Research and Development
The Key to Successful Impeller Design

The key to an efficient mixing system is the impeller. For each application there is an ideal impeller. Lightnin, with over 70 years experience in fluid mixing, are uniquely placed to offer effective solutions for all application areas.

Lightnin’s commitment to research and development has helped to create a unique, modern, spectrum of impellers, which meet the needs of processes accurately and efficiently. Lightnin’s mixers range from fractional kW through to the world’s largest unit at over 2500kW. The use of Lightnin impellers has generated lower capital and operating costs for many thousands of our customers worldwide.

The LIGHTNIN Laser laboratory

Lightnin operates the world’s most advanced mixing laboratory. Using the four laser beams of a Laser Doppler Velocimeter (LDV) fluid motion as pumping capacity and direction at any point of a vessel are converted into digital information vital to impeller design and optimisation.
Computational Fluid Mixing

These accurate data from the LDV are combined with the power of "Computational-Fluid-Dynamics"-Programs (CFD) in order to predict the mixing dynamics in large tanks with unusual geometry or specific process requirements. This powerful capability reduces substantially pilot- or full scale trials.

CFM plots graphically display full scale mixer performance

Finite Element Analysis

Lightnin complement research into fluid dynamics and impeller design by employing advanced computational techniques in the form of (Finite Element Analysis - FEA). FEA is used principally in two areas:

- Modal Analysis. The natural frequencies of the mixer and its mounting structure can be predicted, thus ensuring that potential costly vibration problems are eliminated at the design stage.

- Optimising agitator design. FEA calculates mechanical and structural integrity, without unnecessary overdesign, thus ensuring customers receive the most cost effective mixing solutions for their particular process.

Finite element analysis of high efficiency impeller blade
**Unique Impeller Range for accurate,**

**Impeller type:** A310 - A510

**Low viscosity and flow-controlled applications**

The A310 - A510 series provides a combination of performance characteristics and high flow efficiency not available from other types of axial flow impellers.

The A310 - A510 can produce the same flow and process results at a lower power than other axial flow impellers thus reducing operating and capital costs.

**Impeller type:** C100 - C110

**Draft-tube circulators.**

Designed specifically for dependable draft tube service, the C100 - C110 has a true airfoil shape and provides high flow, even in unstable process conditions, whilst minimising power requirements. A specific family of impellers (unique to Lightnin) based upon the C100 - C110 design is available for use in draft tubes.

Processes include alumina, gold, uranium and potash.

**Impeller type:** A340

**Gas/ liquid applications with up-pumping characteristics**

The A340 with up-pumping axial flow is the most recent development for gas/liquid applications.

The A340 can be used for coalescing and non-coalescing systems and allows better:

- mass transfer
- heat transfer
- shorter mixing times
**Impeller type:** A312  
Axial flow impeller for side entry applications

The A312 is designed for the arduous requirements of pulp and paper applications. It is also used in other side entry applications such as oil storage and FGD (Flue Gas Desulphurisation). It is an axial flow impeller with a minimal radial flow component, unlike other conventional side entry mixer impellers.

**Impeller type:** A320  
High flow impeller for higher viscosity applications.

The A320 is designed to operate in higher viscosity fluids. The effectiveness of many high efficiency impeller systems which are designed to operate in the turbulent flow regime is impaired as the viscosity of the fluid increases and the Reynolds Number decreases. This is not the case with the A320. The unique design of the impeller reduces both capital and operating costs. Blend times are also reduced compared to other 'open' impellers used at low Reynolds numbers.

**Impeller type:** R400  
Two bladed anchor for higher viscosity applications.

The R400 is a contoured two bladed anchor. It has applications in blending and particularly, heat transfer, where the viscosities range from 10000 to 100000 centipoise.

**Impeller type:** R100 - R130  
High shear mixing and gas-liquid applications.

The R100 Rushton turbine is the traditional impeller for gas-liquid mass transfer controlled systems. It is also used where higher shear is needed. The R130 shown above has similar characteristics to the R100 but gives:

- A higher power input in the gassed condition (reduced ‘K’ factor effect)
- Lower power in the ungassed condition

**Impeller type:** A400  
Helical impeller for high viscosity applications.

Where very high viscosity (above 100,000 centipoise) is involved, helical impellers can be used. A variety of options in terms of number of flights, pitch and helix are available to suit the specific requirements of the duty.

The A400 also promotes surface renewal and heat transfer.

**Impeller type:** R500 (SAW Tooth)  
High shear, typically used for difficult to disperse pigments.

The R500 provides high shear rates. It is generally used in conjunction with a high flow impeller in applications involving a combination of blending and a need for physical change created by fluid shear.
**Impeller Selection**

Mixing is the key to process design. Impeller selection is a key to mixer design.

How impellers convert energy into fluid motion is fundamental to their ability to provide a predictable process result.

All the energy ($P$) applied by any mixing impeller produces a pumping effect ($Q$) and a velocity head ($H$), so that

$$P \propto QH$$

A knowledge of how this balance of energy distribution can change with impeller geometry is fundamental to mixer design. Lightnin has used its extensive knowledge of impeller fluid mechanics to develop a family of efficient, process specific, impellers.

**Impeller Comparison**

**Basic formula**

Not all impellers perform at a similar level of efficiency even though they may superficially look to be similar in design. The performance capability of flow impellers can be compared by an evaluation of flow efficiency.

A knowledge of the flow numbers ($N_q$) and power number ($N_p$) of the impellers being compared is required.

The following basic equations can then be applied:

- $N_p = \frac{P}{N^3D^5\rho}$
- $N_q = \frac{Q}{ND^3}$
- $N_re = \frac{ND^2\rho}{\mu}$

**Impeller Spectrum**

Impeller spectrum indicates relative power apportioned to $Q$ and $H$ for various impeller types.

- $N_p = \text{Impeller power number}$
- $N_q = \text{Impeller flow number}$
- $N = \text{Impeller rotational speed (1/sec)}$
- $N_re = \text{Impeller Reynolds Number}$
- $\mu = \text{Viscosity in Pas}$
- $P = \text{Impeller power (W)}$
- $D = \text{Impeller diameter (m)}$
- $Q = \text{Impeller primary flow (m}^3/\text{sec)}$
- $H = \text{Head (Shear)}$
- $\rho = \text{Fluid density (kg/m}^3\text{)}$
Comparison Basis

Before two impellers can be compared, a basis for the comparison must be established. Whilst many combinations of parameters can be applied (e.g. power required at constant flow and speed, or constant speed and diameter), the most applicable to the flow controlled operations of blending, solids suspension and heat transfer is constant diameter, $D$, and constant flow, $Q$. Applying the basic mixing formulae in ratio form gives the following comparison.

Using the formulæ in Table 1, the performance of different impellers can be evaluated in relation to each other. For example, Table 2 compares the Lightnin A510 with a 45° Pitched Blade Turbine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>$\frac{Nq(2)}{Nq(1)}$</td>
</tr>
<tr>
<td>Diameter</td>
<td>1.0</td>
</tr>
<tr>
<td>Flow</td>
<td>1.0</td>
</tr>
<tr>
<td>Power</td>
<td>$\frac{Np1(Nq2)^3}{Np2(Nq1)^3}$</td>
</tr>
<tr>
<td>Flow/Power</td>
<td>$\frac{Np2(Nq1)^3}{Np1(Nq2)^3}$</td>
</tr>
<tr>
<td>Torque</td>
<td>$\frac{Np1(Nq2)^2}{Np2(Nq1)^2}$</td>
</tr>
</tbody>
</table>

Table 2 demonstrates that at constant impeller diameter to tank diameter ratio ($D/T$) and constant flow $Q$ (i.e. constant process result), the Lightnin A510 mixer requires 51% less power and less than half the torque (and therefore lower operating costs), than a mixer fitted with a pitched blade turbine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lightnin A310</th>
<th>Pitched blade A200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Np</td>
<td>0.30</td>
<td>1.27</td>
</tr>
<tr>
<td>Nq</td>
<td>0.56</td>
<td>0.79</td>
</tr>
<tr>
<td>Speed</td>
<td>1.00</td>
<td>0.71</td>
</tr>
<tr>
<td>Diameter</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Flow</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Power</td>
<td>1.00</td>
<td>1.51</td>
</tr>
<tr>
<td>Q/P</td>
<td>1.00</td>
<td>0.66</td>
</tr>
<tr>
<td>Torque</td>
<td>1.00</td>
<td>2.13</td>
</tr>
</tbody>
</table>
Our Organisation

Worldwide Support
Combining Bran+Luebbe, Lightnin, Plenty and Premier Mill has lead to a worldwide network of expertise in process equipment for industrial mixing and metering. With our own companies and representatives you will always find experienced support immediately available.

Guarantee
All our products are built to last and we provide warranty periods that are appropriate for the specific industries where the equipment is located.

Quality
We recognize that our customers demand a high quality product manufactured and serviced in a timely and efficient manner. Working within the process industry we are fully aware of the specific demands for quality standards and all our companies are ISO 9001 accredited.

After Sales and Service
Our dedicated direct service teams are readily available to support your process equipment at all times. Genuine spares and service solutions can be obtained from all our companies and ensure operating capacity of your valuable production equipment.

How to contact us

Bran+Luebbe
http://www.bran-luebbe.de

Lightnin
http://www.lightnin-mixers.com

Plenty
http://www.plenty.co.uk

Premier Mill
http://www.premiermill.com

Your local contact