CHAPTER 1

INTRODUCTION

Among the agriculture-related industries, granulation of fertilizers is one of the most important application of the agglomeration process, at least from the viewpoint of tonnage involved. Annual world production of granular fertilizers probably amounts to at least 200 million tons. The ever-increasing world population is expected to continue to place a heavy demand on crop production and its major inputs—fertilizer, of course, being the largest when measured in terms quantity and cost. A major growth of the fertilizer industry is expected to occur in the developing world where fertilizer consumption remains far short of what is needed to obtain maximum yields, especially if fertilizer-responsive crop varieties are used.

1.1 Introduction to Granulated Fertilizer

1.1.1. Overview of World Fertilizer

From the introduction of this chapter it can be realized that fertilizer becomes worldwide important material which will increase crops quantity.

World fertilizer consumption and production are expected to continue to increase but at declining annual percentages. Table 1.1 and figure 1.1 show projections of world fertilizer consumption from a UNIDO study.

The study of UNIDO reveals that future cost of fertilizers will continue to increase. Future rise in costs can be slowed by technological improvements and more efficient operation of production facilities. These should require those concerned to have enough knowledge to operate fertilizer plant. Furthermore, efficient control mechanism to raise the operating rates of existing plants is required.

The estimated world demand in 2000 is 264 million tons of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) as compared with 83.6 million tons in 1974, a 3.2-fold increase (Figure 1). Assuming an average nutrient content of 42% (N + P_2O_5 + K_2O), the gross weight of annual fertilizer use would be 629 million tons by the year 2000.

It is a platitude to state that increased output from agriculture essentially requires addition of plant nutrient to the soil. It is like stating that human being needs food to survive and improve their health.

Estimates show that the broad order of magnitude of the expected increase in the use of all fertilizer nutrients (NPK) in the period 1975-2000, compared with that achieved in the past 25 years, is as follows.

Table 1.1 : Projections of fertilizer demand based on 1964 - 65 to 1974 - 75 and on the joint working group estimates for 1979 -80 (Classification of countries is United Nations standard classification)

	1980	1985	1990	1995	2000
			million tons		
			Nitrogen Demand		
Developed countries	37.5	47.6	58.9	71.4	85.1
Developing countries	18.1	25.4	33.9	43.6	54.5
World	55.6	73.0	92.8	115.0	139.6
			P_2O_5 Demand		
Developed countries	22.8	26.7	31.0	35.6	40.6
Developing countries	7.6	10.8	14.4	18.6	23.3
World	30.4	37.5	45.4	54.2	63.9
			K_2O Demand		
Developed countries	22.8	27.8	33.3	39.3	45.8
Developing countries	4.3	6.3	8.6	11.3	14.4
World	27.1	34.1	41.9	50.6	60.2
			NPK Demand		
Developed countries	83.1	102.1	123.2	146.3	171.5
Developing countries	30.0	42.5	56.9	73.5	92.2
World	113.1	144.6	180.1	219.8	263.7

Table 1.2 : Estimates of the magnitude of expected increase in the use of all fertilizer in period 1975 - 2000.

Year	Population (Billions)			Fertilizer Use, NPK Million Tons			Fertilizer Use, kg per Capita		
	1950	1975	2000	1950	1975	2000	1950	1975	2000
Developed countries	0.86	1.13	1.35	13	62	171	15	55	126
Developing countries	1.64	2.84	4.89	1	20	92	0.6	7	19
Total world	2.50	3.97	6.24	14	82	263	-	-	-

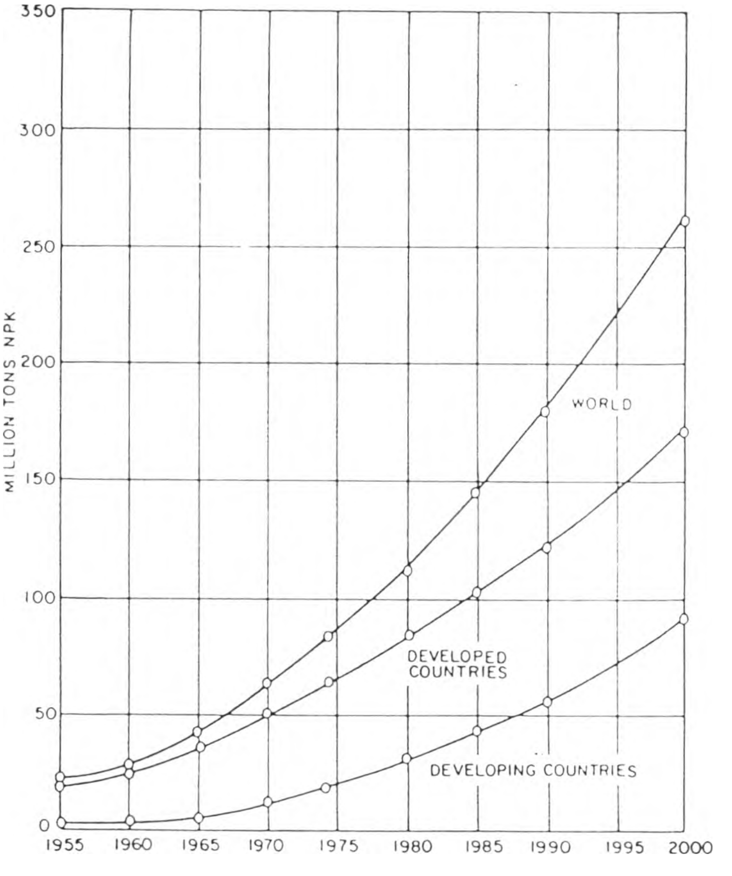

Figure 1.1: World Fertilizer Use : Projection 1980 - 2000

From the above data, no matter if a forecast of a higher or lower figure is taken for world demand for NPK in the year 2000, the increased need to produce and use more fertilizer is evident.

1.1.2 Overview of Fertilizer Use in Thailand

Thailand is a country where agriculture has been the main backbone for a long time. One of the largest sources of national incomes was from agriculture. No wonder how important is fertilizer to the agricultural economics.

Demand for chemical fertilizer in Thailand during 1980 - 1994 is approximately 786,000 - 3,300,000 tons. This means that the demand increases at an average of 10.9 percent per annum. Local consumption of NP/NPK fertilizer increases despite decreasing agriculture area.

Table 1.3 : Thailand fertilizer consumption in the year 1984 - 1993

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Total consumption of fertilizer	1,246,688	1,250,000	1,400,000	1,548,765	1,992,633	2,297,733	2,648,910	2,487,082	2,806,784	3,195,576
Total consumption of NP/NPK fertilizer	1,066,517	910,542	1,036,006	1,095,034	1,436,936	1,858,121	1,919,387	1,722,706	1,985,135	2,291,884
Nitrogen demand	227,712	252,900	319,927	342,784	439,720	494,923	576,517	525,825	600,176	769,086
P_2O_5 demand	142,623	124,999	137,409	148,344	200,833	188,823	318,337	272,318	325,713	430,233
K_2O demand	67,916	55,663	72,930	96,245	137,456	117,793	148,937	164,016	191,858	250,147
Total nutrient	438,251	433,562	530,266	587,373	778,009	801,593	1,043,791	923,159	1,117,747	1,449,475

1.1.3 Knowledge on NP/NPK Fertilizer

Broadly speaking, a fertilizer is any substance, that may be added to the soil to furnish one or more of the chemical elements that are necessary for plant growth. Commercial fertilizers are mainly composed of inorganic substance, although a few commercial fertilizers contain some organic materials.

Sixteen chemical elements are recognized as essential to plant growth, including hydrogen, oxygen and carbon, which are supplied via air and water. By custom the other 13 essential elements are classified as follows :

	Element	Symbol
Primary elements	Nitrogen	N
	Phosphorus	P
	Potassium	K
Secondary elements	Calcium	Ca
	Magnesium	Mg
	Sulfur	S
Micronutrients	Boron	B
	Chlorine	Cl
	Copper	Cu
	Iron	Fe
	Maganese	Mn
	Molybdenum	Mo
	Zinc	Zn

The above classification is arbitrary ; some authors include sulphur as a primary nutrient. Some other elements, not proven to be essential, also play a useful role in the nutrition of some crops.

The fertilizer industry has traditionally concerned itself with the three primary "nutrients, although other nutrients are often added either in fertilizer as "Trace Elements" or separately when there is a recognized need for them. Fertilizer statistics are stated in terms of equivalent weight of the primary nutrients, specifically nitrogen, calculated as the element (N); phosphorus, calculated as the oxide (P_2O_5) and usually called phosphate; and potassium, calculated as the oxide (K_2O) and usually called potash. World production of nutrients (N + P_2O_5 + K_2O) comprised 98.2 million ton of N, 45.4 million tons of P_2O_5 and 41.9 million tons of K_2O in 1980.

The "fertilizer grade" is the guaranteed analysis of the product expressed as a percentage of N, P_2O_5 and K_2O in that order. The guaranteed analysis is not necessarily the total content; it is usually the amount found by prescribed analytical procedures.

Straight fertilizers or fertilizer materials are those containing only one of the primary nutrients, whereas mixed or compound fertilizers contain two (NP, NK or PK) or all three (NPK) of the primary nutrients.

The term " granulation " is used to include all methods for producing solid fertilizers of the desired size range and with the desired physical properties whether starting with solids, solution, melts, chemical reactants, or combinations of these forms.

Although the term "granular" is used in general to include all products that meet the size and physical qualifications, it is common practice to use other terms, such as prilled, crystalline, aggregation, or compacted, to designate a specific processing method for producing a granular material.

1.1.4 Process Description of NP/NPK Fertilizer Granulation Process

Figure 1.2 shows a typical fertilizer drum granulation process . For the production of NP/NPK fertilizers using the pipe reactor technology, phosphoric acid (in the region of 49% H_3PO_4 concentration) is made to react with ammonia vapour in a pipe reactor to produce a solution of ammonium phosphate salts which depend on the stream feed ratio. In the pipe reactor process, the smelting slurry is formed with the chemical reaction heat when NH_3, H_3PO_4 reaction is directly used for granulation. The large quantity of chemical reaction heat produced from violent chemical reaction vaporizes the water in the reactor, which is exhausted from the outlet of the reactor to the tail gas of the granulator . When the slurry is fed to the rotating fertilizer bed, the water is vaporized from the product granules. Due to this smelting slurry granulation feature, the particle size distribution of the raw materials also affects the size of ammonium phosphate salt in the granulator. Granules leaving the granulation drum are first dried and then screened to separate out the product size. Product size specification is often very strict, e.g. from 2 mm. to 4 mm.. Oversize granules are crushed and recycled with undersize granules.

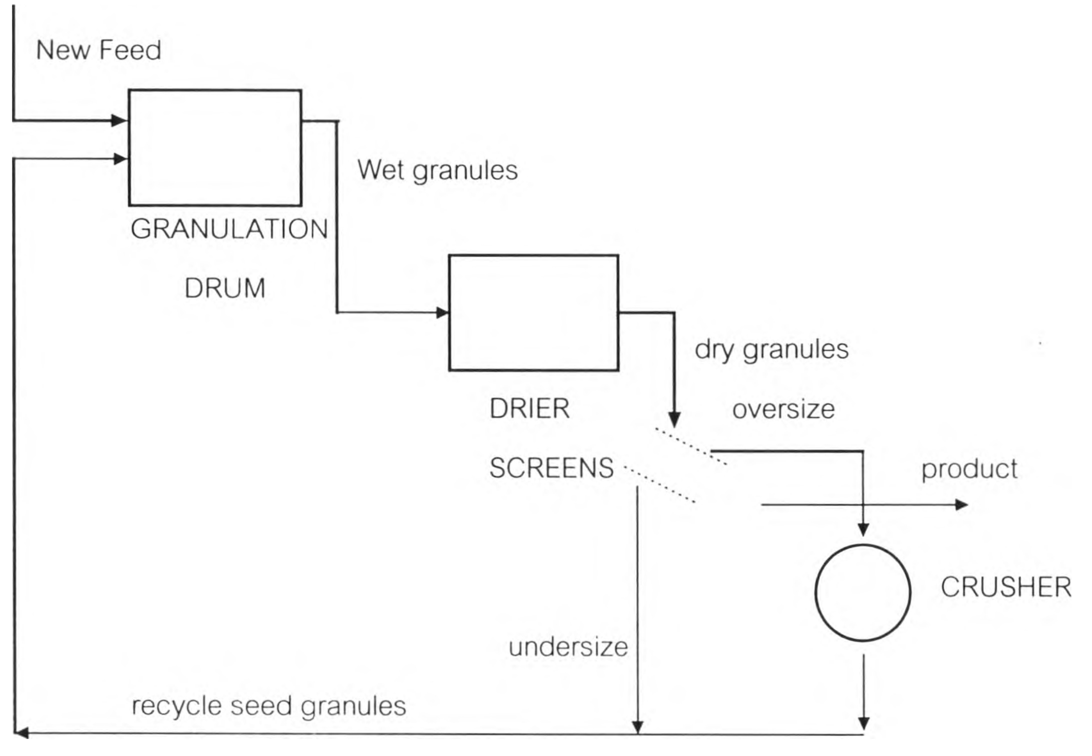

Fig. 1.2 : Schematic diagram of a fertilizer granulation plant.

1.2 Objectives of Thesis

1). To study the fundamental mechanism of granule formation in the drum granulator.

2). To develop a mathematical model of the granulation process.

3). To study the effect of some process variables, such as the solution phase ratio.

1.3 Scope of Work

The whole work may be divided into 4 parts as follows:

1. Technical literature review.
2. Development of mathematical models for the granulation, screen and crusher.
3. Validation of the models.
4. Simulation of the granulation process to find out the effects of solution phase ratio.