

Continuous masterbatch process for the cellulose fiber industry

The quality and throughput of cellulose dope has been limited by the need to operate the cellulose dissolver with low viscosity mixtures due to the limits of the downstream filter and spinning nozzles. List AG, Arisdorf/Switzerland, developed the MasterConti process to overcome this limit by decoupling the dissolution process and the downstream processes. The process has been demonstrated and can now be used for new installations as well as for increasing the capacity in existing installations.

Andreas Diener, Oliver Tretzack
List AG, Arisdorf/Switzerland

Masterbatch processes are used for producing highly concentrated materials due to the ability to optimize the mixing conditions for a specific application. However, the masterbatch process is subject to the inefficiencies of any batch operation. These inefficiencies include rework of material due to batch to batch variations caused by non-repeatable conditions that can occur when heating up and cooling down the batches and by residual material that may not be removed from previous batches. These issues make batch operations inherently less efficient than continuous operations for large production runs of materials.

The continuous masterbatch process MasterConti was developed to provide highly concentrated materials while eliminating the inefficiencies of a traditional batch process. It provides:

- Very good product quality via steady state continuous processing without start and stop breaks; higher shearing for better homogenization of "inhomogeneous" mixtures; less viscosity differences for solids, melts and pasty product as well as the ability to produce a wider range of materials.
- Process intensification via increasing production capacity per line without enlarging

the plant by 50–100%; increasing flexibility of existing installations for different applications, for example staple fibers and nonwovens materials; overcoming the process limitations by interaction of different process steps for example dissolving and spinning as well as increasing process efficiency for less energy consumption and less utilities per ton of product.

Origin of the MasterConti process

The production of cellulose fibers by dissolution has been industrialized for over 25 years. The dissolution is conducted in a continuous operation by dissolving cellulose material with a solvent in a mixing step to produce a cellulose dope. This cellulose dope is then pumped through a filter and spinning nozzles to produce fibers. It was known from masterbatch trials that dissolution of the cellulose materials occurred faster and was more complete when conducted in a highly viscous phase in a high-volume horizontal kneader/reactor. The shearing over time of the high viscosity mixture led to better homogenization of the cellulose. However, the continuous filtering and spinning process could not be conducted at these higher viscosities due to the pressure drop through the filters and spinning nozzles. Fig. 1 shows the optimum dissolution viscosity and spinning viscosity of a typical Cellulose dope.

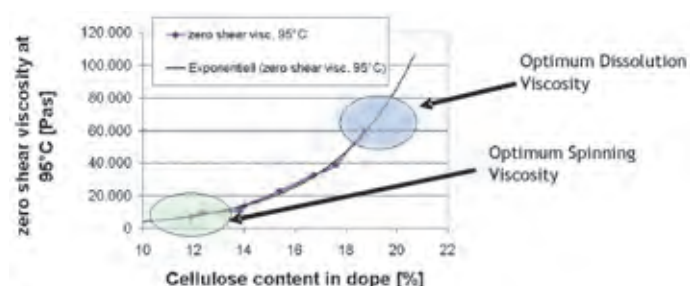


Fig. 1
Dope viscosity in correlation to cellulose content

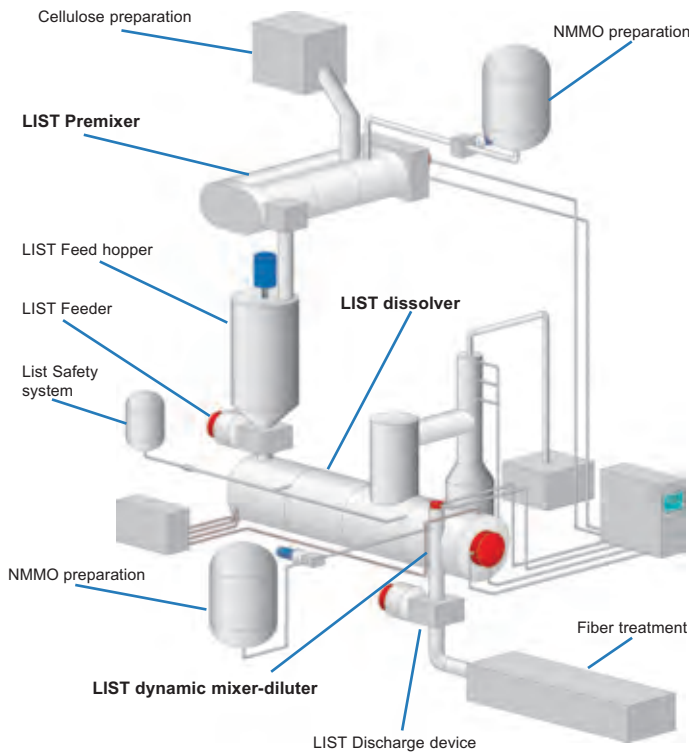
The quality and throughput for the dissolution process had to be limited so the material would be thin enough to be pumped through the filter and spinning nozzles. This led to the question "How can the fast and complete fiber dissolution that is possible in a masterbatch process be achieved in a continuous process?" The answer was to develop and patent the MasterConti process where the dissolution process is decoupled from the spinning process. In this process shown in Fig. 2 the dissolution takes place under the highly viscous conditions that provide the optimum mixing, followed by a List dynamic mixer-diluter that reduces the viscosity to optimum for spinning. This allows the viscosity of the spinning step to be adjusted without impacting the efficiency of the dissolving process and results in intensification of the entire process.

Proof of concept for the process

The term "lyocell process" is used to describe a process where cellulose material is dissolved in NMMNO to produce a cellulose fiber, and the general process is shown in Fig. 3. List kneader/reactors are used for pre-mixing and dissolving cellulose materials in several commercial lyocell plants, so the lyocell process was chosen as the first process for the MasterConti process. A MoDo 615 cellulose was investigated and it was found that the optimum viscosity for spinning was 11–12%. It was determined by batch and continuous tests in a kneader/reactor that this material produces a very good quality cellulose dope when dissolved to a concentration of 16–22%. Increasing concentration in the kneader/reactor from a range of 11–12% to a range of 16–18%, allows the throughput of a given kneader/reactor to be increased by 50–100%!

In June 2010 LIST organized a technology demonstration of the MasterConti process for companies in cellulose fiber industry. A 16 liter kneader/reactor, as shown in Fig. 4 was used as the dissolver for this demonstration. A MoDo type wood cellulose with a DP of 615 was selected for this demonstration. This cellulose had a residual moisture content as received of 6.9%, and it was pre-mixed with a water and NMMO solution before being fed into the kneader. The cellulose in the pre-mixer was maintained at atmospheric pressure and 50–80 °C before being fed continu-

Fig. 2
MasterConti process



ously into the dissolver. The rotational speed of the kneader was varied from 60–68 rpm, the product temperature was kept below 100 °C and the operating pressure was varied from 50–100 mbar absolute. The cellulose was continuously dissolved and water was continuously removed as the cellulose/NMMO/water mixture passed through the kneader. The cellulose solution was spin to fibers, washed, dried and winded. ■

MasterConti = trademark

Fig. 3
Lyocell process

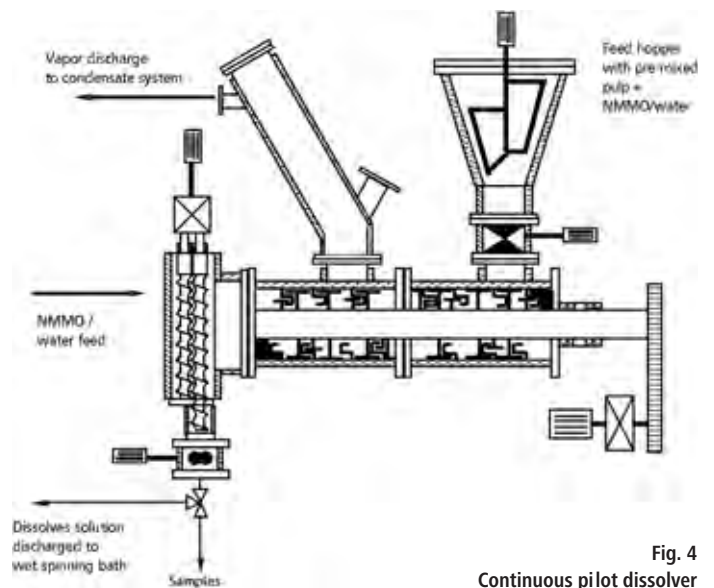
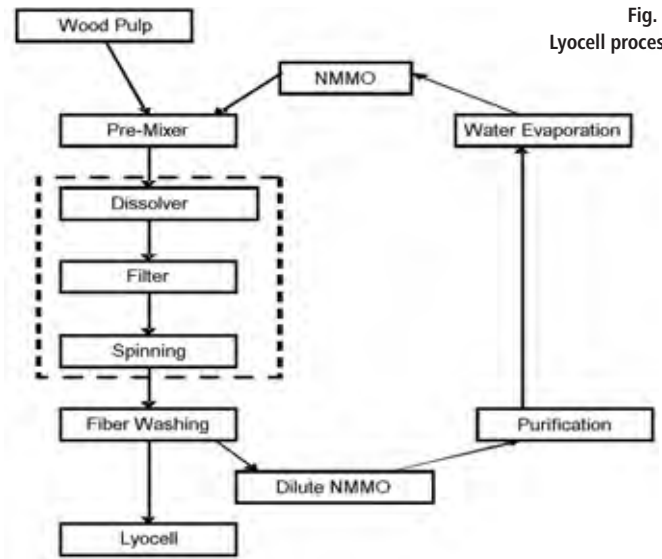


Fig. 4
Continuous pilot dissolver