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Processing of Cellulose in Form of Rolls as Raw Material for Nitrocellulose

During the last years most of the cellulose producers have changed the form of delivery form bales to rolls.
Just some producers in China, India, Uzbekistan, Russia and Israel are still producing cellulose in bales with different dimensions.

In special the industrial nitrocellulose producers are using mostly rolls now. The reason why is because they are using more and more wood pulp cellulose instead of linters cellulose, and for wood pulp the normal delivery form is the roll (due to the delignification and purification process from wood to cellulose).

Wood pulp cellulose is cheaper than linters cellulose and can meanwhile be delivered with nearly all required viscosities.

As most of the nitrocellulose producers do not want to have various systems for opening the cellulose (with different maintenance and different spare parts), the bale opening lines have been closed down.

The linters cellulose suppliers have been following this trend and are now as well producing rolls, even though the production of rolls is more costly with respect to the investment.
The advantage of using rolls is also the fact that the weight of one roll is much higher (approx. 550 kg) compared to the weight of one bale (approx. 60 kg) and you can save personnel by installing a system which is automatically introducing into the opening system several rolls at the same time.

For this opening system several different mills have been tested,

- real cutting machine for producing small cubes of cellulose with highly densified cutting edges and all the disadvantages of the following so-called dense type nitrocellulose,

- rotary cutting granulator with several rotating knifes and screens and

- hammer mill with integrated screen whereby the screen can be adjusted according to the quality of the cellulose roll.

The best results have been achieved by utilizing a hammer mill because only this kind of mill is able to produce the fluffy form of cellulose flock which can be used for producing high quality nitrocellulose.

Only in this fluffy form the cellulose can be used without the risk of:

Deflagration by oxidizing the cellulose or nitrocellulose and

Bad quality by not completely converted cellulose.

The design of the hammering mill system should be in such a way that no overheating or burning of the cellulose may occur.
This would result in change of viscosity, black spots in the final product and/or not reacted cellulose, as the overheated and therefore completely dried cellulose parts will not react any more with the nitrating acid.
Additionally the insertion system should not block or change the shape of the roll into an accordion.

Before the suspension of cellulose fibers and water can be processed to any kind of sheet (by double wire press or paper machine) the fibers in it have to be cut, milled and ground. Only in its milled form the suspension will be free flowing like water and giving a sheeting result on the corresponding machine.
The cutting, milling and grinding operation is producing a high amount of very small fibers (fines) and opened fiber segments. These fines are liberated by opening the cellulose sheet with the hammering mill.

When mixing the opened cellulose flocks with nitrating acid these fines may create some problems.

As they have a much smaller density compared with the density of the nitrating acid they may swim on the surface of the acid in the nitrator.

This effect will cause two problems:

1. The fines are not getting completely and homogeneously nitrated, which will result in a turbid solution of the nitrocellulose as final product. For industrial nitrocellulose this is not acceptable and the complete batch has to be rejected.

   For nitrocellulose in propellants these fines may cause fluctuations in the ballistics of the final propellant, which is also not acceptable, especially regarding ammunition for automatic pistols, rifles and guns with very high number of rounds per minute.

2. The fines swimming on the surface of the nitrating acid can get dry and an oxidation reaction may start, leading to much more nitrous gases, or, in the worst case, to a burning out of the nitrator.

All the above-mentioned problems are neglectable if the following process including a pre-nitrator of special design will be utilized.

After the opening process the cellulose flocks are conveyed by pneumatic means via a filter cyclone and rotary valve to a storage bunker with integrated distribution and discharge systems. A special cellulose dust filter inside the filter cyclone removes the dust and fine particles from the transport air and refeeds them to the process.
The storage bunker, used as head container for the following automatic weighing equipment, gives an optimum flexibility regarding the cellulose opening process. Moreover the complete system is not sensitive to variations in dosing quantities of cellulose rolls or bales to the cellulose opening process respective to the storage bunker. In addition, variations in pressure and quantity

of transport air have no negative effect on the associate cellulose dosing system to the pre-nitrator.

The consecutive continuously working belt balance is equipped with a metal detection system that automatically detects the portion of cellulose containing metal parts.

From the belt balance the cellulose falls via a special design sluice for separating the metal containing portion of cellulose to a screw conveyor for equalization of the cellulose flow and for closing the belt balance against the acid fumes from the pre-nitrator.
Afterwards the cellulose flocks are automatically dosed from the screw conveyor to the continuously working pre-nitrator where nitrating acid is added.

The continuous dosing and weighing of the raw material cellulose with depending control and dosing of nitrating acid have the big advantage that the ratio of cellulose and nitrating acid is always constant, which is very important for a homogeneous product.

As mentioned above, the cellulose from the screw conveyor falls into the continuously working pre-nitrator, while simultaneously nitrating acid from an acid receiver is added.
For safety reasons this acid receiver is installed one level higher than the nitration unit. If, for example, a power failure occurs, it is still possible to feed acid to the nitration unit by gravity.

The volume of acid to be dosed to the pre-nitrator depends on the amount of cellulose charged by the belt balance, so that the ratio of cellulose and nitrating

acid is always constant. This is important for an optimum homogeneity of the final product.
Due to the special design of the pre-nitrator (tooth mill and wetting machine), the cellulose flocks and the nitrating acid are mixed most intensively and the fibers are once more opened to achieve an optimum homogeneity of the final product. Additionally this pre-nitrator is not cutting the cellulose/nitrocellulose fibers and is not producing more fines. This prenitrator establishes a smooth but intensive and fast mixing of the cellulose with the nitrating acid.
According to our experience a simple closed agitating vessel with a fast rotating agitator is not sufficient for an optimum result regarding nitration.

An extra advantage to be mentioned is that also bigger cellulose flakes, which may come, for example, from the bale opener, are additionally opened and well mixed with nitrating acid in this pre-nitrator.
As mentioned above, the cellulose dust, which is continuously separated in the filter part of the cyclone, is most intensively mixed with the acid and **will not** create any problems regarding incomplete nitration. This means that all the dust, which according to our experience may amount to approx. 5% of the total cellulose flow, is not longer waste material and therefore losses in raw material and the above-mentioned disadvantages of the fines are avoided.
When the material has left the pre-nitrator, the nitration reaction is approx. 80% finished.
The consecutive two nitrators are level controlled by special design nitrocellulose/acid pulp pumps in order to adjust the nitration reaction time.

The combination of a hammer mill and a pre-nitrator (tooth-mill) of special design give the best results regarding the produced nitrocellulose when starting from cellulose in form of rolls.