Sulfur solidification and handling systems:

As a result of environmental concerns, the processing of crude oil into fuel, be it gasoline, diesel or kerosene, now requires the extraction of as much sulfur as possible.

The most advanced process is the Claus process, which converts H_2S into elemental sulfur, with the resultant properties:

Temperature: 125 - 145°C

Purity: > 99,9 %

H_2S content: < 10 ppm

As further processing very often requires liquid sulfur (e. g. for the production of sulfuric acid and fertilizer), it is advantageous to transport and store sulfur in liquid form. However, temperatures of between 124 - 145°C mean that handling, transportation, and storage could pose a problem from the point of view of safety and economics, so liquid sulfur is handled only if one or more of the following factors apply:

– Short distances.

– Short storage cycles.

– Availability of adequate storage system.

– Availability of adequate infrastructure for transport, be it road, ship or railway transport.

Formed sulfur

More often, for easier handling, storage and transportation, sulfur is formed into pastilles/semispherical granules.

The pastilles, as produced by the Sandvik Rotoform® principle, are globally accepted as a premium quality product, delivering the following significant benefits:

– High purity (bright yellow colour).

– Low friability and high impact abrasion resistance (low visual dust generation).

– Good flow characteristics, but high angle of repose.

– Easy remelt (no agglomeration).

– Low moisture content.

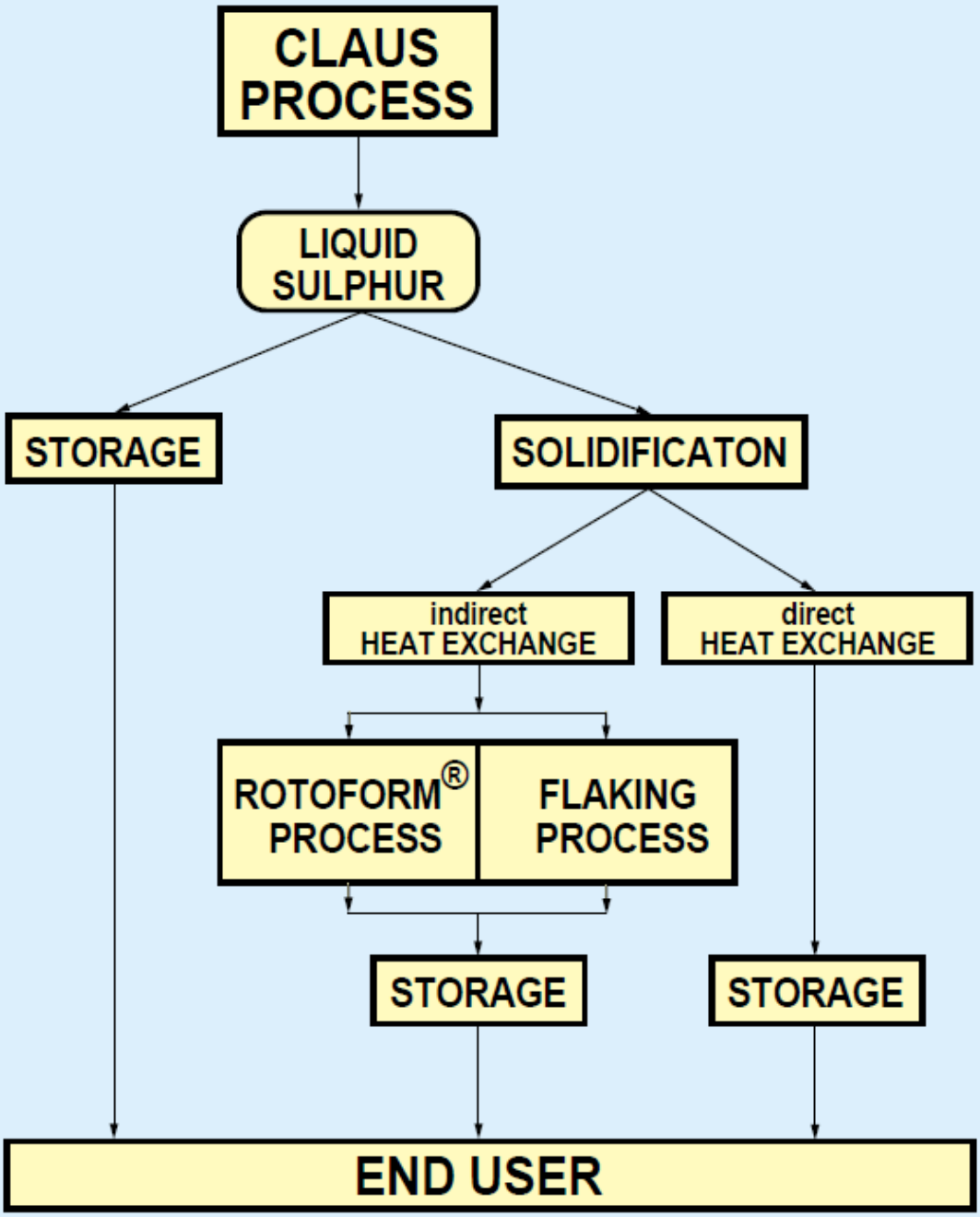
– Stable properties over time.

– Consistent quality.

Considering the fact that formed sulfur is moved on average 15 times between production and re-use (various steps of handling, transport, storage, etc.), much attention needs to be given to low friability and subsequently low dust generation.

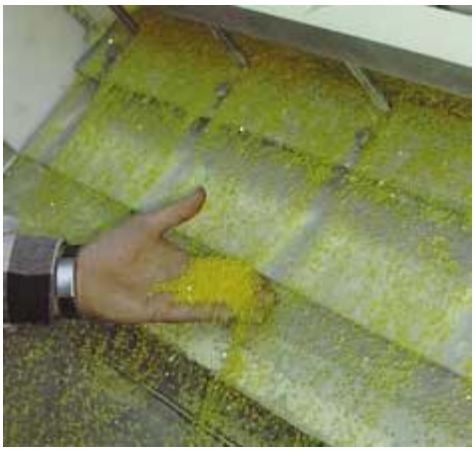
In this respect the Rotoform pastille shows very low dust at stress levels I and II of the SUDIC test (a method accepted worldwide for the simulation of sulfur handling and subsequent generation of dust).

Sulphur Handling



The Sandvik Rotoform process:

Based on steel belt technology, Sandvik has developed an efficient and environmentally friendly process for the cooling and solidification of molten sulfur. The basic principle consists of a continuously running steel belt, which is cooled from the underside by spraying water through nozzles. A specially developed feeding system – the Rotoformer – deposits liquid sulfur in form of droplets onto the steel belt. These are cooled as they run with the steel belt and discharged in form of solid pastilles / semispherical granules at the end of the system.



2.1 Liquid sulfur characteristics:

The characteristics of liquid sulfur as it arrives at the Rotoform unit from the desulfurization and associated degassing plant are as follows:

Sulphur content: not less than 99,5 %

Temperature for premium quality: max. 135°C

Pressure: 1,5 – 2 bar

Viscosity: 4 cP at 125°C

H_2S content: less than 10 ppm

2.2 Process description – pastillation with the Rotoformer

The Rotoform® process consists of several different operations. The process starts with heatable sulfur pumps nearby the sulfur tank or pit.

The flow of the liquid product into the tank is controlled by a valve, which guarantees a constant level of product. Steam or oil heating facilities eliminate the possibility of the sulfur freezing in the tank and all pipework used to convey the product is similarly heated. The pumps supply the liquid sulfur, at a constant pressure, to the Rotoform system.

The Rotoformer consists of a heated, cylindrical stator, which is supplied with liquid sulfur, and a perforated rotating shell that turns concentrically around the stator, depositing sulfur drops across the whole operating width of the steel belt.

The circumferential speed of the Rotoformer is synchronized with the speed of the belt: drops are therefore deposited without deformation. Heat released during solidification and cooling is transferred by the stainless steel belt to the cooling water. This is sprayed against the belt underside, collected in tanks and returned to the recooling plant. At no stage does the cooling water come into contact with the sulfur.

At the cooler end, pastilles are taken off with a discharge knife and pass, via a chute, to a collecting belt for further processing. To eliminate the possibility of damage to the pastilles when being discharged, a silicon based release agent is applied to the steel belt as a thin film. An automatic filling system ensures that a sufficient quantity of the release agent is always held in the tank.

The Rotoformer is equipped with an effective exhaust system, with a tight exhaust hood; an air exhaust and throttle flap is positioned above each Rotoformer. A fan ventilates each plant. The pastilles are transferred to the storage silo via a bucket elevator.

2.2.1 Different types of Rotoformer:

The Sandvik Rotoform process was developed in the early 1980s, for the pastillation of various products in the chemical, food and plastic industries. Since then, more than 1400 units have been installed around the world.

Two different types are available for the pastillation of sulfur, both of which supply pastilles of premium quality and the same semi-hemispherical shape:

a) **Rotoform 3000:**

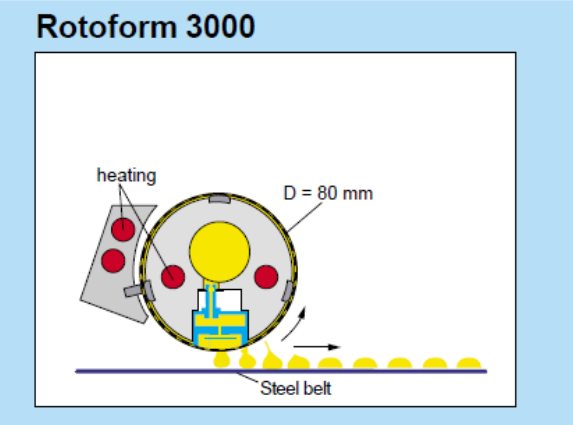
This is the standard Rotoform for this application and provides a granulation capacity of up to approx. 6000 kg/h

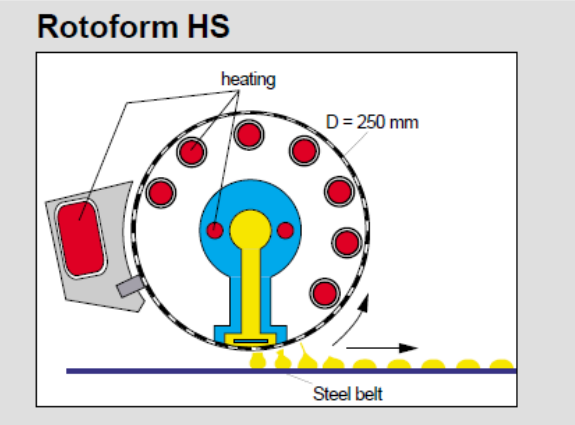
b) **Rotoform High Speed (HS):**

In 2005, Sandvik Process Systems made a significant breakthrough with the development of its Rotoform HS system, a high capacity version of the standard Rotoform offering double the throughput - plus a range of additional benefits including easier, more economical servicing.

The Rotoform HS provides improved safety – if anything is caught between drop former and belt, the drop former automatically raises to minimize the risk of damage or injury. Furthermore, servicing is easier because of fewer components to check and replace.

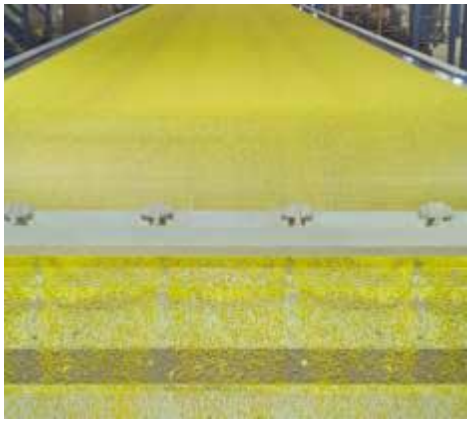
The main difference between the Rotoform HS and the base model is the diameter of the rotating outer shell that deposits the molten product onto the steel belt. Using a 250 mm diameter shell rather than the usual 80 mm means the influence of centrifugal force on the droplet shape is reduced; as a result, the system can be operated at a higher speed while maintaining control of end product quality - in other words, still delivering a consistent pastille with a regular, hemispherical shape.





Sandvik steel belt coolers with Rotoform system

Feeding (liquid sulphur)



Discharge (solid sulphur pastilles / semispherical granules)

2.2.2 Advantages of pastillation:

Both Rotoform types (Rotoform 3000 and HS) provide a number of significant advantages.

a. High quality end product

– The Rotoform system delivers free-flowing pastilles of uniform size and quality ideal for subsequent handling, storage, transportation and remelting or reprocessing.
– Uniform pastilles, diameter between 2 to 4 mm (without screening).
– Excellent crushing strength.
– Low abrasion during handling and, as a result, low visible dust generation.
– High angle of repose.

b. Proven plant design for efficient processing

This is a highly flexible system, its modular design enabling rapid and economical changeover to partial operation as required.
– From liquid to solid in one step.
– Indirect heat transfer - no contact between product and cooling media.
– Well-defined cooling times for controlled crystallization.
– Quick start-up and shut-down of plant.
– Environmentally friendly production – low sound emissions, low dust emissions, minimal air extraction required, closed cooling water system ensures no contamination of water.

c. Designed for long term economy

Sandvik Rotoform systems have been employed in a wide range of applications throughout the world and have proved themselves to be one of the most economical solidification processes available.

– Well proven technology.

– Low energy consumption.

– Low water consumption, only industrialize water for the recooling system.

– Easy maintenance and operation.

– High availability, up to 8600 hours/year.

2.2.3 Use of the preconditioner:

Sulfur can be formed at temperatures ranging from 122 to 145°C but the best results are achieved in the range below 135°C. Therefore, when the sulfur temperature is above 135°C, the use of a preconditioner to reduce the temperature to the optimum level will result in benefits in terms of both capacity and quality. The preconditioner also eliminates temperature fluctuations in the liquid sulfur feed ensuring that it reaches the Rotoformer at a predetermined, uniform temperature within very narrow tolerances.

Cooling is effected by a sulfur cooler (tubular heat exchanger). The sulfur is cooled by a mixture of water and glycol - known as thermal fluid (TF) – which circulates by means of pumps with a delivery head that compensates the pressure loss of the TF-System. The system pressure itself is set by blanketing of nitrogen, allowing temperatures of above 100°C without evaporation of TF.

Preconditioner for liquid sulfur (optional)

2.2.4 Environmental aspects:

Of all the processes available on the market, the Rotoform® process is one of the most environmentally friendly. By means of the continuously operating steel belt cooler, the heat is transferred in an indirect way and neither the product (sulfur) nor the cooling water can be contaminated. Due to very short retention time (less than 10 sec. on the steel belt), only a limited amount of H_2S, SO_2 and sulfur vapour can be released.

Emissions and other environmental data are within the following limits, which are valid as a standard across virtually the entire sulfur producing industry:

SO_2: max. 0.5 g/m^3 at flow > 5 kg/h.

H_2S*: max. 5 mg/m^3 at flow > 50 g/h

Dust**: max. 50 mg/m^3 at flow > 0.5 kg/h

Noise: < 85 dB (A) at 1 m

* valid for degassed sulfur below 10 ppm

** particles < 0.6 mm diameter

3. Handling of solid sulfur:

Rotoform pastilles have been shown to provide the ideal shape and form for solid handling, with a number of key properties.

1. Uniform pastille size

As well as being the ideal form for stockpiling, uniformly sized granules are also important when remelting solid sulfur or blending with granules of other chemicals.

2. Free flowing product

Pastilles are the ideal form for storage, transportation, weighing & bagging and subsequent handling of sulfur.

3. Low friability and low dust content

Pastilles provide a number of environmental advantages, of which these two are among the most important.

4. Low water content and low acidity

Pastilles clearly offer a range of inherent advantages, but an effective granulation system - particularly one used for the pastillation of sulfur – also needs to satisfy a number of key technical issues. Sandvik has the know-how and experience to design, manufacture and commission complete handling installations, tailor-made to the requirements of each client. This includes:

• Systems for the transportation of sulfur, i.e. conveyor belts, inclined conveyors and bucket elevators

• Silos including charging and discharging devices

• Weighing and bagging systems for different types of bags, big bags or bulk material

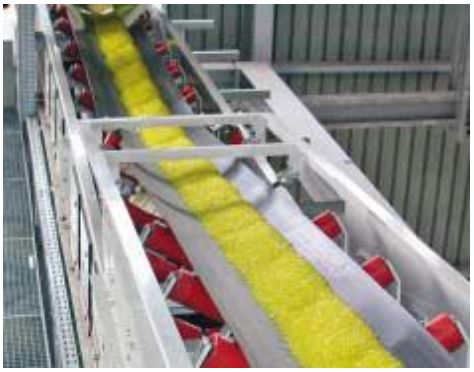
• Truck and railcar loading systems

• Complete control systems

This level of experience extends to systems where expertise in problem-solving is required, such as installations where potential threats such as earthquakes or

explosions need to be taken into account; where the specific weather conditions of the plant location are a factor; or in the selection of appropriate materials to resist the effects of abrasive and corrosive sulfur.

Examples of solid sulfur handling



Sulphur conveying

Bucket elevator with pastilles.

Stacking and reclaiming

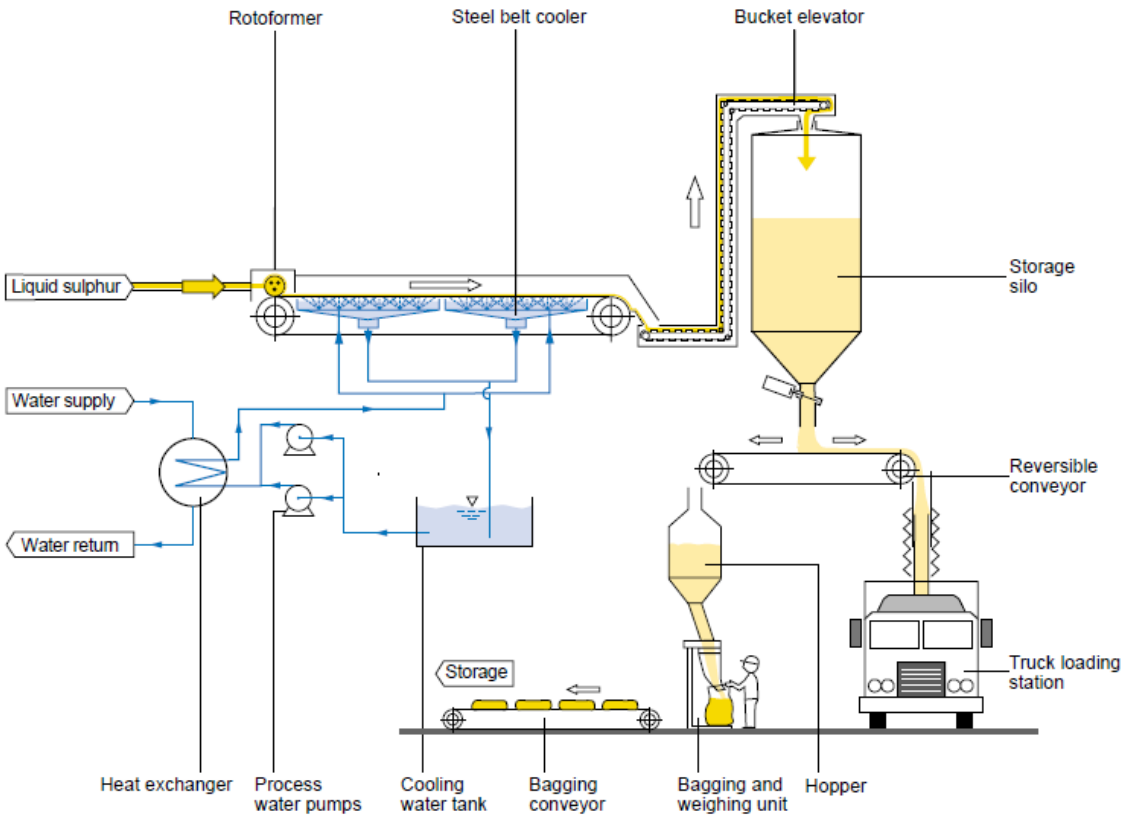
Stacking

Ship loading

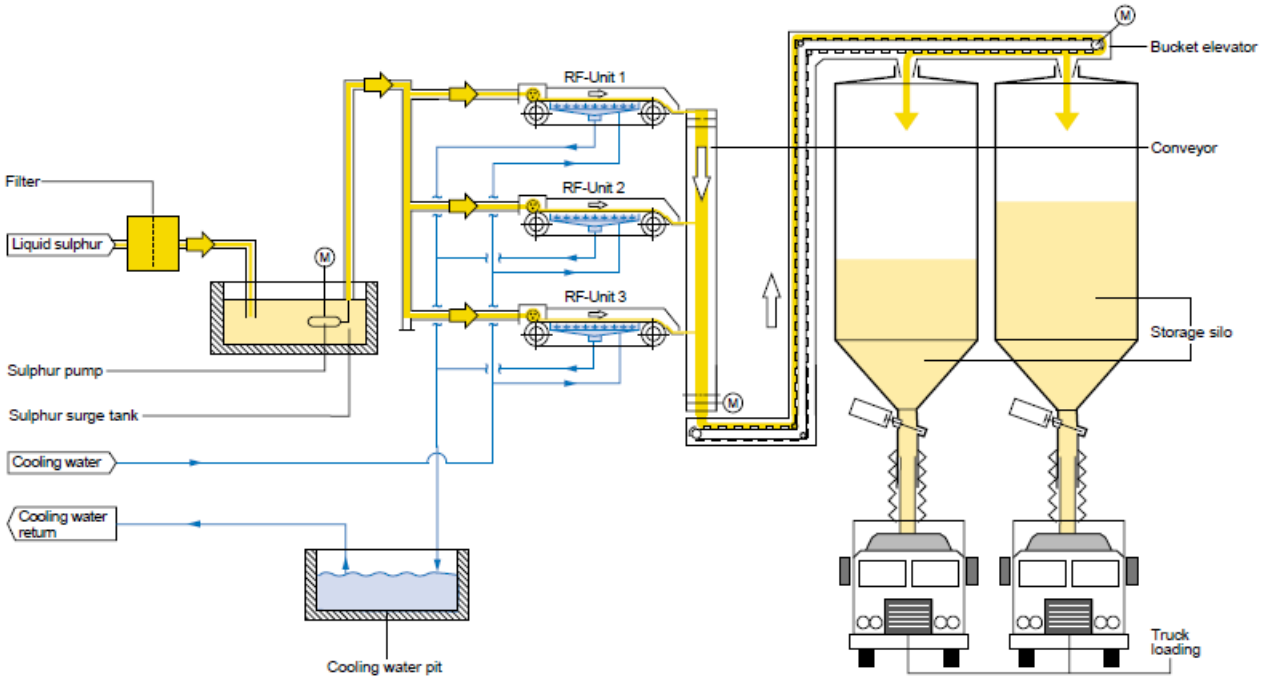
Truck loading

4. Typical plant examples

Sulfur solidification and handling plant at Suez Oil Processing (capacity 150 t/day)



Sandvik Rotoform system for sulfur solidification at Motor Oil Hellas (capacity 450 t/day)



This process is the ideal solution for oil refineries, something that is clearly demonstrated by the fact that all major oil refineries in the world, where sulfur production has increased substantially over the last years, are equipped with this system. In short, this versatile process – which is supported by an efficient and global service network – provides a reliable and environmentally friendly solution to the issue of handling sulfur in the most efficient way possible.