Steam/water granulation

In steam/water granulation process granules are formed by agglomeration. The solid raw materials are proportioned (weighed) and usually premixed before being fed to the granulator where agglomeration is initiated. In some plants, the raw materials are crushed either before or after weighing to obtain a more uniform particle size distribution. In the granulator (usually a rotary drum or a pug mill) steam and/or water or scrubber liquor is added to provide sufficient liquid phase and plasticity to cause the dry raw materials to agglomerate into product size granules. In some processes, the pug mill may be used to premix the solids and liquids prior to the granulation in rotary drum unit. In other cases a small amount of ammonia may also be added during granulation to react with the superphosphate to promote granulation and improve product quality by decreasing the acidity and increasing the CRH. The moist and plastic granules are dried, usually in a rotary drum type, fuel fired dryer and screened to remove the product size fraction. The oversize material is crushed and recycled to the granulator along with the undersize fraction. To ensure a uniform particle size distribution of the material returned to the granulator, it is the best to return the crushed oversize material to the screening unit so that only material passing the product screen recycled to the granulator. In some cases it is necessary to cool the material before screening depending on the fertilizer grade and local conditions. If cooling is required, it is usually performed in a rotary drum type unit that is very similar to the rotary dryer. Fluid bed type coolers may be used to cool product size material, but they are not recommended for cooling material having a wide particle size range.
Chemical granulation

Chemical granulation is the most complex method for preparing granular NPKs. The chemical granulation process is similar to the previously described steam/water granulation process except that most of the liquid phase required to achieve granulation is obtained by reacting ammonia with phosphoric, sulfuric, and/or nitric acid. In some cases, a concentrated solution of urea or ammonium nitrate may also be used. Some processes also involve a significant reaction between ammonia and single or triple superphosphate (SSP or TSP). Much of the ammonia acid reaction is often performed outside the granulator either in a tank type pre-
neutralizer or in a pipe type reactor. In many cases steam, water, scrubber liquor, and/or additional ammonia and acid are also fed to the granulator to optimize the granulation characteristics of each particular formulation. In most NPK chemical granulation plants, a significant amount of solid raw materials is also used; therefore, the granules are formed primarily by agglomeration. The relationship between the consumption of solid and liquid raw materials is determined by a number of variables, including (1) required nutrient ratio (fertilizer grade) and nutrient solubility requirements, (2) liquid phase requirements, (3) heat of reaction and temperature limitations, and (4) process plant equipment capacity and operating features. The granulation process also incorporates the design features recommended for the production of NPKs containing relatively large amounts of urea or other very soluble and hydrosopic materials.

**Drop formation (Prilling)**

The formation of NPK granules by prilling using nitro-phosphate type processing is practiced quite widely. In this process the NPK mixture (solution) is concentrated to approximately 96%-98% solids before it is introduced to the top of the prilling tower through either a nozzle assembly or a perforated vessel referred to as a “prilling bucket”. The nozzle or prilling bucket assemblies are designed to produce droplets of the “molten” fertilizer mixture that, upon solidification, will yield the desired granule (prill) size. NPKs produced by the prilling processes are very homogeneous with respect to the nutrient content. However, due to the practical limitations of the drop formation and solidification process, prilled NPK products usually exhibit a smaller particle (granule) size, typically 1.3 mm-3.0 in diameter, than do NPKs produced by other granulation processes.

**Compaction granulation**

In this process mechanical force is used to form dense particles (granules) from finely divided (non-regular) solid raw materials. With compaction granulation the dry materials are first proportioned and thoroughly mixed (blended) to achieve the desired nutrient ratio (fertilizer grade). This step of the process is identical to that normally used in the steam/water granulation process. The mixture is then continuously fed to a pressure roll compaction machine that forms the powdered mixture into a dense, hard sheet of material usually about 2-3 cm thick and 60-100
cm wide. The compaction machine consists of two horizontally opposed rollers that run inward toward each other. The rollers may be as much as 100 cm wide and about the same diameter. The shaft of one roller has a stationary shaft while the other is movable. Pressure is applied by a hydraulic system to the movable roller shaft and bearing assemblies, which in turn determines the pressing force applied to the fertilizer material fed to the machine. The compacted sheet of material is crushed in a controlled manner to form smaller particles. The crushed material is screened to obtain the desired product size fraction. The oversize material is crushed and recycled to the screens and the undersize material is returned (recycled) to the compaction machine after first being thoroughly mixed with the fresh raw material feed. No chemical reaction is required for the process although the raw material properties (especially chemical compatibility, thermal characteristics and plasticity) have a major influence on the performance of the process. The pressing force of the compaction rollers required to produce an acceptable granular product is measured in terms of tonnes of force per centimeter of roller width. Typical pressing forces required for various fertilizer materials and mixtures.

Fig 2. Typical NPK Fertilizer Compaction
Granular fertilizers prepared by compaction have a more irregular particle shape as compared with the more smooth and rounded (spherical) granules produced by other granular processes. The irregular particle surface and shape characteristics of compacted products may promote caking during storage because of the generation of line during handling and because of the increased surface area of the irregular particle compared with the more rounded granules produced by other granulation processes. The irregular shape of compacted fertilizer granules may cause some resistance among users who are accustomed to the more traditional spherical fertilizer granules. However, experience has shown that market resistance to compacted products can be largely overcome through refinements in the process, for example, tumbling/abrasion, to round the rough edges and produce more spherical granules and through promotion and customer education.