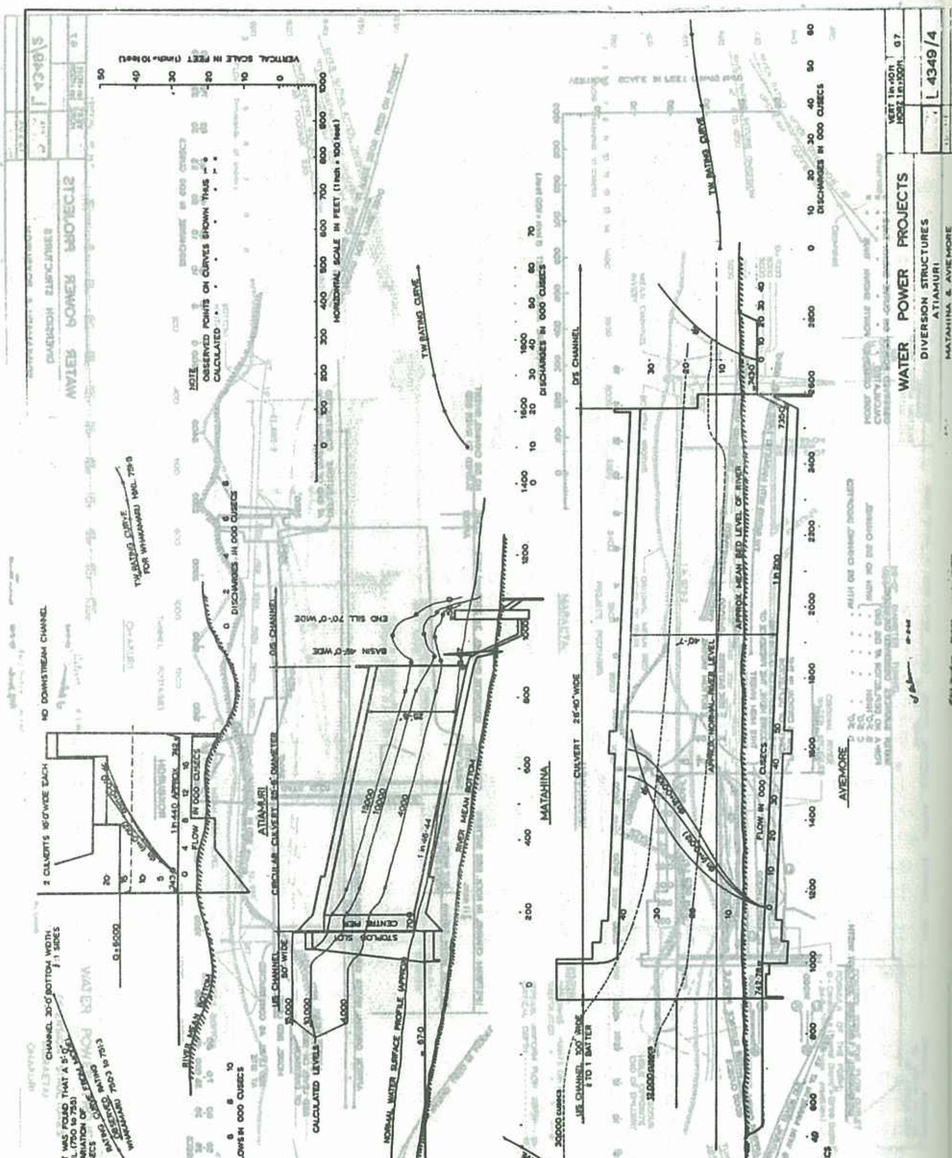

THE USE OF EMULSIONS AND SUSPENSIONS FOR DECREASING ENERGY LOSSES IN PRESSURE CONDUITS

by

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ABSTRACT

This paper examines the possibility of decreasing energy losses in the flow of fluids through pressure conduits by changing the physical characteristics of the fluid. Two such changes are discussed. In the case of a liquid of high viscosity, the energy loss for a specific delivery may be decreased by introducing a sufficient amount of liquid of low viscosity, along with an emulsifying agent, to create an emulsion. In the case of a highly turbulent fluid flow, the energy loss for a specific delivery may be significantly decreased by introducing a relatively small amount of fine grain matter to create a suspension. It is emphasized that the amount of foreign matter introduced into the primary fluid to create either an emulsion or a suspension must be carefully controlled, otherwise the energy loss for a specific delivery may be increased rather than decreased. The authors are of the opinion that, in those instances in which the introduction of foreign matter into the primary fluid is permissible, the procedures discussed in this paper may be of significant practical value.

TEXT

The pressure flow of fluid through a conduit, whether it be that of a liquid of high viscosity through the small tube of a mechanical device or that of a fluid of low viscosity through a large pipe or duct, is associated with costs of operation which have long been of concern to some engineers. Of the thought that has been directed toward reducing such costs, there seems to have been very little devoted to the possibility of achieving some measure of success by changing the physical characteristics of the fluid. Two such avenues of investigation are the changes in characteristics that would result from the deliberate creation of an emulsion or a suspension. The immediate objective in such a procedure would be the reduction of energy losses in the system. Even though this immediate objective may be achieved, the introduction of foreign matter into the primary fluid may not be permissible. However, there are instances in which the foreign matter would not be objectionable or could be easily separated from the primary fluid at the terminal end of the conduit.

The remainder of this paper concerns the reduction of energy losses in pressure conduits by the use of an emulsion or a suspension rather than a continuous fluid. The introduction of a liquid of low viscosity, along with an emulsifying agent, into a liquid of high viscosity to form an emulsion can result in energy losses considerably below those for the continuous liquid of high viscosity, provided the relative amount of the liquid of low viscosity is sufficiently great. The introduction of a relatively small amount of fine grain matter into a fluid stream which is characterized by a high degree of turbulence to form a suspension can result in energy losses below those for the continuous fluid, provided the relative amount of fine grain matter is not excessive.

The authors understand that, several years ago, certain industrial interests explored the possibility of reducing energy losses in transporting crude oil through pipelines by creating a water/oil emulsion. The extent and results of this exploration are not sufficiently well known to the authors to justify further comment. Cases in which there is a desire to transport two liquids of greatly different viscosities simultaneously through a single long pipeline or to move a single liquid of high viscosity through the tubing of a mechanical device are of more immediate interest to the study reported herein.

It has been known for some time that particles suspended in a fluid stream tend to interfere with turbulent mixing. Studies of water flowing in open channels indicate that a stream carrying a small amount of suspended matter exhibits a higher hydraulic efficiency than a clear stream in the same channel. The authors do not know of any previous attempt to use this knowledge in connection with flow in pressure conduits.

To illustrate the effects of creating an emulsion, consider the flow of clear linseed oil, water/linseed oil emulsions, and clear water through a smooth, straight tube of constant diameter (5/8 inch) under more or less constant temperature conditions. The emulsifying agent is sodium oleate. Experimental results are shown through dimensionless parameters in Fig. 1, where S is slope of the energy gradient, D is diameter of tube, g is gravitational acceleration, G is weight rate of flow, and ρ is mass density. The percent water/oil emulsion indicates the volume of water as related to total volume of emulsion. Fig. 1 indicates that the relative amount of water in the emulsion determines whether the energy loss for a particular delivery is more or less than that for clear linseed oil. Although a substantial reduction of energy losses can be achieved, the relative amount of liquid of low viscosity necessary to reduce energy losses below those for the clear liquid of high viscosity may seem to be rather high. Evidently, the magnitude of energy losses depends largely upon which of the two liquids serves in the role of carrier. It is probable that, under similar circumstances, the use of emulsions for reducing energy losses would be limited to those cases in which the presence of the liquid of low viscosity is permissible or in which the transportation of both liquids is desirable.

To illustrate the effects of creating a suspension, consider the flow of clear water and a clay suspension in water through a straight commercial pipe of constant diameter (5 inches) under more or less constant temperature conditions. Experimental results are shown in Fig. 2, where the abscissa and ordinate are the same dimensionless parameters as were used in Fig. 1. The particular clay suspension for which data are shown in Fig. 2 had a concentration, by weight, of 1 to 500. This was considered to be the optimum of those concentrations investigated in the sense that it resulted in a minimum of energy loss for a specific delivery. A large-scale increase in concentration would eventually result in energy losses greater than those for clear water. Fig. 2 shows a reduction of energy losses sufficiently below those for clear water to be of some practical significance. The success of creating a suspension for the purpose of reducing energy losses hinges upon the interference of suspended particles with turbulent mixing. Consequently, it is to be expected that such a procedure would be most effective for cases in which the flow of a continuous fluid is characterized by a high degree of turbulence.

It has been emphasized that the conditions under which an emulsion would be used are quite different from those under which a suspension would be used. The emulsion is suggested as a possible means for reducing energy losses in the delivery of a liquid of high viscosity, whereas the suspension is suggested as a possible means for reducing energy losses in the delivery of a fluid with a flow characterized by a high degree of turbulence.

The emulsion is considered on the premise that dispersion of the liquid of low viscosity throughout the liquid of high viscosity is

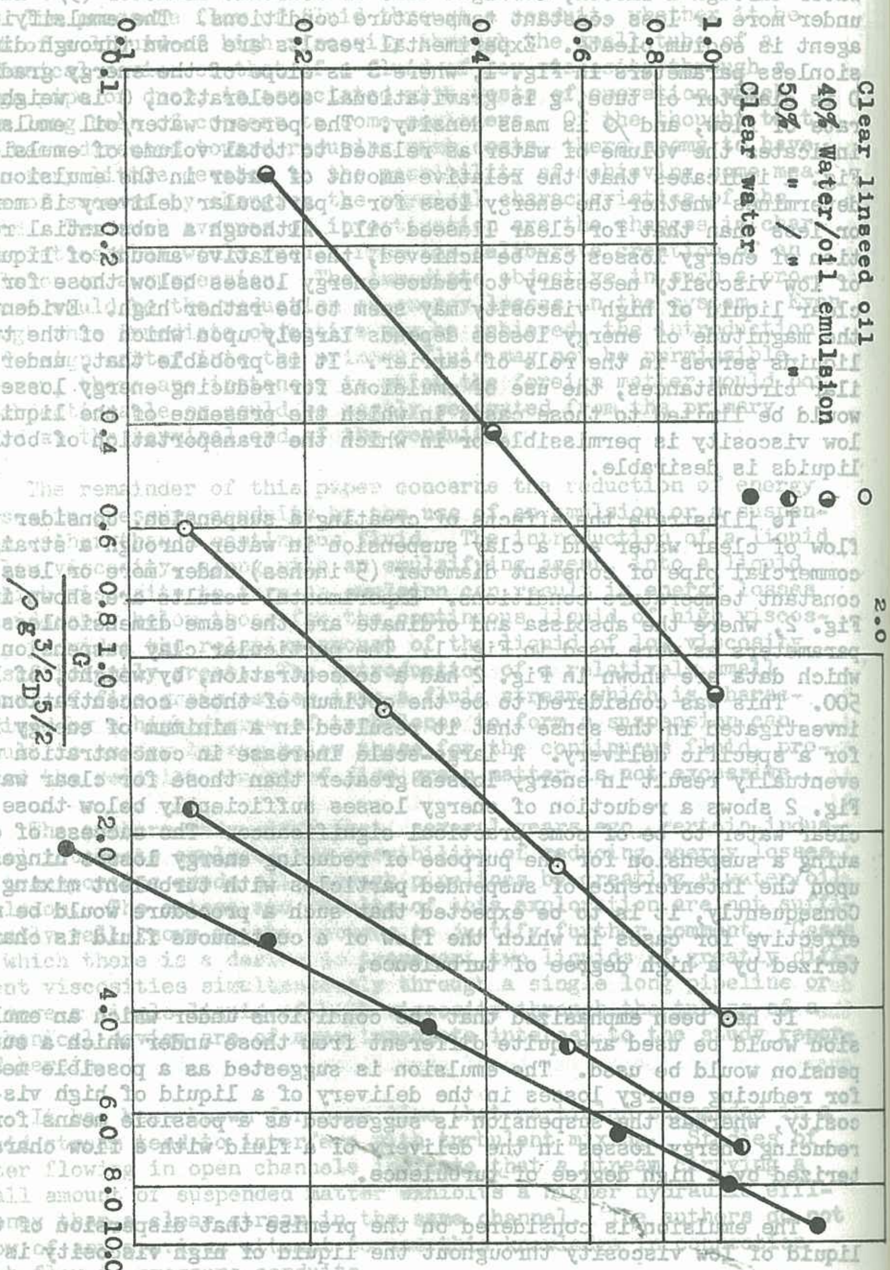

Fig. 1 -- Comparison of clear linseed oil to water/linseed oil emulsions and to clear water

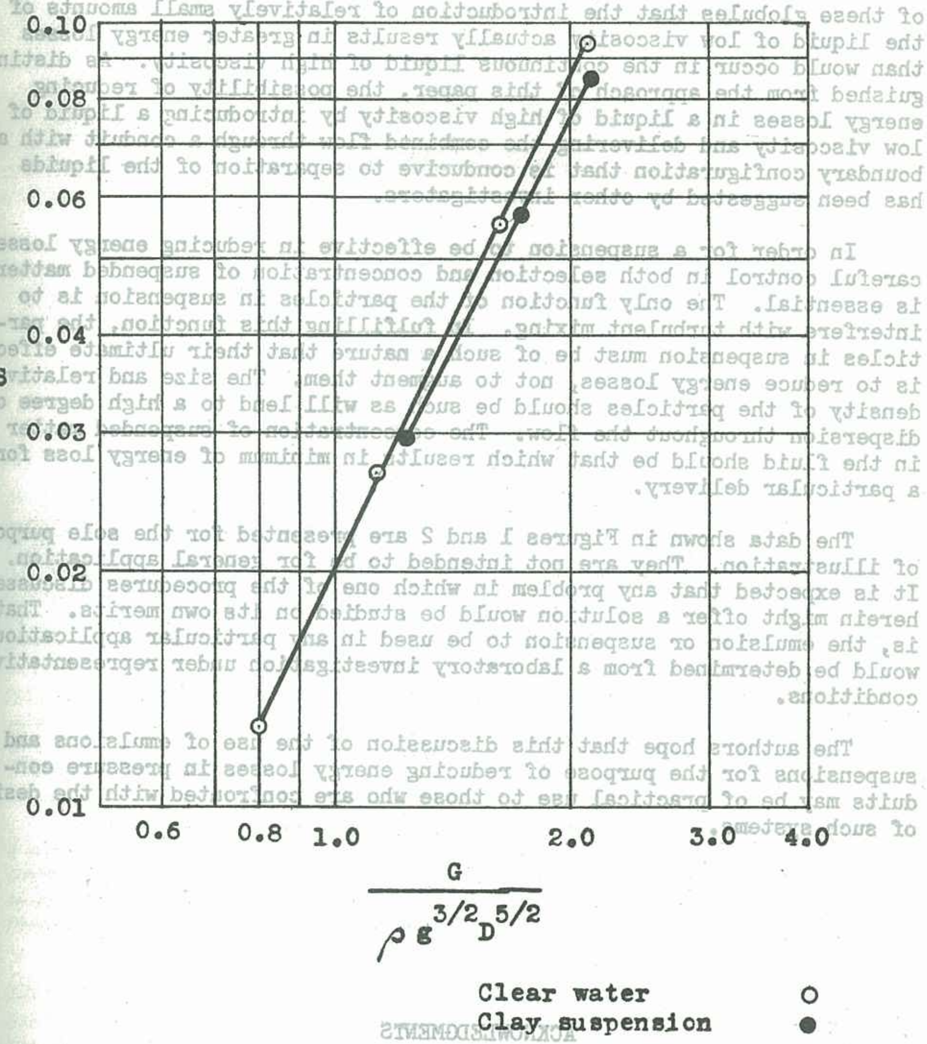

Fig. 2 -- Comparison of clear water to a clay suspension in water

desirable. However, the presence of the minute globules which characterize an emulsion is not, in itself, desirable. In fact, it is because of these globules that the introduction of relatively small amounts of the liquid of low viscosity actually results in greater energy losses than would occur in the continuous liquid of high viscosity. As distinguished from the approach of this paper, the possibility of reducing energy losses in a liquid of high viscosity by introducing a liquid of low viscosity and delivering the combined flow through a conduit with a boundary configuration that is conducive to separation of the liquids has been suggested by other investigators.

In order for a suspension to be effective in reducing energy losses, careful control in both selection and concentration of suspended matter is essential. The only function of the particles in suspension is to interfere with turbulent mixing. In fulfilling this function, the particles in suspension must be of such a nature that their ultimate effect is to reduce energy losses, not to augment them. The size and relative density of the particles should be such as will lend to a high degree of dispersion throughout the flow. The concentration of suspended matter in the fluid should be that which results in minimum of energy loss for a particular delivery.

The data shown in Figures 1 and 2 are presented for the sole purpose of illustration. They are not intended to be for general application. It is expected that any problem in which one of the procedures discussed herein might offer a solution would be studied on its own merits. That is, the emulsion or suspension to be used in any particular application would be determined from a laboratory investigation under representative conditions.

The authors hope that this discussion of the use of emulsions and suspensions for the purpose of reducing energy losses in pressure conduits may be of practical use to those who are confronted with the design of such systems.

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VELOCITY MEASUREMENT WITH THE VIBRATIONS OF AN IMMERSED SPHERE

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SYNOPSIS

A meter was developed to measure velocity at a point area in a fluid flow. The operating principle of the meter is based on the relationship between the velocity and vibrations of a sphere immersed in the fluid flow. The vibrations are attributed to the alternate shedding of vortices from the immersed body. A piezoelectric transducer was used to convert the vibrations of the sphere into electrical energy and shown on an oscilloscope for measurement of frequencies and amplitudes.

The meter was calibrated by establishing a relationship of the air velocity against the vibration amplitude in graphical form. Thus, feasibility of the principle applied for this meter has been demonstrated.

INTRODUCTION

There are many meters or devices for the measurement of velocity at a point area or a small area over a specific location in a fluid flow. However, exploration of new ideas and principles for developing better meters is still important and essential to the advancement of experimental research.

In this study, a meter for velocity measurement at a point area was developed from a new principle based on the characteristics of fluid flow past an immersed body. From previous investigations it is understood that the so-called Von Kármán vortex street is formed as a result of alternate shedding of vortices in the separation zone behind a submerged cylinder. Because the vortices break away from alternate sides of the cylinder, forces are exerted on the alternate sides at the shedding frequency, resulting in vibration of the cylinder at certain amplitudes and frequencies. Since the vibrations are related to the velocity of approaching flow, it is considered feasible to apply this particular relationship as an operating principle for the velocity measuring meter.

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