TECHNICAL REPORT
MIXING EQUIPMENT CO., INC.
ROCHESTER, N.Y., 14603

DOM:pk
10/5/81

PILOT PLANT PROGRAM

FOR POLYMERIZATION

BY: Mixing Equipment Co., Inc.
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Rochester, New York

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A GENERAL OVERVIEW

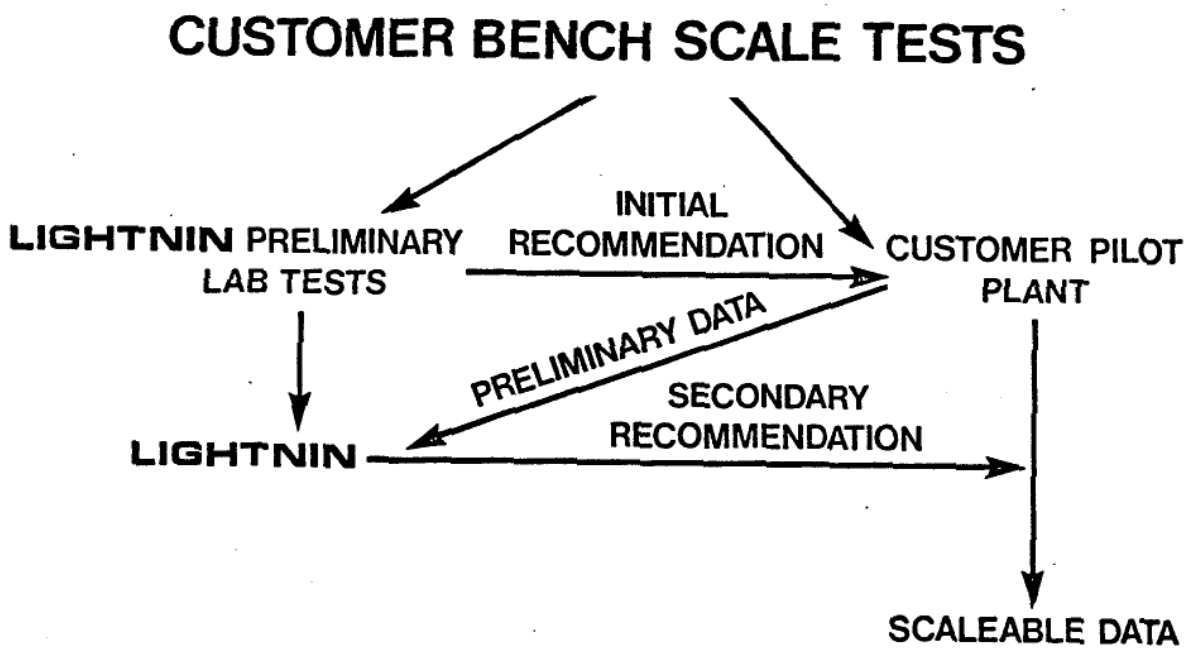
LIGHTNIN has manufactured agitators for the polymerization industry for nearly 60 years. We have been involved in optimizing customer's profits in manufacturing polymers since 1925. In fact, our company was founded at the same time the first synthetic polymers were produced in the world. We have been in business as long as the entire polymer industry.

How would you like to increase your company's profits? A giant step in completing this objective is to discover the LIGHTNIN Pilot Plant Program for Polymerization. It is not a rigid program, but designed specifically for you, the customer, in order to save your time and manpower in the initial stages of a polymerization project. The end result will be the proper information required for scale up of a polymerizer agitator, in a very short period of time. There will be no wasted time researching unknown parameters unaffected by proper mixer scale up. In the long run the entire project - from the research stage to full scale start up - will not be delayed due to unnecessary front-end development. The sooner a plant is put onstream, the sooner the return on investment becomes apparent.

It makes sense to spend a little more time efficiently, at the very beginning to save time, manpower, and cost at the end. Our pilot plant program is ready to assist.

Pilot Plant Program - Options

The LIGHTNIN organization, including our Sales Representatives, Application Engineers, and laboratories are available to assist you in any stage of your program.



There are many options available that together can be followed to save that extra time and manpower.

1. BENCH SCALE OPERATIONS

Mixing is not a major criteria for those "normally performed" bench scale operations. However, LIGHTNIN has vast experience in areas other than mixing for polymerization bench scale operations. We can recommend the proper way in which to take viscosity readings by using a LIGHTNIN viscosimeter package. This will provide more accurate results in high viscosity materials and slurries than the traditional Brookfield Viscosimeter. We have specific recommendations regarding the use of flask tests, magnetic stirrers, and even Waring Blenders.

2. INITIAL PILOT PLANT PROCEDURE

Together we can formally compose a pilot plant procedure that will be directed toward your, and only your pilot plant that will enable the mixing parameters to be defined. This will ensure proper and timely scale up. We will incorporate any bench scale information available, any similar full scale, non-confidential information obtained throughout our 60 years of agitation work in polymerization, or just start from scratch. We can direct this procedure to your existing pilot plant, or if desired, supply pilot plant recommendations such as different mixer, impeller, tank, or pump designs. This procedure can turn a non-optimum pilot plant into one that is optimized by people who know the polymerization market. These pilot plant procedures are nothing new to LIGHTNIN.

The Application Engineering Department comprised of 26 Chemical and Mechanical Engineers, has the technical background and experience to write such procedures. In fact, numerous written pilot plant procedures are on file.

3. LIGHTNIN PRELIMINARY LABORATORY TESTS

In the 1980's the polymerization market will change. There are new polymers being invented every day. In addition, the old standbys - PVC, polystyrene, polypropelene, Polyethylene - are having their formulations reviewed continuously. Because of these new developments, the exact mixing requirements may also be new. If such is the case, our laboratories are available to develop the expertise for full-scale design of the mixers. Our broad range of facilities and laboratory equipment are available to obtain these parameters. It might be necessary to use the five mixer dynamometers available or run a polymerization test from start to finish in our 14" diameter or 30" diameter pressure vessels. Twenty-five different types of impellers are available, ranging from 2" diameter SuperPitch props to 29" diameter specially designed helical impellers. If the system requires heating or cooling to maintain the proper batch temperature, steam and oil circulating heating systems are provided for temperatures up to 400°F, with municipal water for cooling purposes. A full range of control is available to maintain the temperature. To make sure the product is of the right proportion and the correct physical properties, our laboratories are supplied with the latest

standard equipment plus very specialized equipment specifically designed for mixing technology.

Most polymers are manufactured by one of four different methods for polymerizations. Our laboratory is designed to handle tests of this variety. Laboratory requirements are also affected by the type of polymerization, either condensation or addition polymerization.

POLYMERIZATION METHODS[a] in COMMERCIAL USE

Polymerization of	Bulk	Solution	Suspension	Emulsion
ADDITION POLYMERIZATION				
ABS Polymers				A
Acrylic Polymers	A	A	B	B
EPT		A		
Chlorinated Polyether		A		
Polyacetals	A		B	
Polyethylene	A	B	B	B
Polyisoprene		A		
Polypropylene		A[c]	A[c]	
Polystyrene	A	B	A	B
Poly(vinyl acetate)	B	B	B	A
Poly(vinyl chloride)	B	B	A	B
CONDENSATION POLYMERIZATION				
Melamines		A		
Nylon-6		A		
Nylon-6,6	A[b]	B		
Phenolic Resins		A		
Poly(ethylene terephthalate)	A			
Polycarbonate		A		

[a]Key: A, method of polymerization commonly used commercially; B, method of polymerization occasionally used commercially.

[b]Reaction started in aqueous solution, but water is removed during polymerization yielding a bulk polymer.

[c]Polypropylene does not fall into any particular category. Solution methods are usually high viscosity. Polypropylene is made in low viscosity slurries. Also, the polypropylene polymer is not soluble in the diluent, unlike solution polymers. Suspension polymers usually use water as the suspending medium and diluent. Polypropylene uses a solvent (usually kerosine, hexane, or even propylene).

Specifically:

A. Suspension Polymerizations

We have run visual tests of polystyrene and PVC manufactured through the suspension polymerization process. We have the ability to run a polystyrene suspension polymerization test from start to finish because the temperature and pressure are in the ranges of our equipment. This type of polymerization is a batch process which makes it easier to run in our laboratory, but, we can also run continuous polymerizations if required. Since suspension polymerization uses the particle size distribution (peaking) results as the major determination for on spec material, we can easily determine the particle size distribution using standard measuring techniques. By using one of our many drives we can change impellers and speeds to optimize the peaking thus optimizing the profit and the mixer. Different amounts or types of chemicals can be introduced and the effects of mixing analyzed. Since suspension polystyrene normally runs at very high volumes of solids to liquid ratio, particle suspension is a problem. We can modify vessel internals to determine the proper baffle design for different mixer horsepower levels and tank configurations.

(We have run visual tests on PVC, however, an actual polymerization cannot be run in our laboratory. OSHA regulations for the vinyl chloride monomer indicate no emissions can escape to the atmosphere. Certainly in running laboratory tests those emissions would occur. Therefore, we reserve the right to decline polymerization tests of this type.)

Our laboratory capabilities in relation to the polymerizations of polyvinyl acetate, polyacetals, and acrylics can be specifically reviewed if required.

B. Solution Polymerization

The polymerization of propylene into polypropylene without a diluent can not be tested in our laboratories due to the fact that the vapor pressure and temperature to keep the propylene a liquid are much higher than our laboratory capabilities. If a diluent is present the temperature and pressure are normally lower and we can run this polymerization in our

laboratory. Actual visual tests using polypropylene in a diluent have been completed. Solution polymerizations usually require the least heat transfer capabilities. At our laboratories, we have the capabilities of running solution polymerization tests and, in addition, other types of polymerizations with different heat transfer surfaces (such as helical coils, vertical tubes, jackets, and plate coils).

Rubber compounding has been run in our laboratory from start to finish.

C. Bulk Polymerizations

Bulk polymerizations indicate that high viscosity materials will be present in the polymerizers requiring close-clearance impellers. We have numerous close-clearance impellers including different diameter anchor and spiral impellers. Single and double helix impellers are also available. We can test any of these close-clearance impellers in the polymerizer. Many flow comparison tests have been completed in the laboratory with high viscosity bulk polymers. Since these types of polymerizations normally use close-clearance impellers, internal heat transfer surfaces cannot be used. We have jacketed pressure vessels that allow us to run either exothermic or endothermic polymerizations.

D. Emulsion Polymerizations

Emulsion polymerizations are shear sensitive. Too much shear may cause coagulation. Nevertheless, shear is still a requirement for this type of polymerization. Many narrow bladed radial flow turbines or high shear impellers, such as bar turbines, are available for these types of polymerizations. We can run this polymerization in our laboratory and have done so in the past. The types of materials for emulsion polymerizations will indicate feasibility of laboratory tests.

Preliminary laboratory tests can be completed in the LIGHTNIN laboratories. These tests can be used to enhance the direction of a pilot plant procedure or to give actual scale up data. In any event, it is part of the pilot plant program that is essential for the optimization of time, manpower, and profits.

4. TECHNICAL REVIEW OF BENCH SCALE AND PILOT PLANT DATA

From 26 Application Engineers to 14 Research & Development people to Dr. James Y. Oldshue, we have the technical expertise to review bench scale and pilot plant data.

This review includes, but is not limited to:

...evaluation of the data as it pertains to mixing.

...areas of systems design which will save you money.

...additional experiments as necessary, for complete optimization on scale-up.

5. SECONDARY PILOT PLANT PROCEDURES

After the technical review has been completed, it might be necessary to obtain more pilot plant or bench scale data. If this is the case, a secondary pilot plant procedure can be written. We would use the same expertise and call upon the same resources as the initial pilot plant procedure. It may be that this extra little step will prove the difference between a completely successful plant and one that is not as profitable as desired.

6. SCALE UP

Our present research capabilities, combined with prior decades of laboratory testing, have produced the most sophisticated data banks available anywhere in the world. One of the most important design factors for polymerization equipment is the optimal fluid shear rate. We have recently obtained the most accurate information ever generated, relating to fluid shear rates. This information comes from our computer-controlled Laser Anemometry Laboratory, the only one of its kind in the world.

Polymerization is not a simple blending problem. An exact knowledge of fluid shear rates is mandatory in determining proper agitator design. Unlike blending or solids suspension applications, "bigger is not always better" which is why our expertise is to important.

All of these considerations can be topics of discussion at our headquarters in Rochester during a meeting with you and your key personnel. Better yet, we can organize and present a seminar on the subject at your home base or at ours - your choice. Our sales engineers would be happy to assist you in making the necessary preparations.

7. QUOTATION

Our quotation for the full scale equipment may contain one or more alternates. There may be more than one mixer that can economically accomplish a process result. We feel it is our duty to let you the customer review our design and economic evaluation with us. The alternates may also be for different mixers for different process results. For example, a 10 HP mixer and a 20 HP mixer with two different blend times. Because upstream or downstream equipment limitations may be governing, we'll leave the selection up to you. Whatever selection, the quotation states we guarantee the mixing results 100%.

SUMMARY

An agitator cannot be properly designed without developing and understanding important criteria at the very beginning. It behooves both the vendor and customer to work together to obtain the proper scale up parameters. Only then can the mixer and the product of the polymerizer be optimized - leading to improve profits for you. LIGHTNIN will write pilot plant procedures or present technical seminars to your employees, or if you prefer, arrange meetings and discussions at your convenience. We guarantee confidentiality in every phase

of the project. Secrecy agreements and mutual development programs are very common in the field of polymerization. However, even though such agreements may not transpire, we still respect your right to secrecy.

...we have been there before,

...we can help,

...our record speaks for itself - we have sold more agitators to the polymerization market than any other company in the world.