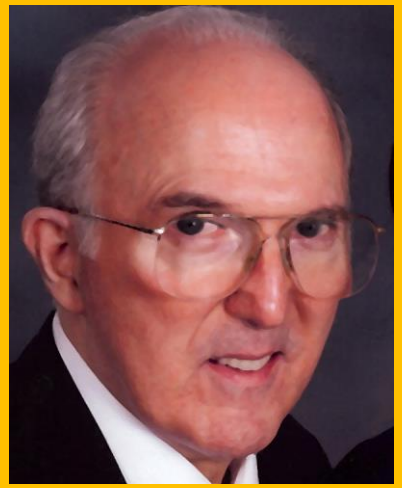

Real-Time Prediction of Incipient Failure in Working Fluids

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Introduction

What is a Working Fluid?

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In this paper, working fluids are defined as the fluidic materials that are employed as lubricants, coolants, and pressure transfer agents in various mechanical systems.

All Working Fluids Eventually Fail

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The Primary Systems Concern is to Predict and Correct Incipient Fluid Failure, before it can cause Systems Failure.

By What Processes do Working Fluids Typically Fail?

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Working fluid failure generally occurs, after a nominal period of time (lifetime), based on mechanical and thermal cycling of the fluid and also the inadvertent introduction of contamination (metal particles, carbon particles, water, other fluids, etc.).

How is the Potential Failure of Working Fluids Remediated Currently?

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In many working fluid applications, (e.g. trucks, planes, military vehicles and weapons, submarines, etc.) it is presently standard practice that the in-machine working fluids are to be removed and replaced (oil change, transmission fluid, etc.) with new fluids before any catastrophic event can occur. The removed fluids are then returned to a laboratory and analyzed.

Is there a better solution to the working fluid failure problem?

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Yes! Using real-time prediction of incipient failure inherently compensates for the variability of both new fluids and the variability of the incipient fluid failure mechanisms from machine to machine.

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Real-Time Prediction of Incipient Failure in a Working Fluid saves both cost and valuable time, as well as being immediately available in critical situations.

Modeling the better solution to the working fluid failure problem.

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Real-time prediction of incipient failure is inherently both machine and fluid independent. The incipient failure point (range) is determined by the electrical characterization of an inherent physical property (electrical admittance {1,2}) of the working fluid in question.

Real-Time Prediction of Incipient Failure in Working Fluids: Governing Equations.

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1. $Y = 1/Z$

   Where: Y is the admittance, measured in siemens

   Z is the impedance, measured in ohms

2. $Z = R + j * X$

   Where: R is the resistance (real part), measured in ohms

   X is the reactance (imaginary part), measured in ohms

   j is the square root of minus one (-1)

What is the Electrical Impedance of a Working Fluid?

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The electrical impedance of a working fluid is determined by the combined electrical properties of the basic fluid and those of the added contaminants.

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When the impedance of the composite material is measured as a function of applied frequency, the added contaminants cause the resulting electrical impedance curve to be different from that of the electrical impedance curve measured for the original, pure working fluid.

How would the better solution to the working fluid failure problem be modeled?

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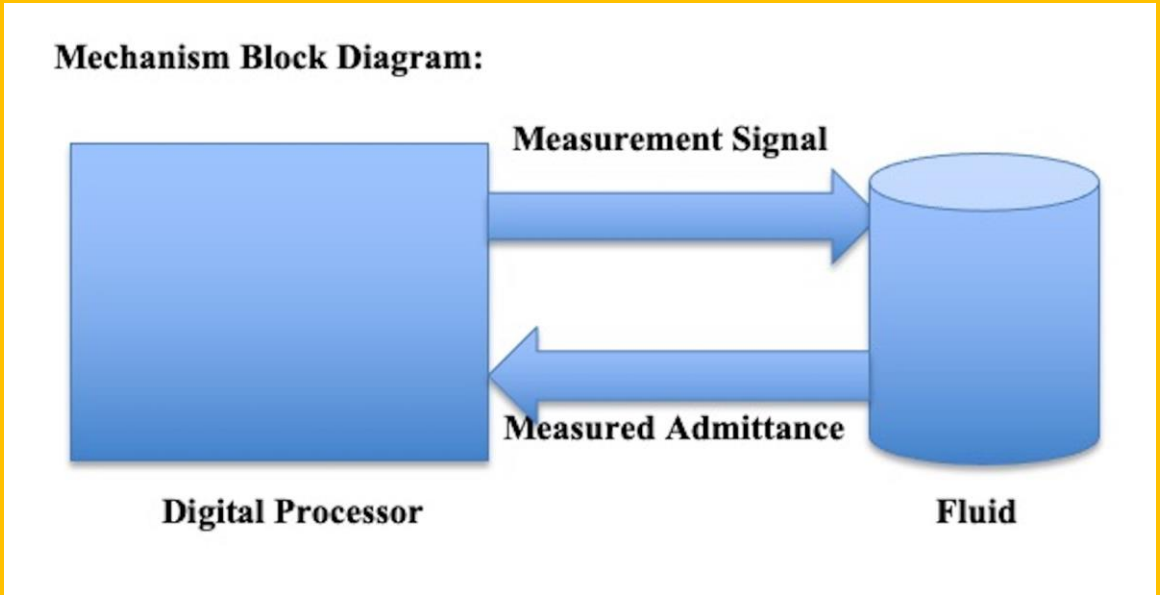

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model.

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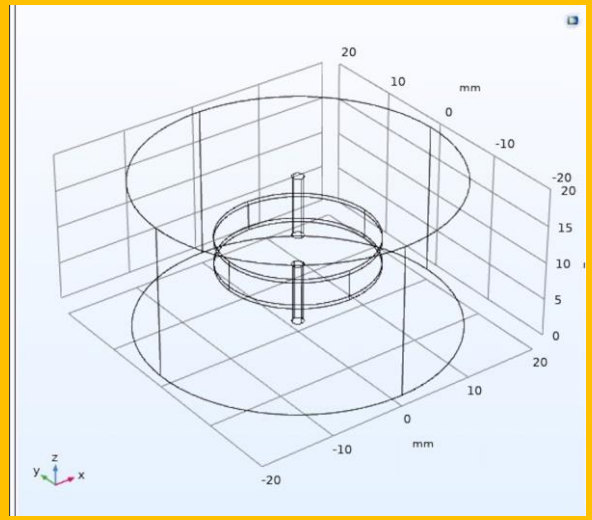
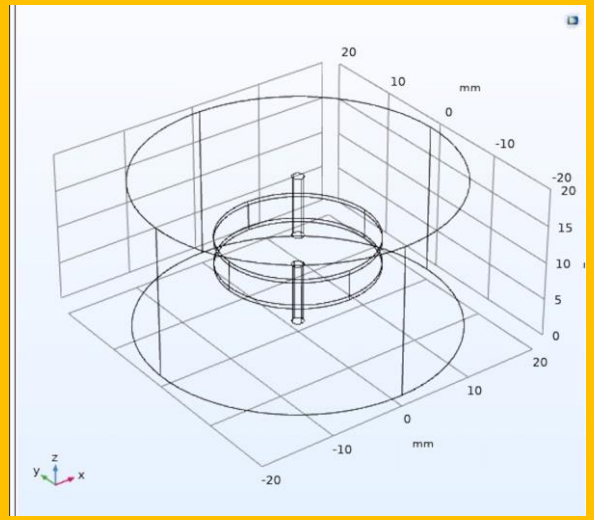


Figure 1 Working Fluid Sensor Model

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model.



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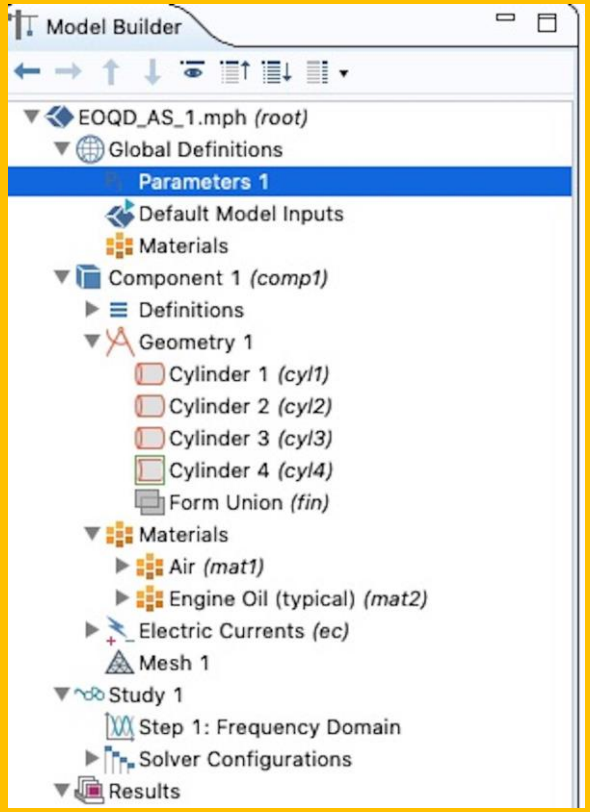

Figure 2 COMSOL Model Builder

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model Parameters.

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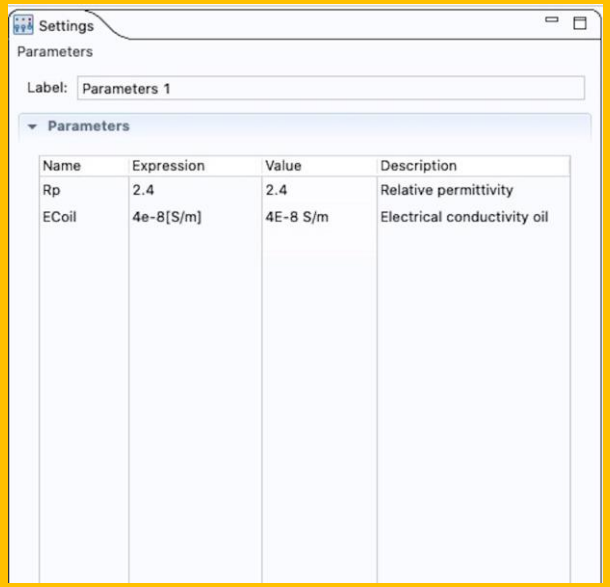

Figure 3

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model Parameters.

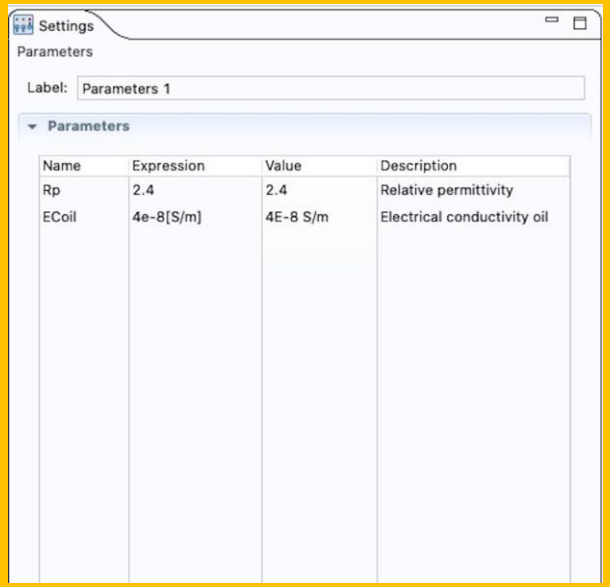

Figure 3

Figure 4

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model, Results.

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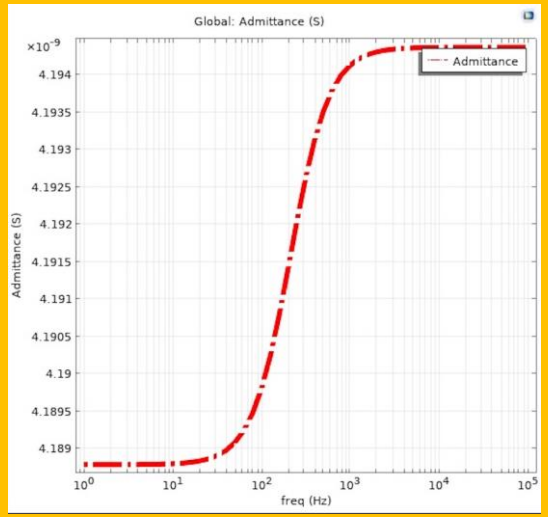
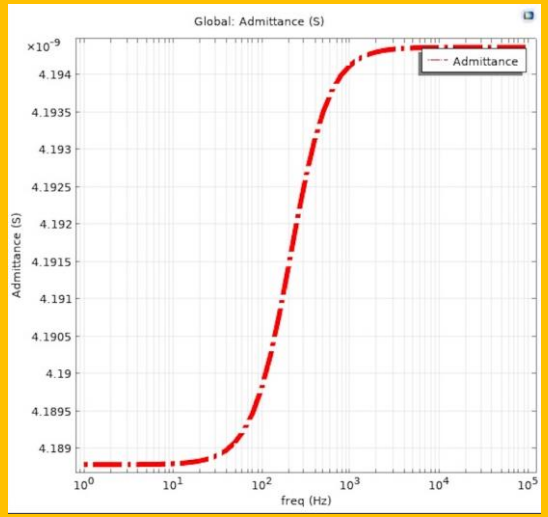


Figure 5 Engine Oil

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model, Results.



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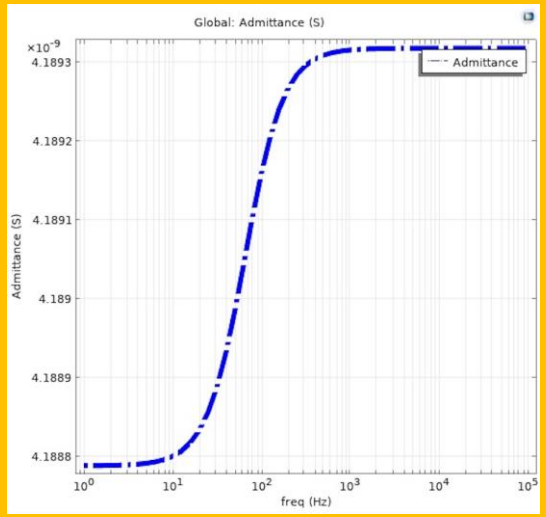


Figure 6 Engine Oil + H2O

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model, Results.

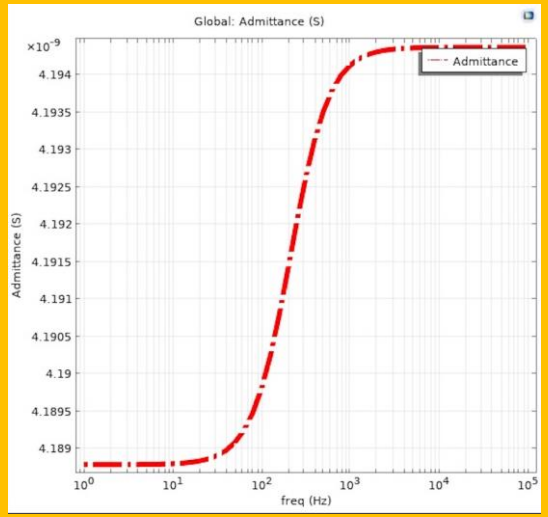
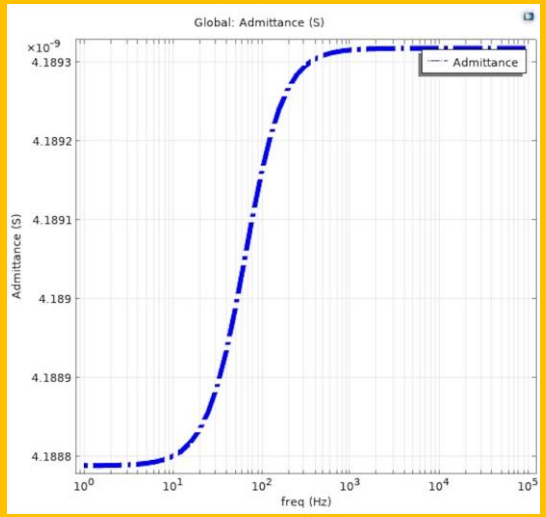


Figure 5 Engine Oil



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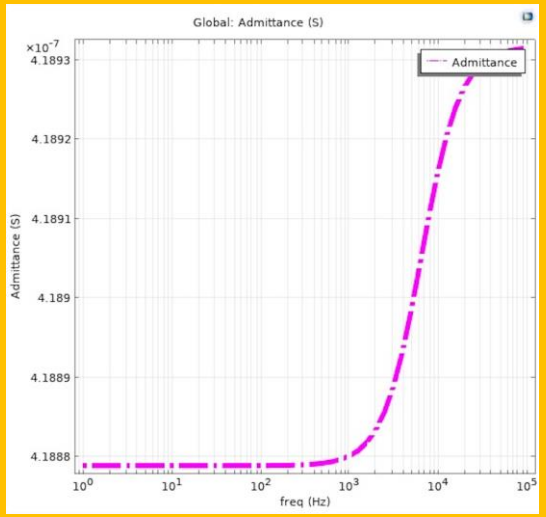

Figure 7 Engine Oil + H2O +Particles

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model, Conclusions

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The use of a real-time prediction methodology for the detection of the incipient failure of each working fluid, in situ, will allow each fluid to be used in a particular machine for an optimum period of time in that machine. The particular fluid will then be replaced, at a convenient time, with new fluid before reaching the catastrophic failure point in that machine.

Real-Time Prediction of Incipient Failure in Working Fluids: COMSOL Multiphysics Model, References

1. https://en.wikipedia.org/wiki/Admittance
2. https://en.wikipedia.org/wiki/Electrical_impedance

Thank You!