and storage problems are acute.

The environmental problem of all these issues has been found to be serious in nature and require a solution.

Possible solutions to the problems caused by energy use

- There is no simple and easy solution to the increasing energy use which is needed for today's life and industry.
- However, efforts are required to find solution to the problem which can be undertaken to get results in short term on SOS basis or follow long-term path to develop strategy to get lasting solutions.

Possible solutions to the problems caused by energy use

(1) Short term solutions on SOS basis——These solutions result in immediate effect and may be possible in a short time period (say within 5–10 years). The efforts in this group include:

- Energy Audit to identify source of energy waste and its plugging,
- technological developments to minimize energy use including automation
- utilization of waste heat,
- development of Green Belt to act as barrier and sink for gaseous pollutants and dust
- eco-friendly disposal of solid waste
- water harvesting to conserve ground water and few other measures.

Possible solutions to the problems caused by energy use

(2) Long-term solutions on diagnostic basis——These solutions may be lasting but would take time to develop (>10–30 years). These solutions are based on the diagnosis of the eco problems which are rooted with use of fossil fuels. The solutions include:

- (i) development of hydrogen as reductant and energy source from nonfossil sources
- (ii) development of biomass carbon as reductant and energy source. These two energy sources are being developed. The efforts to use them in metallurgical industries are given in next sections.

Alternate energy sources for metallurgical use

(1) Hydrogen

- Hydrogen is abundant in nature as water (H_2O). Water is used to produce hydrogen for commercial purposes using various technologies.
- It is an ecologically friendly fuel as the product after use is water which can be recycled in nature.

- Hydrogen can be technically used for a variety of applications in industries which deal in chemical, metallurgical, automobile, and power.

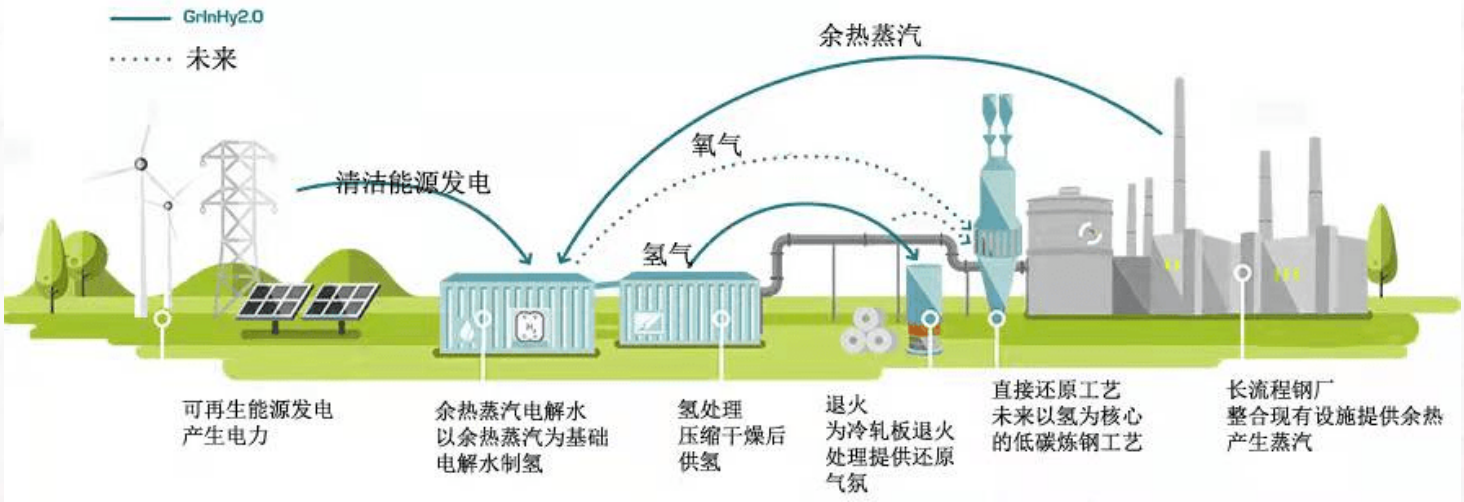
Alternate energy sources for metallurgical use

The hydrogen generation techniques could be divided in three groups:

- (i) thermal processes where the heat energy is used to conduct a chemical reaction. This heat could be derived from fossil fuels, nuclear energy, or solar energy,
- (ii) electrolytic processes use electrical energy to split water by electrolysis into hydrogen and oxygen. The electrolysis using renewable sources of electricity (solar power) and nuclear hightemperature electrolysis are two pathways of greatest interest for large scale hydrogen production
- (iii) photolytic processes use light energy to split water molecule into hydrogen and oxygen. These methods are in their early stage of development.

Alternate energy sources for metallurgical use

- In spite of hydrogen abundance in nature as water and well known for its eco-friendly utility, the hydrogen has not been in large scale commercial use as primary energy source due to technoeconomical reasons.
- The world looks forward to the day when this becomes a reality and hydrogen could be used as an energy source for future metallurgical plants.



Alternate energy sources for metallurgical use

(2) Biomass

- Biomass is the vegetal (plant matter) form of energy. The atmospheric carbon dioxide, water vapor, and solar radiations (photons) are synthesized into glucose molecule which constitutes wood. When the wood is combusted in the presence of oxygen the energy (2880 kJ mol-1) is released in the form of heat and light which can be used for variety of applications.
- Biomass is termed renewable energy as it can be regenerated in a short natural cycle of 5–10 years compared to fossil coal which take a long cycle of more than 100 million years to form in the nature from the same vegetal matter.

Alternate energy sources for metallurgical use

- At present (2000 AD) the use of fossil fuel is producing larger amounts of CO_2 which is causing increase in its concentration in the atmosphere as its recycle back to earth via natural forestation is minimized due to deforestation.

- In future (2050 AD), if a system is generated to have man-made forests for using the biomass energy then rising trend of CO_2 could be arrested due to lesser use of fossil fuels.The use of biomass in future would not only meet energy need but also serve a man-made sink for atmospheric carbon dioxide lowering its rising rate.

Part	Content
Energy sources	Nonrenewable energy sources; Renewable energy sources
Energy demand in metallurgical industry	Process functions; Chemical functions; Thermal functions
Possible solutions	Short term solutions on SOS basis; Long-term solutions on diagnostic basis
Alternate energy sources	Hydrogen; Biomass

- **Homework——Recite the words and phrases; Exercises Part II**

THANKS

End

lecturer: Juan Yang

School of Metallurgy and Environment