AMX AGITATORS
IN CHEMICAL PROCESSING

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introduction

The AMX range of agitators are designed and manufactured to suit applications throughout chemical production plants. Chemical manufacturing is a precisely controlled process, which works best with the correctly sized mechanical tools. Other than the agitator, the reactor vessel and baffle sizing are individual contributors to the completed product, and if any one of these are incorrectly sized, the process will suffer from failing final products, inefficiencies and possibly increased costs.

The processes and reactions in this industry cover a broad scope of mixing requirements such as liquid-liquid, gas-liquid, liquid-solid mixing, as well as various types of batch and crystallisation processing applications. Agitator tasks range from the dispersion of liquids, dissolving of gases and solids, basic mixing and blending, co-current scrubbing, homogenising as well as neutralisation.

industry applications

- Mixing miscible or dispersing immiscible reactants.
- Dissolving gases.
- Providing plug flow with reaction controlled conditions.
- Dispersing liquids in extraction and washing processes.
- Mixing gases in front of oxidation reactors.
- Vaporising liquids in font of oxidation reactors.
- Homogenising process and product streams for representative sampling.
- pH adjustment.

Crystallisation forms the basis for the following chemical reactions and is generally applied to bulk chemical mixing.

competitive-consecutive reaction

This reaction is when insufficient mixing occurs, and consecutive and competitive side reactions occur creating unwanted reactions and depleting the available solution of chemicals that are required to manufacture the primary products.

The AFX F3 axial flow hydrofoil impeller is the dynamic workhorse of AFX's solutions in eradicating the occurrence of competitive-consecutive reactions. This impeller is suitably adjusted for the process design to ensure process guarantees. The F3 impeller is capable of producing high pumping rates at a low power draw than when deploying the commonly witnessed pitched blade turbines. The F3 impellers shear rate remains low when correctly sized and powered, offering the client an energy efficient and cost saving solution.

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gas-liquid reaction

These types of reactions often require a self-inducing process or a gas sparge type installation to facilitate the dispersion of gas into the liquid.

AFX has worldwide success in many processing industries utilising its mass transfer agitators and sparging solutions. AFX has been successfully designing and implementing scale-up solutions in this industry. The incorporation of the R&D department in developing ongoing solutions has made AFX a world leader in these applications. AFX predominantly uses its P4 mass transfer impeller and gas dispersion agitator solutions in this reaction.

solid-liquid reaction

These solutions require a mixing process that avoids settling of the solids on the bottom of the tank, which directly affects the mixing rate. The use of baffles is normally recommended in this reaction.

AFX design engineers utilise the calculated velocities in the tank, to design solutions, that can be process guaranteed based on the client's process data. The F3 axial flow hydrofoil impeller would most commonly be selected for these types of applications due to its robust design as well as versatility.

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liquid-liquid reaction

These reactions suffer from scale-up due to the fact that drop formation and coalescence change with scale. The scale-up problem is often remedied with over mixing and exposing the droplet to a higher concentration of the reagent in the aqueous phase.

AFX has evaluated the typical problems in scale-up of this reaction type and designed solutions that do not over mix or unnecessarily increase the power draw required. The AFX design tools allow for the meticulous design of the mechanical solution, ensuring the required process is achieved.

Depending on the particular solutions as well as their properties, AFX would combine various impeller solutions to ensure competent processing. This could include a combination with FS4 and F3 impellers or P3 and F3 combination.

reactive crystallisation

When both a reaction and crystallisation need to occur in the mixing process the application engineer's design becomes more critical. In the scale-up process, the design of the agitator needs to accommodate the balance between a growth-dominated process which cannot be too fast so as to cause crystal fracture coupled with the requirements of mixing fast enough for the micro-mixing effective of fast reactions.

Particular applications require low-velocity movement on the floor of the reactor, or they may call for solids suspension, which would result in increased power requirements. Our F3 range of impellers includes various blade pitches that allow AFX to solve all the crystallisation processes challenges.

principals of reactor design and mixing

The rate of mixing is determined by the chemical reaction speed. Insufficient mixing may lead to the formation of side reactions which are the impurities in the final product. The creation of side products is related to concentration differences in the tank on a micro level. If pH balancing is incorporated into the process and neutralisation is required to halt a process, then inefficient mixing speed will result in a delayed neutralisation event which could result in by-products being formed.

Generally speaking, four types of mixers are included in the design of mixers in the chemical industry.

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principals of reactor design and mixing

The following mixer types form part of the existing pipework and take up very little space and have low running costs:

- Pipeline
- Tee-mixer
- Static mixer

The following mixer types are commonly found in solutions that are top-entry or side-entry mixers:

- Stirred tank

A pipe, or tubular reactor, is the most common designed reactor. Reactants are injected into one end and an obstruction that causes turbulent flow is present in the pipes. The tee-mixer is a variation on the pipe mixer, wherein two reactants are injected into the t-joint at pressure, utilising turbulence with pressure energy. Static mixers are placed in the pipes to create obstructions that promote mixing. The stirred tank consists of the vessel and the mixing device with stirred tanks being the most versatile option for mixing.

The reactors geometry and the position of the feed point affects the reactions yield. The optimal feed point is near the tip of the impeller where maximum turbulence is present. Some designs use this principal to create multipoint feeds which allow the flow rate to be reduced without decreasing productivity.

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scale-up

Some factors affect the scale-up process:

- **Shear Rate & Energy Dissipation in The Tank:** Thermodynamics work logarithmically based on volume therefore cooling and heating is not extrapolated in a linear calculation using linear multipliers. This typically would result in hot spots and unwanted chemical reactions which affects the rate at which chemicals can be introduced into a tank, to ensure the correct concentrations.

crystallisation

Crystallisation is essential in the development of products and mixing has a direct effect in the production process. Mixing affects crystal nucleation, growth and slurry maintenance. This makes scale-up a challenge when designing these processes. AFX's application engineers are equipped with the knowledge and the tools to successfully design mixers for this scale-up to mass production.

AFX designs accommodate:

- Control of the crystal size with the type, size and speed of the impellers in the mixing vessel.
- The quantity of nucleation occurring to avoid excess and fracturing of crystals.
- The occlusion of impurities due to poor mixing action and unacceptable physical properties of crystals.

equipment

Crystallisation is normally achieved in a multipurpose vessel with hydrofoil impellers like AFX's F3. Good circulation with low shear in the tank is necessary to avoid secondary nucleation and crystal breakage. Baffles are used to ensure good mixing.

mixing and crystal growth

Balance in the mixing process is required between growing crystals and not breaking them. A high mass transfer rate is required to avoid super-saturation around the crystal growth area while ensuring good heat transfer rates and dispersion of the additives, avoidance of settling and uniformity of the crystals in the product. Over-mixing would result in crystal breakage and secondary nucleation, which is undesirable as it is a by-product which results in reduced yield of the required product and requires removal from the main product to maintain the products purity level.

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