ATS Fluid Mixer

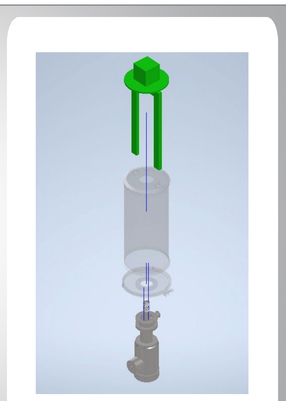
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Sponsors: Automated Technical Services, Nord Drivesystems, and GlassAct Studios

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Automated Technical Services, LLC

Focus

To design and create a low-speed mixer that would integrate with current ATS tanks and meet customer needs related to cleanability, manufacturability, and mixing performance for a variety of fluids.



Applications for hygienic fluid mixers:

- Cosmetic products
- Medicines
- Foodstuffs
- Chemical R&D

Customer needs

Needs were based on ATS target metrics, industry standards, and interviews with potential customers.

#	Mixer need	Priority
1	effectively mixes products in specified viscosity range	high
2	is food safe	high
3	is highly cleanable	high
4	has effective tank scraper system	med
5	is cost effective to manufacture	med
6	is easy to set up and operate	med
7	is long-lasting	low
8	is easily maintainable	low

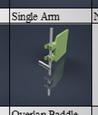
Concept Generation

Individual Brainstorming

- Over 100 ideas generated

Morphological chart

- A Morph chart was used to assess compatibility between different design choices

Aspect					
Mixer					
Description	Horse Shoe	N Shape 1	Single Arm	N Shape 2	H Shape
Scraper attachment					
Description	Sliding lock	Rotating lock	Overlap Paddle		
Features					
Description	Slot blade	Reducer Nozzle	Diffuser/nozzle	Slots	Oval nozzle

Concept Selection

Decision Matrix

- The most promising designs were graded in a decision matrix. These ideas were explored and quantified in the prototyping process and analysis

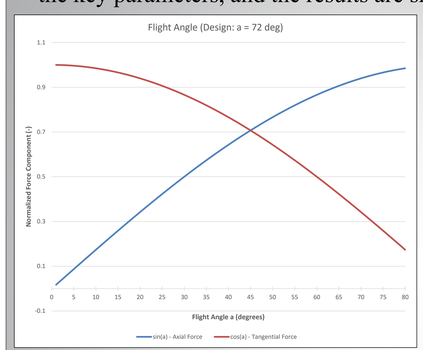
Metric	Cost/Labor	Cleanability	Manufacturability	Maintenance	Functionality	Durability	
Metric Weights	0.75	0.95	1	0.8	0.85	0.7	
Design							**Weighted Score**
"H" shaped	76%	79%	77%	73%	76%	79%	76%
"n" shaped	79%	81%	84%	84%	64%	79%	79%
Single straight arm, "Γ" (capital gamma) shape	90%	86%	91%	83%	46%	67%	78%
Helix, small angle like DNA	45%	53%	43%	60%	88%	73%	60%
Horseshoe shape with paddle ends	73%	73%	75%	77%	80%	80%	76%
Inverted anchor	75%	67%	75%	60%	70%	77%	70%
Flow Separation	50%	38%	47%	52%	88%	82%	58%

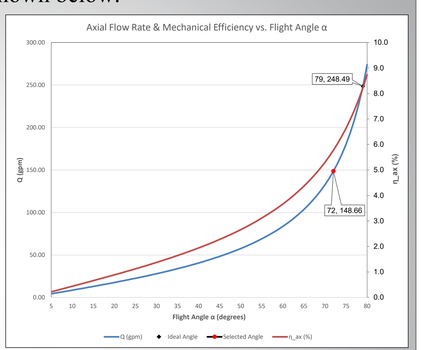
Metrics	Cost/Labor	Cleanablity	Manufacturability	Maintenance	Functionality	Durability	
Metric Weights	0.75	0.95	1	0.8	0.85	0.7	
Design							**Weighted Score**
Nozzles to speed up fluid as it moves through the mixer ar	65%	42%	75%	67%	83%	80%	68%
Angled fins to direct fluid up/down	87%	73%	74%	77%	89%	80%	80%
Pickets to agitate fluid	68%	62%	80%	84%	84%	76%	76%

Analysis

Quasi-Helical Mixer Analysis

The mixer is not a true helix due to the inverted anchor framework. Analysis of flight angle vs fluid flow was conducted. Prototyping showed that axial fluid movement greatly affected mixing time. Given physical design constraints, a 72° quasi-helical flight angle was selected. Flight angle and tank turnover rate were the key parameters, and the results are shown below.

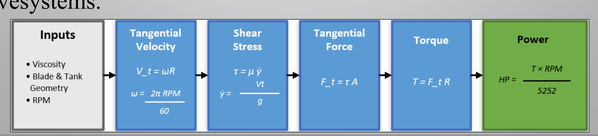




Tank Turnover Rate		
Calculated	1 turnover =	~3.8 sec
Actual	1 turnover =	~4.0 sec

HP and Torque Analysis

Using the maximum values of our design requirements and a safety factor between 2 and 3, a horsepower requirement for the motor and gear system was calculated to be 0.82 hp. A 1.5 HP motor and 60 RPM gearbox were donated by Nord Drivesystems.



Prototyping

A ½ scale model was created to test various mixer blade designs for flow characteristics

1. **Slot design:** Provided good lift, the narrow tank geometry inhibits toroidal mixing.
2. **Quasi-helical design:** Simplified geometry has better cleanability though still has slow mixing.
3. **Quasi-helical bidirectional:** Oscillating upward and downward flights force vertical fluid mobility.
4. **Quasi-helical bidirectional optimized:** Has same benefits as before but more structurally stable and reduces locations of trapped eddy flows.



1. Mixing time 165 sec. (low viscosity)



2. Mixing time 30 sec. (low viscosity)



3. Mixing times: 12 sec. (low viscosity) 75 sec. (high viscosity)



4. Mixing time 48 sec. (high viscosity)

Completed Project

Conclusion

The final product provided significant improvement to mixing at high fluid viscosities over the original, while being cheaper to manufacture.



A special thank you to Automated Technical Services (ATS) for sponsoring this project, to Nord Drivesystems for providing the motor and gear box, and to GlassAct Studios for waterjet services.