Lecture 10

Ammonium Sulphate

Ammonium sulfate was once the leading form of nitrogen fertilizer, but it now supplies a relatively small percentage of the world total nitrogen fertilizer because of the rapiud growth in use of urea, ammonium nitrate. The main advantages of ammonium sulfate are its low hygroscopicity, good physical properties (when properly prepared), chemical stability and good agronomic effectiveness. It reaction in the soil is strongly acid forming, which is an advantage on alkaline soils and for some crops such as tea; in some other situations its acid forming character is a disadvantages. Its main disadvantages is its lower analysis (21%N), which increases packaging, storage and transportation costs. As a result, the delivered cost at the farm level is usually higher per unit of nitrogen than that of urea or ammonium nitrate. However, in some cases, ammonium sulfate may be the most economic source of nitrogen when the transportation at low cost, or when a credit can be taken for its content.

Ammonium sulfate is available as a byproduct from the steel industry (recovered from coke oven gas) and from some metallurgical and from chemical processes.

Commercial form, storage and transportation:

Fertilizer grade ammonium sulfate specifications normally indicate a minimal nitrogen content, which is usually not less than 20.5%. limitations on free acidity and free moisture are also generally demanded; typical figures are 0.2% for free H_2SO_4 and 0.2% for free H_2O. occasionally, maximal values for certain organic or inorganic impurities may also be specified for byproduct material.

Properties of Pure Ammonium sulfate:

Formula	$(NH_4)_2\ SO_4$
Molecular weight	132.14
Nitrogen content	21.2%
Color	White
Density of soild, 20^0	1.769

Specific gravity of saturated solutions	1.2414 at 20^0C
	1.2502 at 93^0C
Specific heat of solid	0.345 cal/g-^{0}C at 91^0C
Specific heat of saturated solutions	0.67 cal/g-^{0}C at 20^0C
	0.63 cal/g-^{0}C at 100^0C
Heat of crystallization	11.6 kcal/kg from 42% solution
Heat of dilution	6.35 kcal/kg from 42% to1.8% solutions
Melting point	512.2^0C
Thermal stability	Decomposes above 280^0C
pH	5.0
Loose-bulk density	962kg/m^3
Angle of repose	28^0
Critical relative humidity	
At 20^0C	81.1%
At 30^0C	81%
Solubility, g/100g of water	
At 0^0C	70.6
At 100^0C	103.8

Several factors contribute to trouble free storage of ammonium sulfate and other fertilizers. First, the product should be of uniform crystal size and should contain a low percentage of lines. It should be dry and preferably have below 0.1% free moisture. No free acidity should be cooled with dry air under controlled condition after drying, particularly when the ambient temperature and humidity are sufficient high to cause subsequent moisture condensation after cooling in a bulk storage pile or in sealed bags. Ammonium sulfate is commonly shipped in polyethylene or paper bags.

The majority of its production is coming from coking of coal as a byproduct. Ammonium sulphate is produced by the direct reaction of concentrated sulphuric acid and gaseous ammonia and proceeds according to the following steps.

1. ***Reaction of Ammonia and Sulphuric Acid:***

Liquid ammonia is evaporated in an evaporator using 16 bar steam and preheated using low pressure steam.

The stiochiometric quantities of preheated gaseous ammonia and concentrated sulphuric acid (98.5% wt/wt) are introduced to the evaporator – crystalliser (operating under vacuum). These quantities are maintained by a flow recorder controller and properly mixed by a circulating pump (from upper part of the crystalliser to the evaporator)

2. ***Crystallization***

The reaction takes place in the crystallizer where the generated heat of reaction causes evaporation of water making the solution supersaturated. The supersaturated solution settles down to the bottom of crystalliser where it is pumped to vacuum metallic filter where the A. S crystals are separated, while the mother liquor is recycled to the crystalliser.

3. ***Drying of the wet Ammonium Sulphate Crystals***

The wet A.S crystals are conveyed (by belt conveyors) to the rotary dryer to be dried against hot air (steam heated) and then conveyed to the storage area where it naturally cooled and bagged.

The following presents the process block diagram for ammonium sulphate production.

Fig 10.1 Process Flow Diagram for Ammonium Sulphate Manufacturing