Knowing What’s Next in Mixing of High Viscosity Materials

Unique Mixers & Furnaces Pvt. Ltd.

Jayesh R. Tekchandaney
Director - Technical @ Unique Mixers
Founder @ Mixing Expert

Author - “Process Plant Equipment - Mixers” @ John Wiley, 2012
Contributor - “Dictionary of Industrial Terms” @ Scrivener-Wiley, 2012
DISCUSSION

◊ Importance of Mixing
◊ Challenges 20-20
◊ Mixing Mechanisms
◊ **What’s Next In High Viscosity Mixing**
◊ Mixer Selection, Specification & Design Guidelines
MIXING

◊ Process of thoroughly combining different materials to produce a homogenous mix
◊ Consistency in chemical composition, color, flavor, reactivity
◊ Mixing is a critical process
◊ Quality of the final product, attributes depend on the mixing performance

“Cost of poor mixing is estimated as US$ 100 million / year ”
PROFITABILITY !!!

◊ Polymer Product
◊ Product purity - 90%, US$ 45,000/ton
◊ Market demand - 95%, US$ 50,000/ton
◊ Change in mixer operating parameters - 92 to 93 %
◊ Change in mixing agitator design - 95 %
◊ Production capacity ~ 55,000 tons/yr

“Mixer is no longer a generic production tool. It is a critical and decisive business tool.”
The viscosities of materials to be processed are constantly on the rise, as there is an urgent need to cut levels of volatile organic compounds in most parts of the process industry.
CHALLENGES 20-20

◇ Increased customer expectation, constant development of new products
◇ Minimum time from new product conception to implementation
◇ Little time for lab trials - pilot scale - production
◇ Need for higher product purity, yields
◇ Price reductions, increasing costs
◇ Frequent Product Change Overs
◇ Multi-purpose equipment - Coating, granulation, heat transfer, drying
◇ HSE compliances
“Liquid mixing depends on the creation of flow currents, which transport unmixed material to the mixing zone adjacent to the impeller.”
Primary Mechanisms of Solid Blending

◊ Diffusion Blending
◊ Convection Blending
◊ Shear Blending
“Mixing in viscous systems can be achieved only by mechanical action or by the forced shear or by elongation flow of the matrix”
Equipment Design, Scale-Up: Because of the viscosity and temperature changes that occur during the mixing process, it is difficult to model the system. Mixer drive systems should provide constant torque throughout the speed range, even at very low rotational speeds.

Power Requirement: Mixing requires large amounts of mechanical energy for shearing, folding over, dividing and recombining.

Heat Transfer: Heat transfer is generally poor in viscous materials. Mixers for high viscosity materials therefore need to be designed for promoting efficient heat transfer.

Constraints - shear sensitive materials, hard to disperse powders, abrasive components, dense sticky material, hard agglomerates, volatile solvents, material rheology
MULTI-SHAFT MIXERS

Anchor Agitator & Saw tooth Impeller

www.mixing-expert.com

<table>
<thead>
<tr>
<th>VISCOSITY (Centipoises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>DUAL SHAFT MIXER</td>
</tr>
<tr>
<td>TRIPLE SHAFT MIXER</td>
</tr>
</tbody>
</table>
PLANETARY DISPERSERS

<table>
<thead>
<tr>
<th>VISCOSITY (Centipoises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

PLANETARY MIXER WITH HIGH SPEED DISPERSER
DOUBLE PLANETARY MIXER

Double Planetary Mixer Operation

www.mixing-expert.com

<table>
<thead>
<tr>
<th>VISCOSITY (Centipoises)</th>
<th>1,000,000</th>
<th>5,000,000</th>
<th>7,500,000</th>
<th>1 million</th>
<th>3 million</th>
<th>5 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOUBLE PLANETARY WITH RECTANGULAR BLADES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DPM WITH HELICAL BLADES, HSD

<table>
<thead>
<tr>
<th>VISCOSITY (Centipoises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

DOUBLE PLANETARY MIXER WITH HELICAL BLADES
DISCHARGE SYSTEM

• Large batch sizes can be discharged in minutes
• Eliminating time wasted in scraping heavy or sticky materials
• Avoiding operator exposure to hazardous material

Discharge is often overlooked and can end up as a bottleneck
Use of multiple vessel extends the production capacity

- Mixing
- Discharging
- Cleaning
- Loading
KNEADER MIXER

High Viscosity Mixing
In Kneader Mixer

www.mixing-expert.com

<table>
<thead>
<tr>
<th>VISCOSITY (Centipoises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>KNEADER MIXER (SIGMA BLADE, MASTICATOR BLADE)</td>
</tr>
</tbody>
</table>
KNEADER EXTRUDER

<table>
<thead>
<tr>
<th>VISCOSITY (Centipoises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>KNEADER MIXER EXTRUDER (SIGMA BLADE, MASTICATOR BLADE)</td>
</tr>
</tbody>
</table>
Mixer under vacuum can achieve several process goals and offer several benefits:

**De-aeration** - Superior visual appeal of an air-free product, reduced risk of product failures.

**De-oxidation** - The removal of oxygen prevents the oxidation, degradation of sensitive ingredients, improves product stability.

**Solid/liquid injection** – Under vacuum, liquids and lightweight powders can be injected into a batch through a sub-surface port in the vessel. This accelerates mix cycle, especially by wetting out powders instantly.

**Vacuum drying** - Excellent method for drying heat-sensitive materials without fear of thermal degradation.
**Vacuum Mixing**

**Solvent recovery** - Solvents drawn off with vacuum can be recovered, reused.

**Densification** - With densification, the physical properties of the end-product are often improved.

**Applications**

**Adhesive and sealants** - Vacuum mixing results in higher density and better tensile properties due to increased shear and contact of different components.

**Food and pharmaceutical formulations** - Vacuum mixing reduces the entrapped oxygen and leads to longer product shelf life and better stability.

“Vacuum can improve the performance of almost any mixing, blending or drying system”
# High Viscosity Mixers

## Batch Mixers
- Dual Shaft Mixer
- Triple Shaft Mixer
- Planetary - HSD
- Double Planetary
- Kneaders

## Continuous Mixers
- Kneader Extruder
- Intensive Mixer
- Banbury Mixer
- High Intensity Mixer
- Roll Mill
- Pan Muller Mixer
- Single Screw Extruder
- Twin Screw Extruder
- Pug Mill

<table>
<thead>
<tr>
<th>Viscosity (Centipoises)</th>
<th>Dual Shaft Mixer</th>
<th>Triple Shaft Mixer</th>
<th>Planetary - HSD</th>
<th>Double Planetary</th>
<th>Kneader Extruder</th>
<th>Intensive Mixer</th>
<th>Banbury Mixer</th>
<th>High Intensity Mixer</th>
<th>Roll Mill</th>
<th>Pan Muller Mixer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50,000</td>
<td>1,000,000</td>
<td>5,000,000</td>
<td>7,500,000</td>
<td>1 million</td>
<td>3 million</td>
<td>5 million</td>
<td>8 million</td>
<td>10 million</td>
<td>&gt; 10 million</td>
</tr>
</tbody>
</table>

- **Dual Shaft Mixer**: Slow speed anchor agitator with one high shear impeller
- **Triple Shaft Mixer**: Slow speed anchor helical-agitator with two high shear impellers
- **Planetary Mixer with High Speed Disperser**
  - **Double Planetary with Rectangular Blades**
  - **Double Planetary Mixer with Helical Blades**
  - **Kneader Mixer (Sigma Blade, Masticator Blade)**
  - **Kneader Mixer Extruder (Sigma Blade, Masticator Blade)**
BASIC CRITERIA

◊ Process setup
◊ Mixer operating parameters
◊ Mixing accuracy
◊ Mixer cleanability
◊ Equipment costs

◊ Viscosity
◊ Density
◊ Degree of Shear
◊ Sequence of addition
◊ Power consumption
◊ Process cycle time

“There are many variables in each application and as a result no standard set of rules pinpoints which type of mixer is best suited for an application. Selection and scale-up of high viscosity mixers should be carried out after trials and in consultation with mixer manufacturers.”
Laboratory and pilot test results can be useful data with respect to the selection of mixer capacity, power requirements, heat transfer and above all the performance of the mixing process.
**DESIGN GUIDELINES**

**Mixing element** should preferably operate within all parts of the mixing vessel.

Maintain **low clearances** between the mixing element and the mixing container (1 to 2 mm).

The mixing elements may comprise of **intermeshing blades** that prevent the material from cylinerding along with the rotating mixing element.

Mixers should be provided with close-clearance blades and / or scraper devices to move stagnant material away from heat-transfer surfaces.

**High connected power** per unit volume. (upto 6 kW / kg of product)

High viscosity mixers operate at **low speeds**, require high power and therefore need **high torque**.

**Discharge** of materials after mixing may be **difficult** and may require special arrangements.

As the forces generated during mixing process are high, mixers should be **rigid in construction**.
Design, Manufacture, Supply, Installation, Commissioning of

**Liquid Agitators, Reactors...**

**Solid Blenders**
- V-Blender
- Ribbon Blender
- Plough Share Mixer...

**Viscous Mixer**
- Planetary Mixer
- Kneader Mixers
- Kneader Mixer Extruders...

**PRODUCTS & SERVICES**
- Mixing process review
- Mixing equipment review
- Laboratory & pilot scale trials
- Scale-up
- Mixing Simulation
- Mixer troubleshooting
- Short courses, seminars
- Engineering services
THANK YOU

Jayesh R. Tekchandaney
Unique Mixers & Furnaces Pvt. Ltd
jayesh@uniquemixer.com, info@mixing-expert.com
Phone (+91-22)-25801214, 25822385

“No matter how good you are, you can always get better. And that’s the exciting part”