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ENERGY & ENVIRONMENT DIVISION

HYDROLYZED WOOD SLURRY FLOW MODELING

Jim Wrathall and Sabri Ergun

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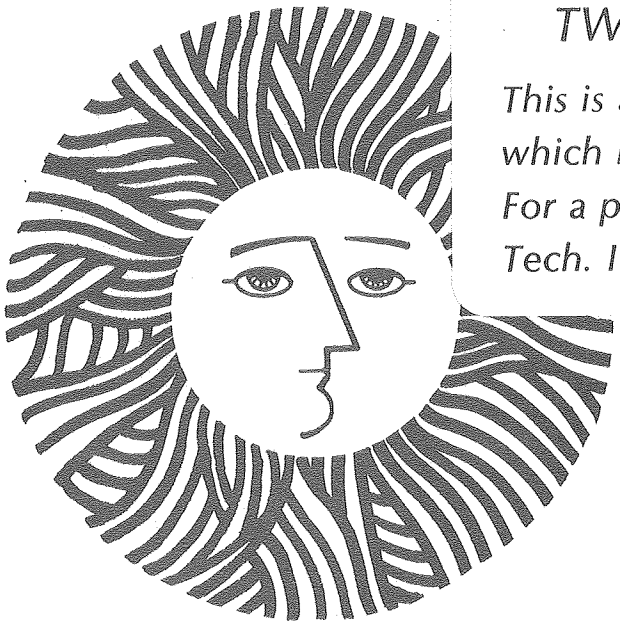

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DISCLAIMER

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HYDROLYZED WOOD SLURRY FLOW MODELING

Jim Wrathall and Sabri Ergun

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

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INTRODUCTION

Our project involves catalytic conversion of hydrolyzed wood slurry to fuel oil. Based on our experience at the Albany PDU (operated by Rust Engineering), we have designed a process to convert Douglas Fir chips into a pumpable fuel at costs comparable to current spot prices for Middle Eastern crude oil. Part of our task includes overcoming operating difficulties that have developed at the Albany pilot plant, one of which is production and handling of a pumpable, non-clogging hydrolyzed slurry as feedstock for a liquefaction process.

We have set up a flow system to investigate the properties of the hydrolyzed slurry in hopes of acquiring proficiency in control of slurry flow and development of conditions and correlations that will be of general usefulness to the chemical engineering community. We expect to issue operating directives based on our research which will be of value in solving some of the problems encountered at the Albany facility.

DISCUSSION OF SLIDES 1 - 5

As is shown in slide 1, our slurry flow modeling system consists of a hold tank, recirculating pump, high pressure pump, and a glass coil, and is designed to simulate a system of similar size that incorporates a fired tubular reactor in place of the glass coil.

The coil itself is a 3/8" outer diameter pyrex tube with a coil diameter of 14.5" and coil spacing of 1", making it 27" high. The internal diameter of the coil is 5 mm. As is seen from the data in slide 2, the laminar flow pressure drop for the coil is only 10 - 15% higher than that for a straight tube of equal length, indicating that the coiling has no serious effect on flow resistance.

The high pressure pump is a reciprocating pump (Bran-Lubbe) with stroke adjustable to 30 mm. Volumetric displacement (flow) is linear with stroke, as is seen in slide 3. The range of flow attainable with this pump corresponds quite well with our proposed residence times for both 1-litre and 4-litre tubular reactors.

Our experimental feedstock is a hydrolyzed wood slurry infused with gas. The stirred hold tank and recirculating pump (Moyno progressive cavity design) serve to homogenize the 3-phase slurry and push it to the high-pressure pump. The slurry itself presents the problems of settling (at low flow rates) and high viscosity. Proper homogenization eliminates settling but increases viscosity. The relationship between viscosity and concentration at constant gas volume percent is shown in slide 4.

Visual observation of the slurry flow shows it to be strictly laminar; in other words, there is absolutely no radial or axial mixing. Infused gas bubbles retain their size, shape and position in the flowing slurry. As seen in slide 5, for a given flow rate, pressure drop increases with concentration. Application of the Hagen-Poiseuille equation shows, in addition, that apparent viscosity decreases with increasing linear velocity, an effect confirmed by use of a spindle viscometer. This information indicates that the slurry is a pseudoplastic fluid similar in behavior to a polymer solution or a colloidal suspension.

CONCLUSION

In the course of these preliminary investigations we have encountered no problems of settling or clogging that have plagued the Albany facility on earlier occasions. Our success in handling the slurry in a reproducible manner suggests that it will present no roadblock in the overall process development.

Future work will involve careful development of pumping procedures for startup, process conditions, and shutdown. We will develop correlations of interest involving the several variables of pressure, stirring shear and power, gas volume, recirculation and recycle rates, viscosity, and concentration. We will attempt to develop a numerical or theoretical treatment of the previously uncharacterized three-phase hydrolyzed wood slurry, in close cooperation with the U.C. Chemical Engineering Department. Thus, our results will not only be of general usefulness to us in developing and perfecting our process, but will also be of interest to researchers studying fluids of a similar nature.

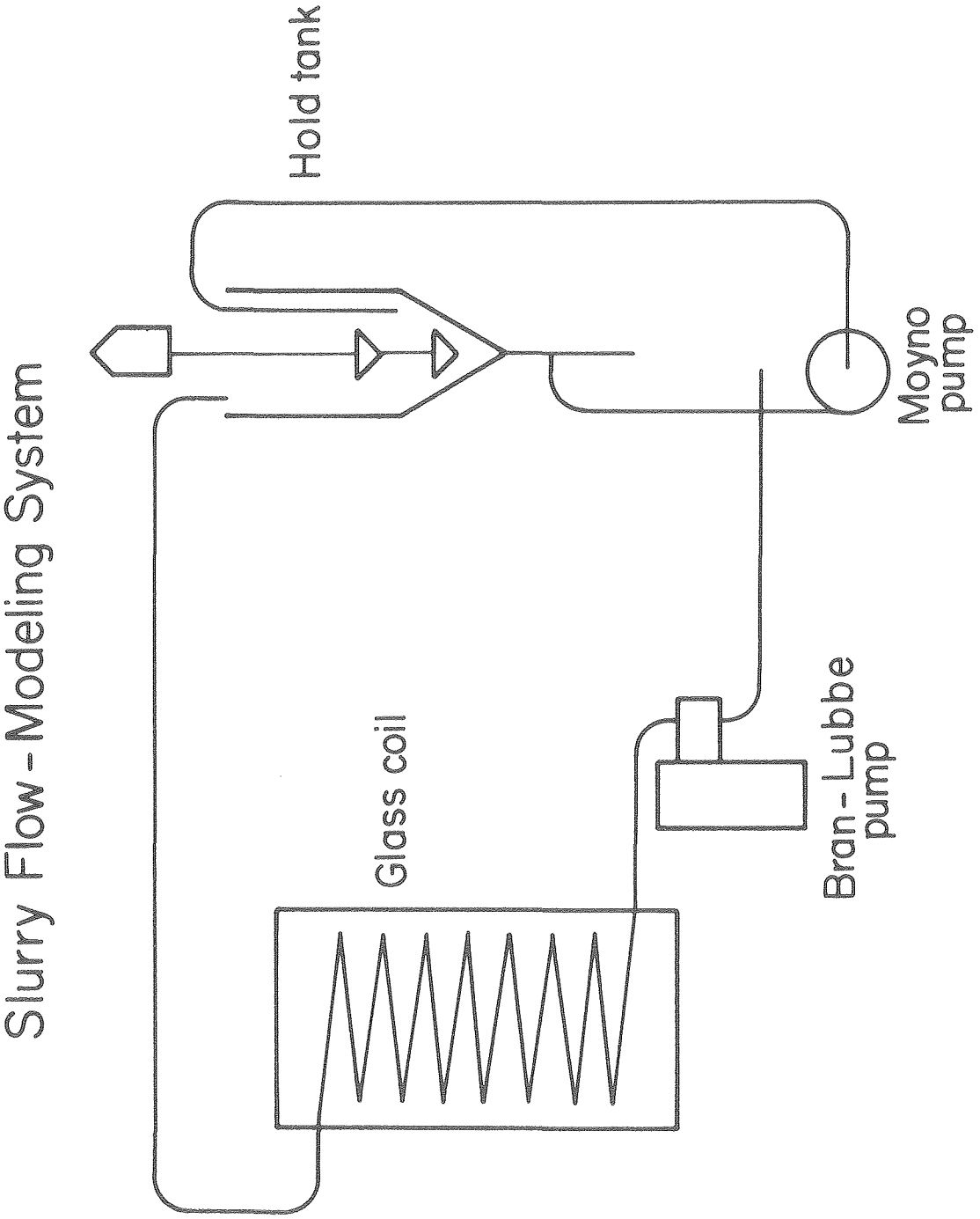

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Figure 1

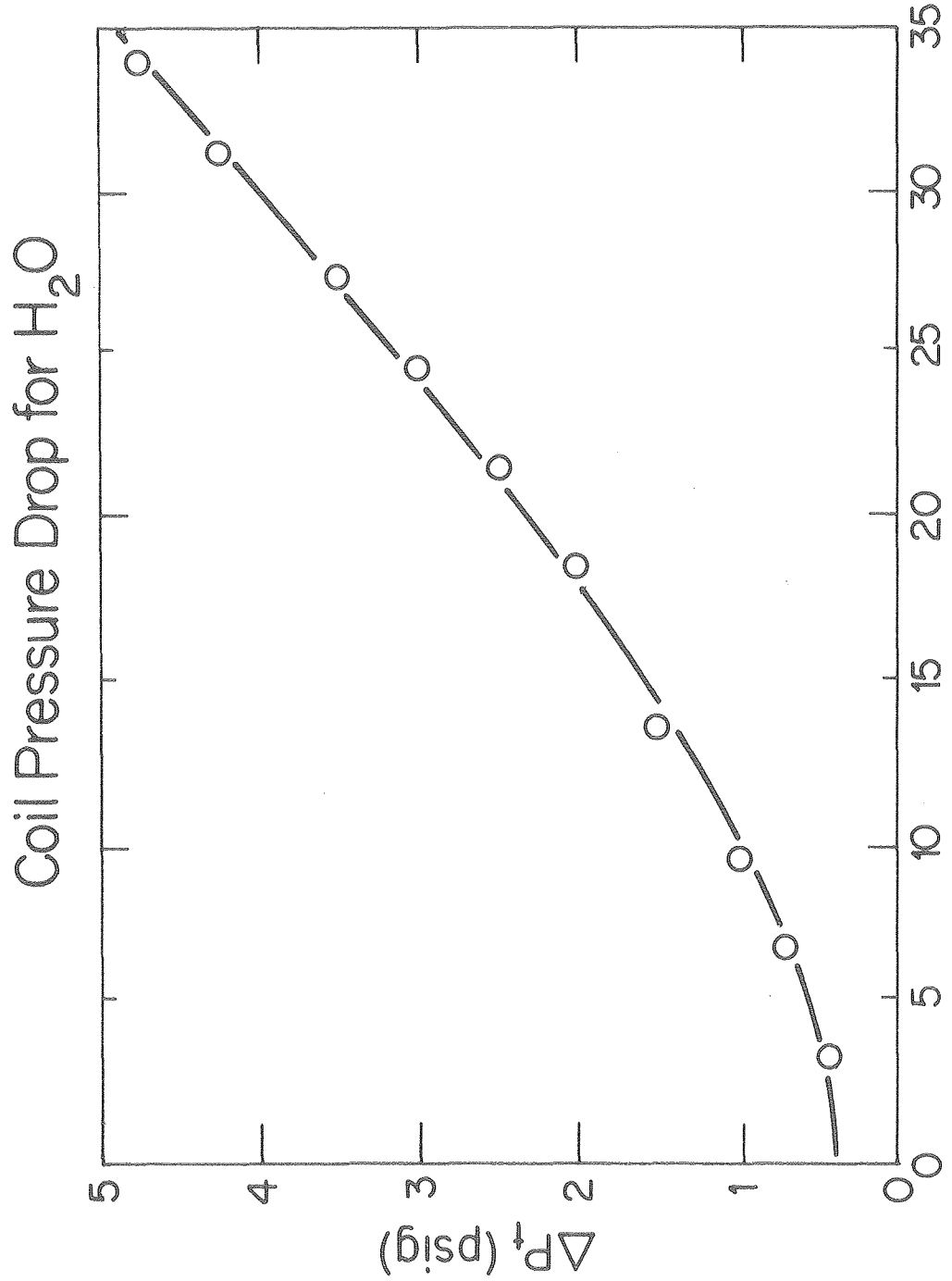

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Figure 2

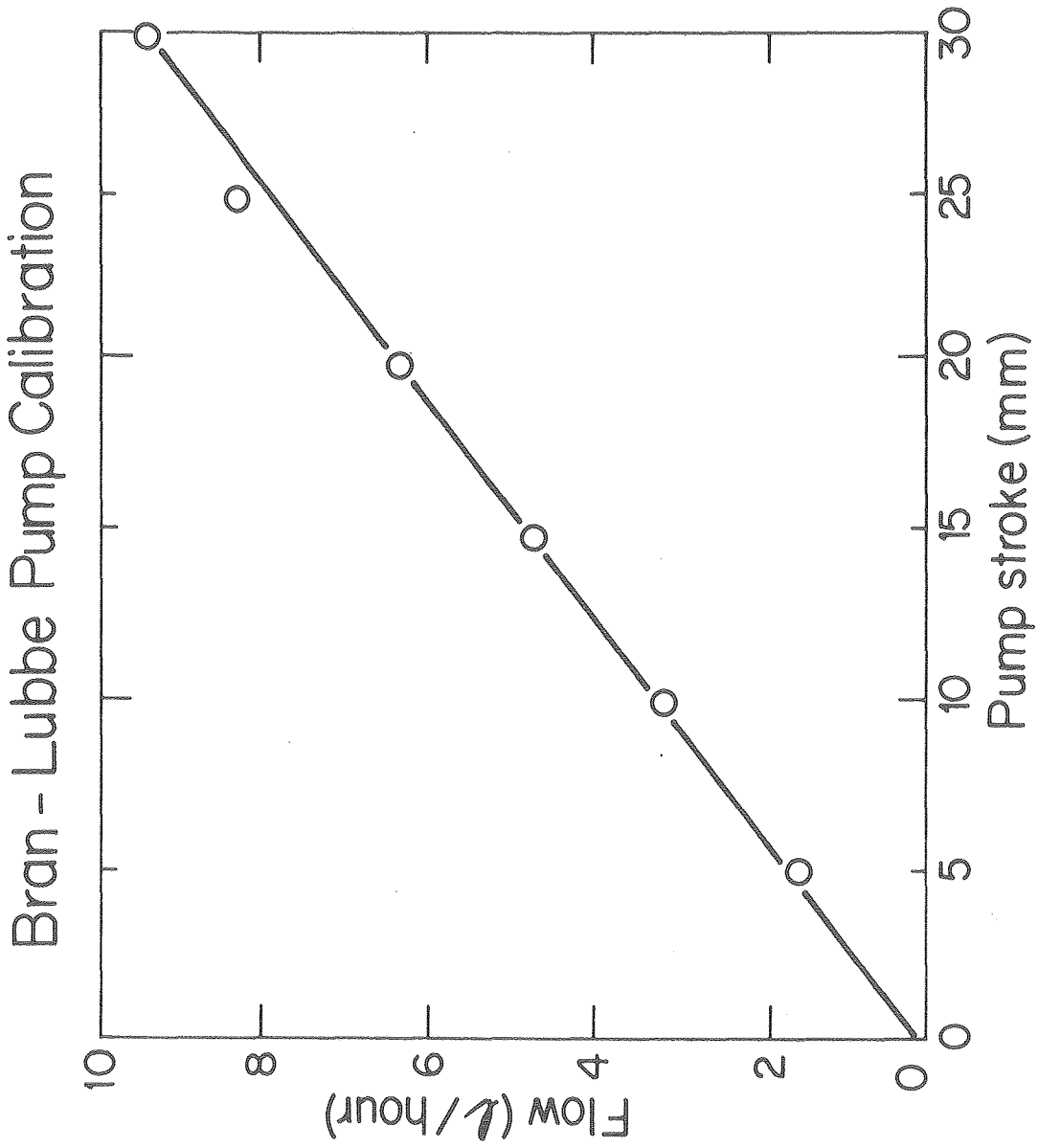

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Figure 3

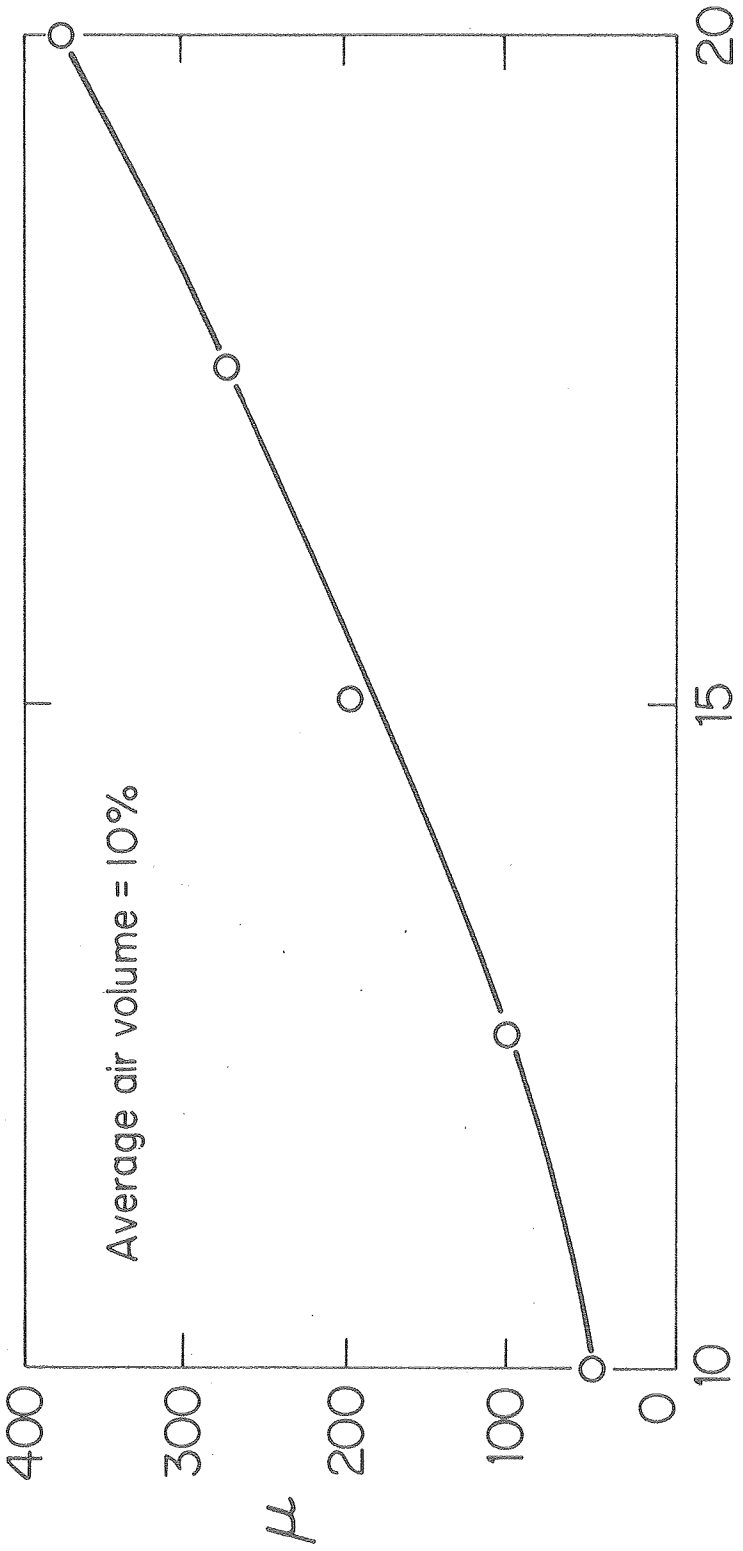

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Figure 4

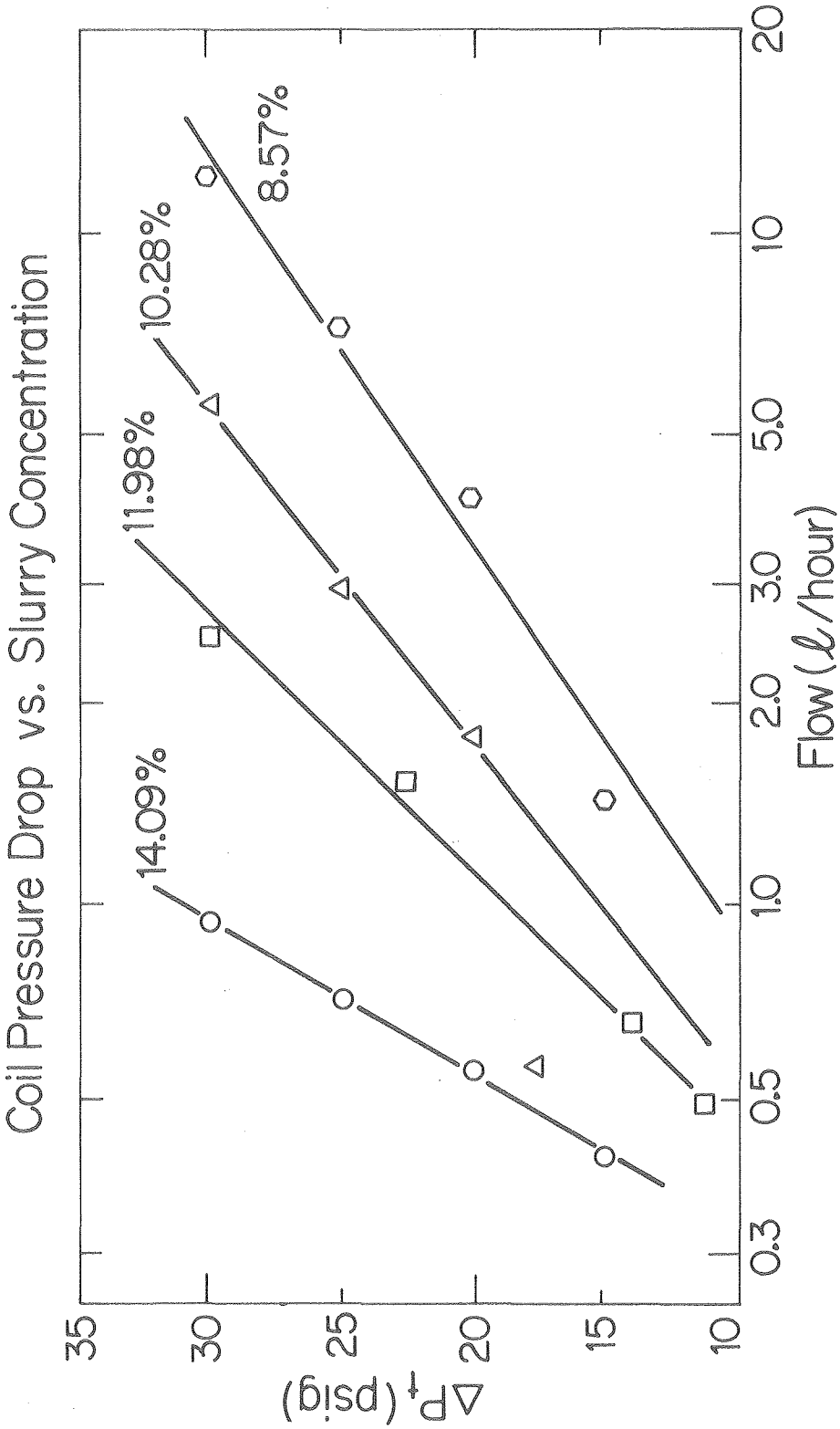

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Figure 5