Reduced Power Required by using Cold Plus

1.0 Introduction

It is known that a refrigerant typically exhibits substantial lubricating properties. Removing oil fouling and the resultant improvement in heat transfer in the evaporator are other aspects of improving efficiency in A/C and refrigeration units. Cold-Plus™ is a patent pending polymer that permanently bonds to all metal surfaces within the system and provides benefits other than the removal of oil fouling. The addition of the polymer allows the flow of the refrigerant to occur with less flow friction resistance which results in an improved performance of the evaporator coils and reduced power consumption by the unit.

Additional benefits of friction reduction occur throughout the system. The molecular structure of the polymer provides friction reduction within the compressor, particularly within reciprocating compressors. This friction reduction shows in the reduced power for the compressor during the first minute of operation and throughout the life of the system. The reduction in flow friction results because of the increased Reynolds Number (Re) that occurs with the addition of the additive to the refrigerant. As shown in the Moody Diagram (Figure 1) the friction factor, **f,** decreases with increased Reynolds Number for both laminar and turbulent pipe flow. For turbulent flow in a smooth pipe, a 15% increase in the Reynolds Number of the refrigerant with polymer additive results in approximately a 25% reduction in flow friction. This decrease in friction results because of the interaction of the polymer with the flow of refrigerant. The addition of polymer solution in the flow of refrigerant dampens the turbulence next to the wall of the pipe and reduces the flow friction and reduces drag.

The reduction in drag as a result of an increase in Reynolds Number is significant for lower, laminar flows. These types of flows occur during startup and with the addition of the Cold-Plus™ additive, the friction drops significantly as shown in

Figure 1. This will again <u>provide significant reduction in the power required to start and operate the system.</u>

The addition of polymers in the refrigerant will reduce the flow friction to a maximum limit identified as the `MDR asymptote' as shown in Figure 2. Increasing the polymer concentration does not lead to drag reductions in excess of this asymptote (which is insensitive to polymer species, molecular weight, or the type of polymer). However, Figure 1 and Figure 2 both show that by increasing the flow Reynolds number with the addition of a polymer, the flow friction is reduced. The effects of the interaction of the Cold-Plus™ polymer with the refrigerant boundary layer flow and this turbulent mixing reduces the flow friction and improves the operating efficiency of the system and which results in an increase in the operating life of the equipment and <u>reduced power required</u>.

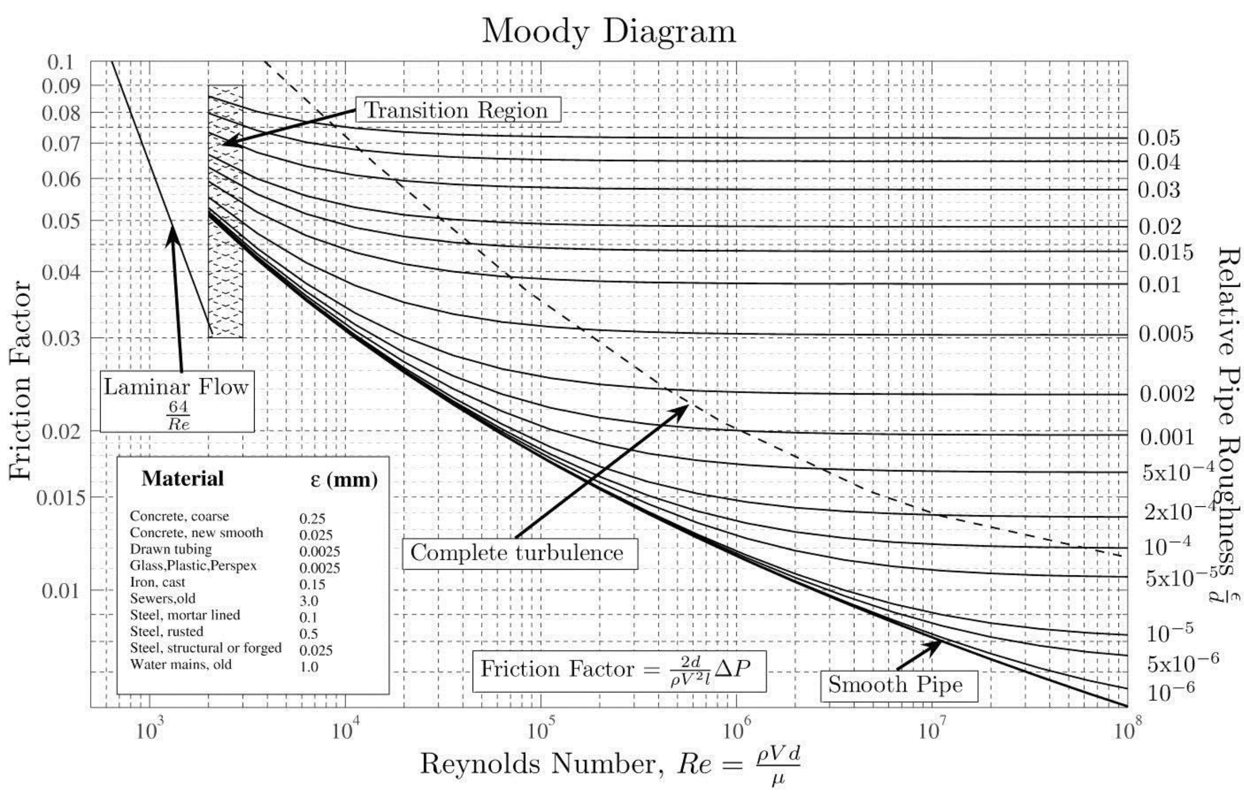

Figure 1 - Moody Diagram for Friction Factor for Pipes

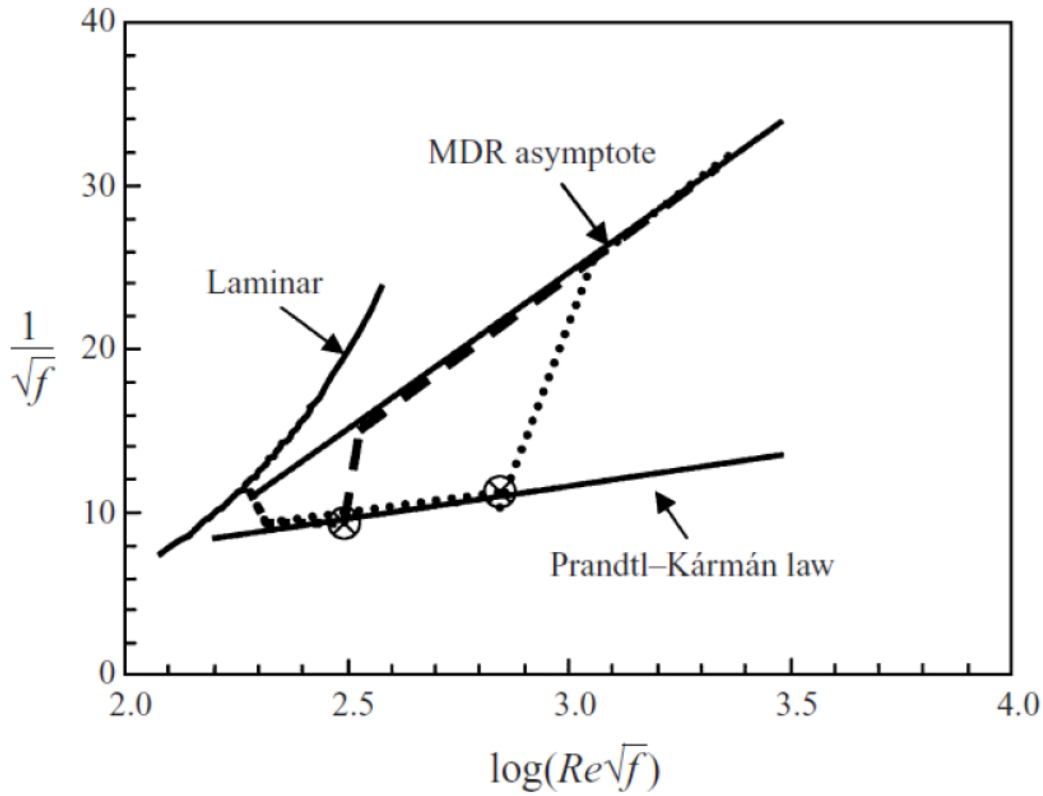

Figure 2 Drag Reduction Regions for Pipe Flows

2.0 The Mechanisms of Drag Reduction

The mechanisms of drag reduction combines the interaction of two fields, namely polymers in solution and turbulent flows. How this interaction occurs can be explained by considering the flow in a pipe. Many aspects of the drag reduction in pipes occur because of several changes in the flow: changes in the mean velocity profile, alteration of turbulent stresses and the reduction of the correlation between the stream wise and radial velocity fluctuations, reduction of high-order moments of fluctuations, modification of the turbulent structure, and especially at the wall. Attention will be focused on the two first-order effects, both of which are explained best with reference to Figure 2.

Figure 2 shows the conventional friction drag for pipe flows in the so-called Prandtl-Karman (P-K) coordinates. The friction factor, ***f*,** in Eqn. (1) is related to the pressure drop *p* across a length *L* of the pipe of radius *R* as

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$$f = \frac{\Delta p}{\rho V^2} \frac{R}{L}. \qquad (1)$$

The pressure drop in the turbulent pipe flow of a Newtonian fluid follows the straight line denoted as the Prandtl-Karman law. A dilute solution of a polymer follows the P-K law up to a certain Reynolds number but abruptly departs from it at higher Reynolds numbers. This point of departure is the onset of drag reduction. The onset occurs at a lower Reynolds number if the polymer concentration is increased, as shown qualitatively in the figure.

As the Reynolds number is increased, the drag reduction curves of Figure 2 will ultimately merge with the line denoted as the `MDR asymptote'. It should be noted that increasing the polymer concentration does not lead to drag reductions in excess of this asymptote (which is insensitive to polymer species, molecular weight, or the type of polymer).

3. Conclusion

The information given in this paper is to provide insight into why the addition of the PTFE polymer reduces drag and power requirements in refrigeration systems. The friction drag is directly related to the flow Reynolds Number , and as the Reynolds Number increase with the addition of the PTFE additive, the resulting flow friction, f, is reduced. This reduction in flow friction results because of the way the polymer interacts with flow boundary layer and turbulence in the pipes. As a result of this reduction in friction and drag, the <u>system power requirements are reduced</u> and there is an overall improvement in the system efficiency.

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