New Impeller Type for Mixing Efficiency Improvement and Energy Saving

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Revolmixing
www.revolmixing.com

1. Challenges of Mixing
2. Mixing Mechanism
   - Of Existing impellers
   - Expected
3. New Impeller Performance
4. Applications

1. Challenges of Mixing

- Improper mixing
  - Insufficient mixing:
    - Slow reaction
    - Low productivity
    - Larger reactor
    - High local concentration kill/inhibit cells
    - Unwanted byproduct
  - Over mixing
    - High shear-Share sensitivity/cell carrier
    - Flocculation
  - Price : Billion dollars annually.

1. Challenges of Mixing

- Mixing Efficiency
- Energy Efficiency
- Scale-up
- Specific Requirements
  - Multi stage chemical reactions with different mixing requirements.

2. Mixing Mechanism-Existing Impellers

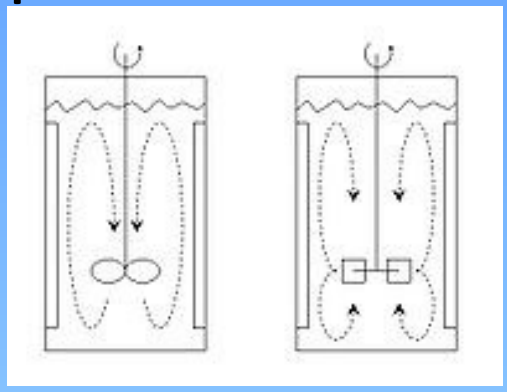
Impellers

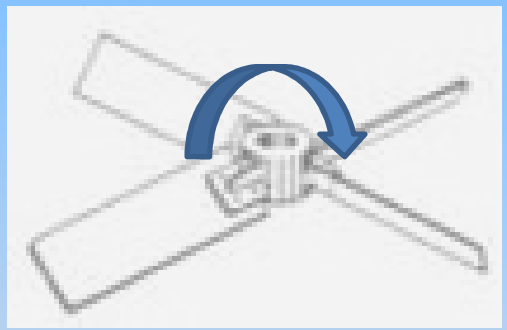
- Marine propeller
- Pitched blade
- Turbine (Ruston)
- Submersible mixer
- Amendments of above.
  - Short or long, wide or narrow, bend
  - At corner, or cut a corner, etc.
  - Create large flume of flow
  - Good mixing Rely on baffle to create turbulence

2. Mixing Mechanism-Existing Impellers

Flow Pattern

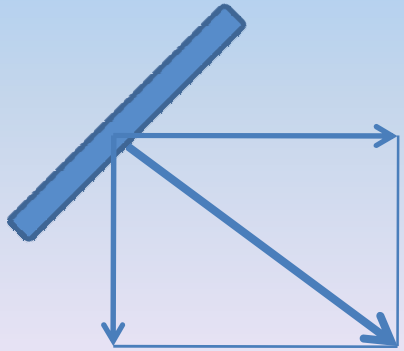
- Push liquid downwards/Upwards/ around
- Create Vortex
- Baffles are needed
- Distribute large circulation loop/ flume of liquid





Baffles

- Increase flow friction/resistance to create **turbulence**
- Energy dissipator



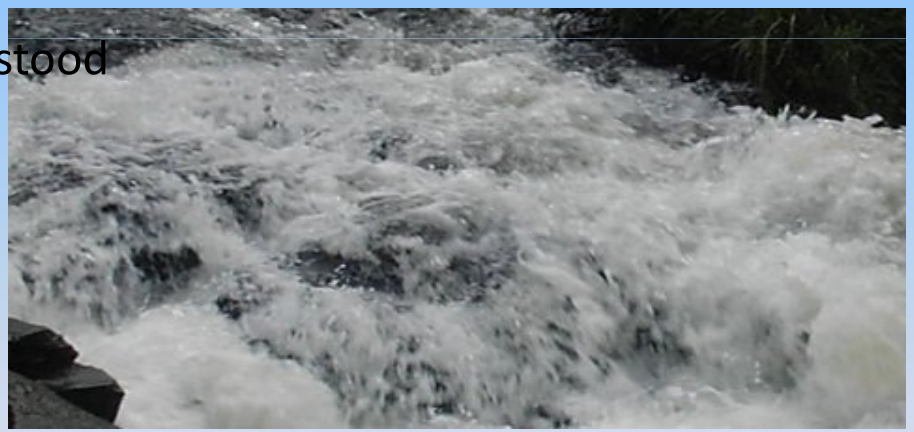
2. Mixing Mechanism-Existing Impellers

Current Research areas:

1. Pumping more liquid
2. Create more turbulence or smaller drops/eddies

Turbulence:

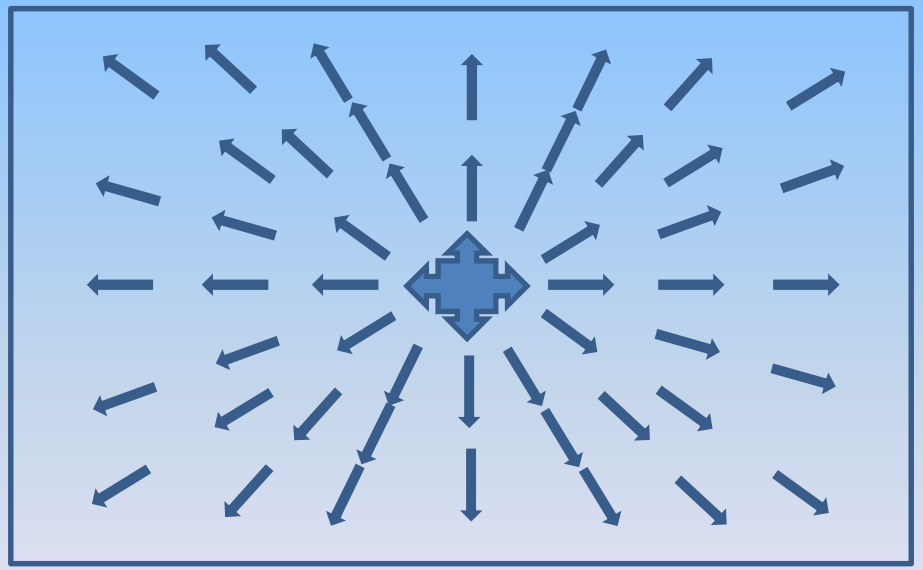
- Flow velocity fluctuation
- Bulk mixing
- Still studying and not well-understood
- Difficult to predict/model
- Too many variables:
  - » Reactor geometric
  - » Impeller type/position/speed
  - » Power input
  - » Liquid Viscosity
  - » Baffle
  - » Each application may need develop a model
  - » Cause of difficulties to scale up/down



2. Mixing Mechanism-Expected

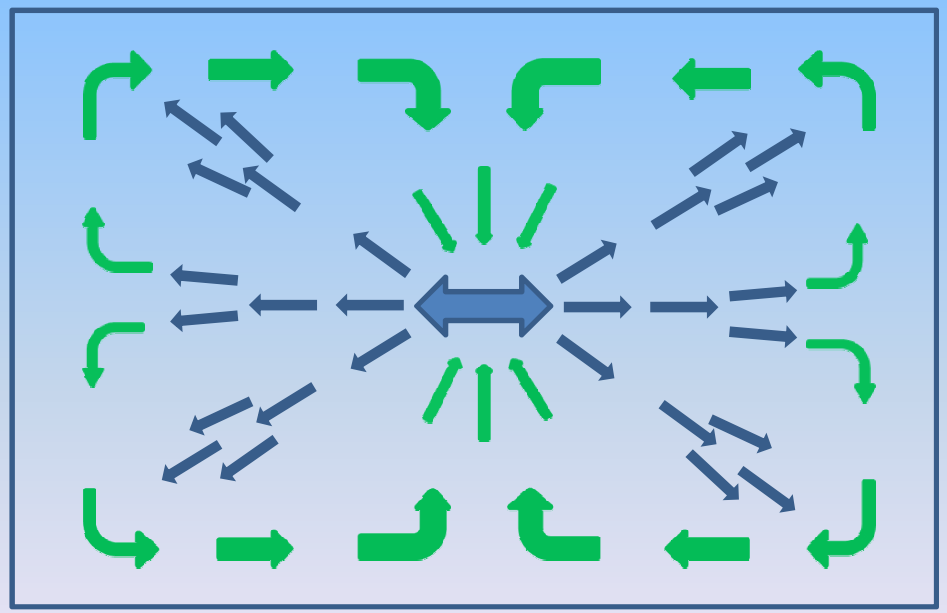
- Mixing—reduce non-uniformities
- Bulk motion-small eddies-dispersion-molecular diffusion
  - Distribution-Bulk circulation
    - Limited effect on mixing
  - **Dispersion—New generation mixing**
    - Break bulk flow to smaller eddies.
    - **(Physical Chemistry:) to cause (particles) to separate uniformly throughout a solid, liquid, or gas.**
    - (chemistry:) mixture in which fine particles of one substance are scattered throughout another substance.
    - Apply energy directly to dispersion
  - Diffusion
    - Reaction requires molecular contact-ultimate goal
    - Molecular level (Brownie Motion) - temperature related
    - Improve dispersion will improve diffusion

2. Mixing Mechanism-Expected
   - Good/Ideal/preferred Mixing

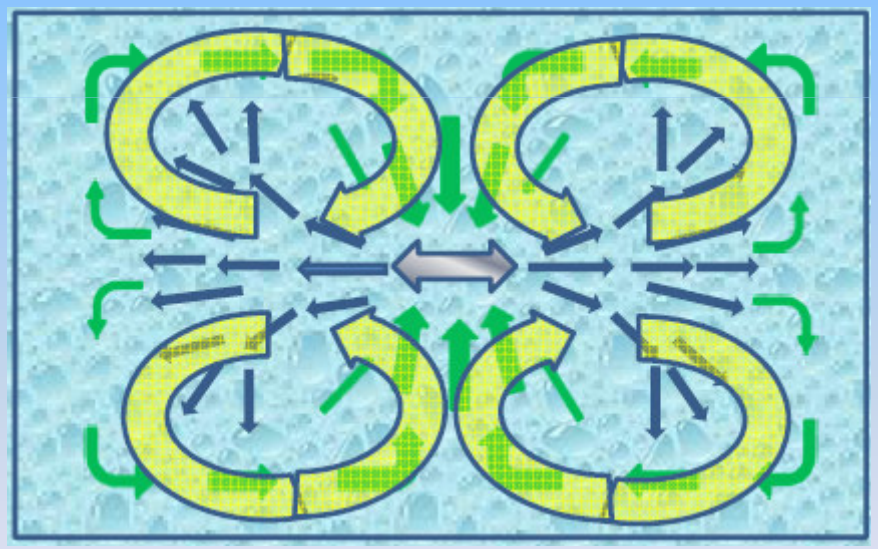


2. Mixing Mechanism-Expected

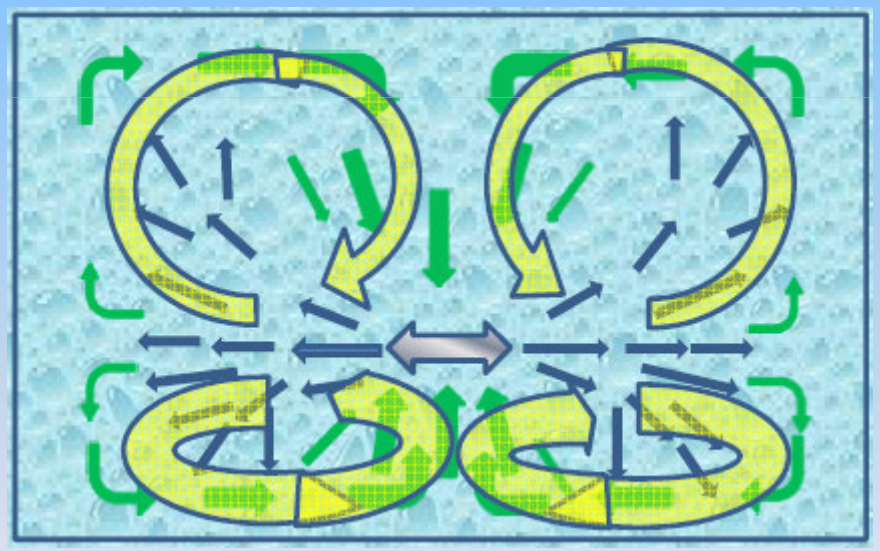
- Good/Ideal/preferred Mixing
  - Circulation loop



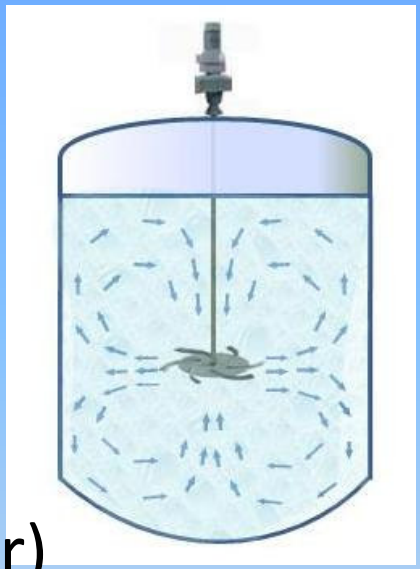
2. Mixing Mechanism-Expected
   - Center location



2. Mixing Mechanism-Expected
   - Bottom location for high flow under impeller. Such as for solids suspension.



2. Mixing Mechanism-Expected



Performance Tests

Tank size:	22 inch diameter,
Water Depth:	33 inch
Volume:	60 Gallon (220 Liter)
Impeller:	7.5 inch,
speed:	120—150 rmp
Impeller location:	10 inch above bottom (center)

3. Performance of New Impeller

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3. Performance of New Impeller

- Various impeller positions possible
- What's the flow under the impeller?
- Much lower impeller speed (30 rpm) also works.
- Dished or coned bottom desired

3. Performance of New Impeller

Observations:

1. Solids are fully suspended—not pushing to bottom edge
2. On-bottom Motion speed is the complete off-bottom (just) suspension speed, even Total Uniformity speed (Power Ratio: 1:2-5; or 1:4-25-Oldshue (1983).
3. Satisfactory uniformity
4. Combined radial flow, axial flow, centralized circulation with strong dispersion at the center.
5. Minimum vortex—desired for circulation loop
6. Little turbulence, mostly laminar flow
7. Minimized stagnant area
8. No short circuit

4. Applications

1. **Fast mixing—**polymer dilution/coagulation
2. **Complete solids suspension**
3. **Easy modeling**
4. **Precise scale up/down**
5. **Little surface disturbance—**Oxygen sensitive reactions
6. **Little shear force—**flocculation/biomass/biocarrier
7. **Convenient impeller location—**Top/bottom/middle/eccentric
8. **Convenient Inlet/outlet—**top/bottom/middle
9. **Various mixing strength required—**Change mixing speed to suit reaction requirement.
10. **No baffle**
11. **Saving cash and payback**
    - Smaller Reactor
    - Purer products
    - Energy

4. Applications

- Trend:
  - The reactor be shaped for optimized flow pattern: egg shaped fomenters

REVOLMIXING
High Performance Dispersing Impellers

- Thank you!
- Any questions?