Lecture 1

Introduction

Chemical engineering is concerned with processes that transform raw materials from the environment into desired products. They also return spent products and by-products to the environment in an ecologically sustainable manner.

What do Chemical Engineers do?

Chemical engineers study, design and operate processes to provide food, water, energy, clothing, medicine and materials.

Some chemical engineers design processes and solve problems using their computing skills and specialist knowledge of reactions, separations, heat transfer, fluid flow, control, and economics.

Dimensions, Units, and Their Conversion

1.1 Units and Dimensions

Dimensions are our basic concepts of measurement such as length, time, mass, temperature, and so on.

Units are the means of expressing the dimensions, such as feet or centimeters for length, and hours or seconds for time.

In this lectures you will use the two most commonly used systems of units:

1. SI, formally called Le Systeme Internationale d'Unites, and informally called SI or more often (redundantly) the SI system of units.
2. AE, or American Engineering system of units.

Dimensions and their respective units are classified as fundamental or derived:

- Fundamental (or basic) dimensions/units are those that can be measured independently and are sufficient to describe essential physical quantities.

- Derived dimensions/units are those that can be developed in terms of the fundamental dimensions/units.

Tables 1.1 and 1.2 list both basic, derived, and alternative units in the SI and AE systems. Figure 1.1 illustrates the relation between the basic dimensions and some of the derived dimensions.

One of the best features of the SI system is that (except for time) units and their multiples and submultiples are related by standard factors designated by the prefix indicated in Table 1.3.

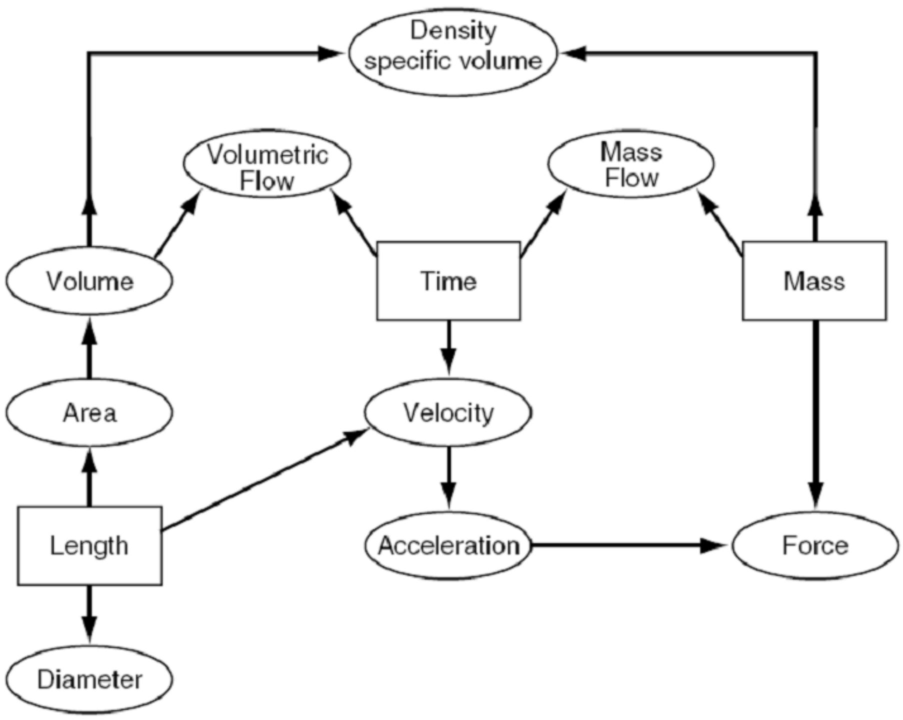

Figure 1.1 Relation between the basic dimensions (in boxes) and various derived dimensions (in ellipses).

Table 1.1 SI Units

Physical Quantity	Name of Unit	Symbol for Unit*	Definition of Unit
	Basic SI Units		
Length	metre, meter	m	
Mass	kilogramme, kilogram	kg	
Time	second	s	
Temperature	kelvin	K	
Molar amount	mole	mol	
	Derived SI Units		
Energy	joule	J	$kg \cdot m^2 \cdot s^{-2} \rightarrow Pa \cdot m^3$
Force	newton	N	$kg \cdot m \cdot s^{-2} \rightarrow J \cdot m^{-1}$
Power	watt	W	$kg \cdot m^2 \cdot s^{-3} \rightarrow J \cdot s^{-1}$
Density	kilogram per cubic meter		$kg \cdot m^{-3}$
Velocity	meter per second		$m \cdot s^{-1}$
Acceleration	meter per second squared		$m \cdot s^{-2}$
Pressure	newton per square meter, pascal		$N \cdot m^{-2}$, Pa
Heat capacity	joule per (kilogram · kelvin)		$J \cdot kg^{-1} \cdot K^{-1}$
	Alternative Units		
Time	minute, hour, day, year	min, h, d, y	
Temperature	degree Celsius	°C	
Volume	litre, liter (dm^3)	L	
Mass	tonne, ton (Mg), gram	t, g	

Table 1.2 American Engineering (AE) System Units

Physical Quantity	Name of Unit	Symbol
	Some Basic Units	
Length	foot	ft
Mass	pound (mass)	lb_m
Time	second, minute, hour, day	s, min, h (hr), day
Temperature	degree Rankine or degree Fahrenheit	°R or °F
Molar amount	pound mole	lb mol
	Derived Units	
Force	pound (force)	lb_f
Energy	British thermal unit, foot pound (force)	Btu, (ft)(lb_f)
Power	horsepower	hp
Density	pound (mass) per cubic foot	lb_m/ft^3
Velocity	feet per second	ft/s
Acceleration	feet per second squared	ft/s^2
Pressure	pound (force) per square inch	$lb_f/in.^2$, psi
Heat capacity	Btu per pound (mass) per degree F	Btu/(lb_m)(°F)

Table 1.3 SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^9	giga	G	10^{-1}	deci	d
10^6	mega	M	10^{-2}	centi	c
10^3	kilo	k	10^{-3}	milli	m
10^2	hecto	h	10^{-6}	micro	μ
10^1	deka	da	10^{-9}	nano	n

Operations with Units

The rules for handling units are essentially quite simple:

Addition, Subtraction, Equality

You can add, subtract, or equate numerical quantities only if the associated units of the quantities are the same. Thus,

the operation

5 kilograms + 3 joules

Cannot be carried out because the units as well as the dimensions of the two terms are different. The numerical operation

10 pounds + 5 grams

can be performed (because the dimensions are the same, mass) only after the units are transformed to be the same, either pounds, grams, or ounces, or some other mass unit.

Multiplication and Division

You can multiply or divide unlike units at will such as

50(kg)(m)/(s)

but you cannot cancel or merge units unless they are identical. Thus, $3m^2$/60 cm can be converted to 3 m^2/0.6 m, and then to 5 m, but in m/s^2

, the units cannot be cancelled or combined.

Example 1

Add the following:

(a) 1 foot + 3 seconds (b) 1 horsepower + 300 watts

Solution

The operation indicated by

1 ft + 3 s

has no meaning since the dimensions of the two terms are not the same. In the case of

1 hp + 300 watts

the dimensions are the same (energy per unit time),but the units are different. You must transform the two quantities into like units, such as horse power or watts, before the addition can be carried out. Since 1 hp = 746watts,

746 watts + 300 watts = 1046 watts