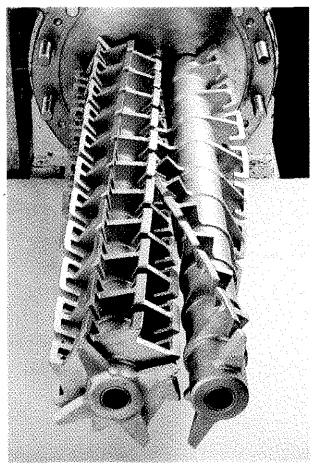
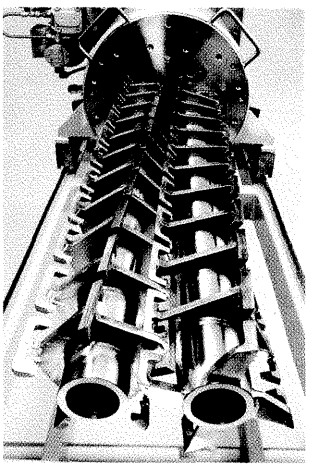
Swiss Expertise in High Viscosity Processing

LIST AG

Mixing/blending of liquids or of free flowing granular materials, with or without heat transfer, can be achieved with a number of well established equipment. In many processes, however, engineers are faced with substances whose rheological state changes during processing from liquid to high viscous, pasty and eventually to a free-flowing solid, or vice versa. Furthermore, in the chemical and related industries there is an increasing demand to substitute processes which take place in the presence of large amount of solvent with "dry" ones in the absence of solvents.



LIST-ORP



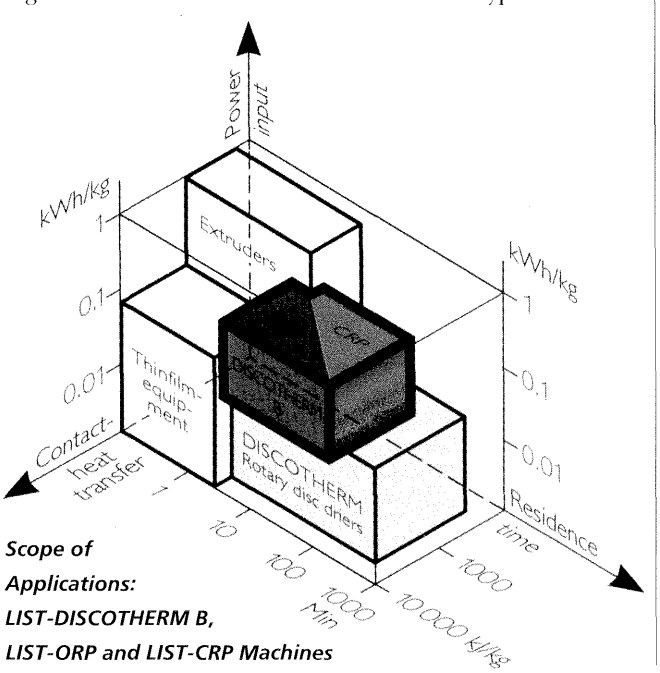
LIST-CRP

These kinds of processes are feasible only if equipment available is capable of handling very viscous intermediate, or permanent, phases or materials which tend to bake on to the surface of the equipment. Taking into account that in many of these processes heat and/or mass transfer is the limiting factor this type of equipment must provide:

- an intensive mixing and kneading action
- extensive self-cleaning heat exchange surfaces
- large volumes enabling even slow processes to be conducted economically.

Typical processes requiring this type of performance are mixing and kneading operations in the early and final stages of chemical processes, heterogeneous reactions, concentration by evaporation, crystallisation, drying, degassing of polymers and compounding.

The LIST-ORP *(Opposite Rotating Processor)*, LIST-CRP *(Co-Rotating Processor)*, and LIST-DISCOTHERM B mixing kneading machines meet theses criteria in the field where mechanical, thermal and chemical processes interface. In respect of application and in relation to other types of processing equipment are positioned as shown in our diagram.



Scope of Applications: LIST-DISCOTHERM B, LIST-ORP and LIST-CRP Machines

Operating Principles: LIST-DISCOTHERM B, LIST-ORP and LIST-CRP Machines

LIST-DISCOTHERM B, LIST-ORP and LIST-CRP kneading machines are positioned between straightforward kneaders or screw type extrusion equipment, which have relatively small volume and heat transfer areas and conventional paddle dryers with larger volumes, greater heat transfer area, but lack a kneading effect and self-cleaning of heat exchange surfaces.

These machines combine the effective mixing and kneading action of screw type units, (specific kneading energy as high as 0.2 kWh/kg) with capacities and heat transfer areas comparable to the classical paddle dryer or submerged disk dryers.

LIST-DISCOTHERM B machines can be designed for either continuous or batch operations. They are ideal for thermal processes involving materials that change consistency during processing from liquid to highly viscous, pasty, or crusting intermediate phases, and eventually to a free-flowing solid. The unit consists of a horizontal, cylindrical housing, and a concentric agitator shaft with disk elements perpendicular

Mixing & Kneading with Visous, Pasty and Granular Materials

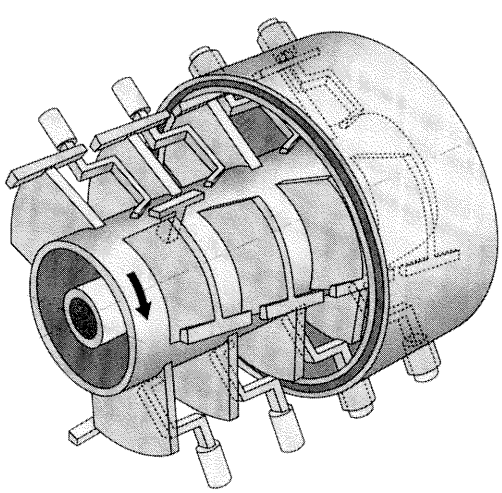
*Mixing as unit operation is widely applied in all kinds of process industries. Mixtures of solids and liquids are blended in a variety of equipment types, depending on the physical characteristic of the mixture. Low viscosity, pumpable suspensions are commonly mixed in tanks agitated with an impeller or fluid jet. Non-flowing pastes are processed in slow-speed non-cirulating mixers. High viscosity products are blended in a variety of extrusion or kneading equipment. The difficulties involved when the rheological state of materials changes between liquid, high viscous, pasty and solid during processing can be avoided by using the LIST-ORP (**O**pposite **R**otating **P**rocessor), LIST-CRP (**C**o-**R**otating **P**rocessor) and the LIST-DISCOTHERM B mixing/kneading machines.*

to the axis carrying peripheral mixing/kneading bars (see second diagram). Stationary hook-shaped bars set in the shell interact with, and clean, the shaft and disk elements as they rotate.

LIST-ORP and LIST-CRP machines are horizontal twin shaft processors with large working volumes and self-cleaning heat exchange surfaces. They have two parallel inter-meshing agitators rotating and moderate speed in a horizontal housing of roughly figure-of-eight cross-section. Both machine types can be designed for either continuous or batch operations.

A large number of U-shaped mixing/kneading bars, welded on the disk segments of both agitators, intermesh during rotation at a synchronised speed ratio. The kinematic contour lines generated during the revolution of the shafts practically ensure the absence of dead spaces (self-cleaning effect). The arrangement of the U-shaped mixing/kneading bars and the disk segments in designed to provide a gradual forward conveyance of the process material, coupled with intensive lateral inter-mixing.

The shell housing, agitator shafts, and disk elements of any machine type can be heated or cooled, giving a very large heat exchange area in relation to volume. The intensive mixing and kneading



LIST-DISCOTHERM B Operating Principle

The arrangement of the disk elements, the mixing/kneading bars and the shape of the static counter hooks impart a forward plug flow movement to the material.

action, coupled with self-cleaning of the heating surfaces, combines to break up baked-on crusts, agglomerates and lumps, ensuring a high rate of product surface renewal for both heat and vapour transfer.

The kneading and agitation forces are high. To handle the required power, these units operate with agitator shaft speeds between 10 and 40 rpm and max. available torque's as high as 250.10^3 Nm. A spiral arrangement of the kneading elements imparts regular axial conveying, even for highly viscous pasty materials. All machines are easily adaptable to changing feed rates or composition.

LIST-DISCOTHERM B, LIST-ORP and LIST-CRP kneading machines operate with fill levels around 60-80 % of total, which leaves adequate free volume for vapour disengagement.

Final product is usually a free-flowing material, whether a granular or powdery solid or liquid. The average fill level in the unit is controlled by the height of an adjustable weir plate at discharge. Unlike screw type processing units, the axial conveying rate is independent of agitator speed, making it possible to select the rotation for optimisation of heat transfer, residence time, and minimisation of attrition.

The disk elements do not affect the forward conveying function, but prevent back-mixing enabling the processing of liquid feed stocks directly through to a solid free-flowing material without recycling of dry product.

Our sidebar summarises the characteristics and features of LIST-DISCOTHERM B, LIST-ORP and LIST-CRP machines.

LIST-DISCOTHERM B, LIST-CRP & LIST-ORP Kneading Machines Main Characteristics at a Glance

Intensive mixing and kneading action.	Enhanced heat and mass transfer. Ability to handle all product states/ phases in a single unit.
Extensive heating and cooling surfaces.	Permit high rates of energy input or dissipation and ensure precise temperature control.
Self-cleaning.	Improve heat transfer coefficients.
Intensive renewal of phase boundary layers.	Enhancement of mass and heat-transfer.
Large useful volume.	High throughput and effective handling of continuous processes with long residence times - (0,5 - 3 h).
Minimal axial intermixing.	Virtual plug flow ensuring narrow residence time distributions.
Large cross-sectional area.	Permits feeding and disengagement of gases and vapours.
Closed, contained construction.	Allows processing and handling of toxic, explosive, or hazardous substances.

Scale of Operation and Options

LIST-DISCOTHERM B units for continuous operation are available in a number of sizes up to 16,500 litres, corresponding to a heat exchange area of 128 m^2.

For batch operation 11,000 litres corresponding to 64 m^2 is the current maximum size. The housing shell can be jacketed or limpet coiled and heated together with the agitator shaft and disk elements with steam, hot or pressurised water or thermal oil. If necessary, cooling can be effected with water, brine, or thermal oil.

LIST-ORP and LIST-CRP machines are primarily furnished for continuous operations in sizes up to 10,000 litres, with heating surface of 88 m^2 (ORP) respectively 98m^2 (CRP). The figure of eight shell can be jacketed or limpet coiled, and both agitator shafts and the disk elements can be heated or cooled with the same media as

LIST AG at a Glance

LIST AG, Arisdorf, Switzerland, was founded in 1966 by Heinz List. Since this time, LIST's activities have centred on the supply of thermal technology for processing highly viscous or crust forming materials. This technology has earned the company a title as a world leader in the processing of highly viscous materials.

LIST's focus over the past 25 years has been on the supply of quality, state-of-the-art equipment. Through research in its own laboratories, LIST is continually upgrading and developing technology, to meet the current needs of the chemical processing and allied industries.

LIST systems have enabled the company to forge new territory in the processing of concentrated, viscous, pasty or sticky products.

In 1991, LIST, Inc., headquartered in Acton, Massachusetts, was formed with the objective of bringing LIST technology and services to the United States and Canada. LIST's multidisciplinary staff (65 employees) has proven experience in equipment design, process development and process engineering.

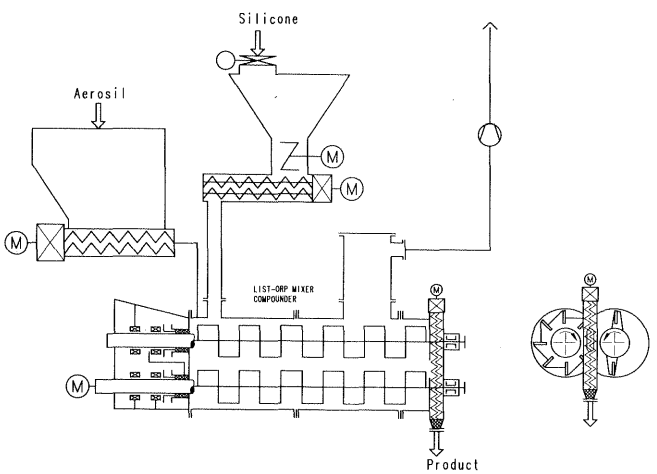
Testing services are available in the United States and Switzerland.

for the LIST-DISCOTHERM B. Any type of weldable material can be used for fabrication, and the drives can be either mechanical or hydraulic. Various types of stuffing boxes are available for shaft sealing, and mechanical seals can be used as appropriate.

Mixing and Compounding

The unique geometry of the internals of the LIST-CRP, LIST-ORP and LIST-DISCOTHERM B CONTI machines, their large working volume and the plug flow characteristics prevailing in the process chamber make possible their applications as mixers/compounders of low bulk density fillers with high viscous compounds. Our diagram below shows the application of a LIST-ORP CONTI mixer/compounder for the mixing/compounding of Aerosil, with a bulk density in the 0.03 kg/l to 0.1 kg/l range, with a silicone mass with a viscosity of 100,000 Poise.

Similar processes are mixing of talcum, sawdust, chalk and glass fibres into plastic melts. When glass fibres are used as fillers, the low degree of fibre destruction, due to the soft mixing action on the bulk of the processed materials is permanently present due to the interactions between rotating and static elements of the internals of these processors.



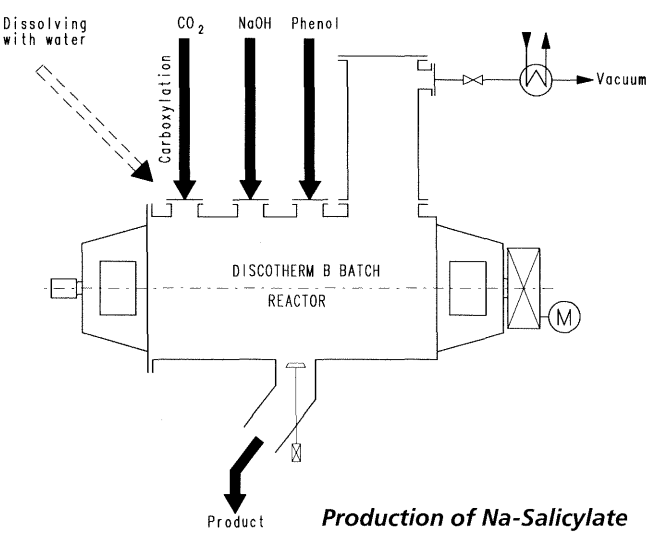
Mixing/Compounding of Silicone with Aerosil

Scope of Applications - Typical Processes

The application of the LIST-DISCOTHERM B, LIST-ORP and LIST-CRP machines, for the processes and materials as listed in our sidebar, require a permanent and effective mixing. This is of major importance considering the large working volumes of these machines (processes take place in bulk) as well as the type and state of the processed compounds. This compounding characteristics of the LIST-CRP machines, is of special importance.

LIST-DISCOTHERM B, LIST-ORP and LIST-CRP Machines

PROCESS	APPLICATION
Mixing and Kneading Concentration by evaporation Crystallisation Drying Compounding Degassing of polymers Heterogeneous reactions Vacuum Sublimation	Solids, pastes, suspensions solutions, products with high viscosity and/or encrusting intermediate phases



Production of Na-Salicylate

Production of Na-Salicylate

An application demonstrating the features and benefits of the LIST-DISCOTHERM B machine is the Kolbe-Schmitt-Process for the production of Na-Salicylate. This is a five step process that takes place in one single LIST-DISCOTHERM B batch type reactor. The first step is the reaction of phenol with sodium hydroxide solution. An exothermic reaction demanding for good mixing of the reactants and for close temperature control. While the reaction is under progress water is formed, which is removed by simultaneous evaporation. This leads to the crystallisation of Na-phenolate (2nd process step) and eventually to its drying (3rd step), the later under vacuum conditions, to a free flowing powder. The fourth process step is the carboxylation of Na-phenolate with CO_2 under elevated pressure. The yield of this gas-solid reaction depends on the close temperature control. This is a difficult task considering that the reaction mass goes through a pasty phase, where the efficient kneading action of LIST-DISCOTHERM B is of major importance. Finally, the Na-Salicylate is dissolved in water. Compared to other reactors, LIST-DISCOTHERM B offers many advantages, including higher specific capacity, high yield and reduction of by-products by a factor of 10. ■

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