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MODELING OF AIRCRAFT FUEL SYSTEM

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Abstract: *Measurement of fuel temperature is one of task fuel-measurement system of aircraft. Determination of the fuel temperature is necessary, because temperature change as modifications are made to the fuel properties. Influence these changes is change the fuel flow in the fuel line and thus the supply of fuel to the engine. This may be a little change, but for large temperature changes fuel already experiencing significant changes in fuel flow. Temperature changes and therefore the density of the fuel can be measured directly or also compile model of fuel system and simulate these changes fuel properties in the software simulation environment. For the implementation such simulations is now available amount of software applications. These applications can be divided into applications that only specialize in flow measurement of liquids in pipes and change their properties and the software applications that allow simulate other systems and change in their properties.*

Keywords: *Simulation, Aircraft, Fuel, Fuel Flow, Density.*

1. INTRODUCTION

The primary task of aircraft fuel systems is the fuel supply to the engine and ensuring the necessary thrust for the aircraft. In this process is of course necessary to achieve optimum fuel flow through the fuel line. The optimum flow rate of fuel through the fuel line depends on several factors such as fuel density, performance of fuel pumps, fuel pipe diameter, their length etc. The first factor, which is the density of aircraft fuel can dramatically affect fuel flow in pipes. Variation in density of the fuel causes a change in temperature, it is necessary to ensure thermal stability of the fuel. Before there is build of aircraft as well as fuel system aircraft, it is necessary to test the functionality of the system. The ideal way to offer software simulation testing environment. One is the software Matlab. Although it is a general simulation software contains a number of libraries that offer many features and tools for building and modeling of aircraft fuel system. It is also possible using these tools to verify the aforementioned behavior the change of fuel to change its density as well as changes to the fuel flow in the fuel line.

2. FUEL PROPERTIES

2.1 Fuel Viscosity

The viscosity of aircraft fuel the rate its ability to flow and increases with decreasing temperature. Although the general relationship between the freezing point and viscosity can lead to large scatter in the measured temperature when the temperature approaches the freezing point. Standard tests for aircraft fuel viscosity is happening in the capillary. If a too high viscosity, it leads to degradation of the burner. Therefore, engine manufacturers require that the viscosity of fuel that flows into the engine does not exceed a predefined threshold 12 cm^2/s it typically a limit. Figure 1 shows a graph of change kinematic viscosity with temperature for fuel JP-4 and Jet A.

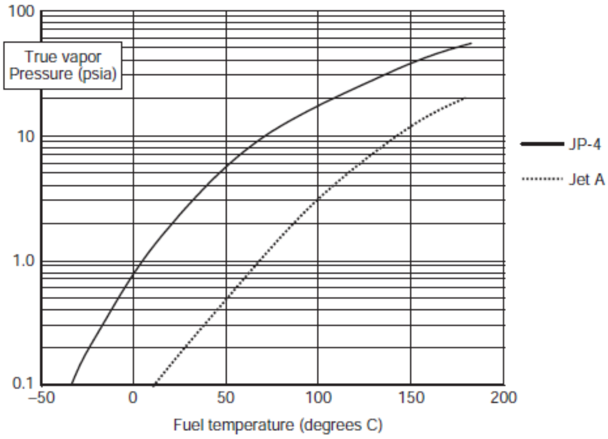


Fig.1 The Dependence of fuel temperature on vapor pressure

2.2 Diagrams and charts

Since the fuel is a mixture of different hydrocarbons, where each has a different freezing point, the entire fuel does not solidify at a specific temperature. They form the place of wax, which is composed of crystals hydrocarbon of fuels, which have a higher freezing point. The next decrease of temperature causes changes in the fuel mixture similar to snow, eventually fuel solidifies completely. As for the fuel system of an aircraft must ensure that this did not occur in the tanks of the aircraft because it can avoid the defuel of the fuel tank. Also, the wax and the emerging crystals can block entry to the fuel pump. Testing the freezing point of a particular type of fuel consist of heated in the fuel samples and determine the temperature at which it disappears the last solid crystal. Engine manufacturers also specify the minimum temperature of fuel supply due to the freezing point.

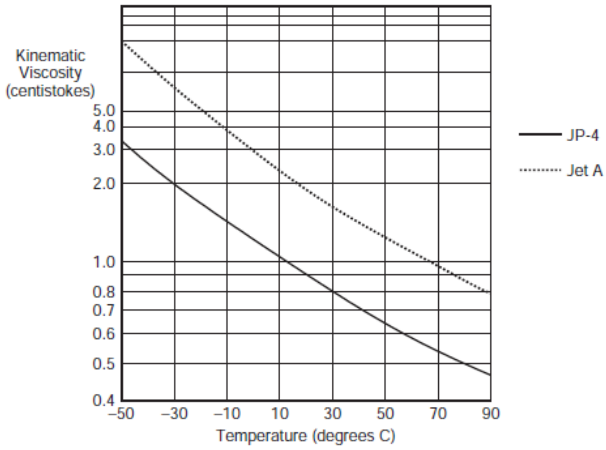


Fig.2 The Dependence of kinematic viscosity on fuel temperature

2.3 Density

The density of fuel is an important property, because her size may differ depending on temperature. The size of its change may be in the range up to 25% for most types of transport aircraft. Fuel quantity is proportional to his weight, which determines the amount of energy conservation. Due to the large changes in the density range under the influence of temperature may be a smaller refuel volume of fuel especially in areas where the climate is hot. Just in these conditions the amount of fuel is lower due to higher temperatures. Of course contrast, if the temperature is low the aircraft can refuel more fuel.

2.4 Stability of Temperature

When the fuel is exposed to high temperatures may oxidized and create as it were the rubber coating. This can cause blockage of fuel filters, fuel dispensers, nozzles, fuel-oil heat exchanger. The requirement for high temperature stability is a major challenge especially in the engine fuel system, where the occurrence of high temperatures. Thermal stability of the fuel is important especially for aircraft that can fly at supersonic speeds, this concerns mainly military aircraft. While flying at supersonic speeds occurs to aerodynamic heating and therefore ensure the thermal stability is very important. Aircraft fuel can also be used for cooling oil or some of the systems which can ultimately lead to the next thermal instability.

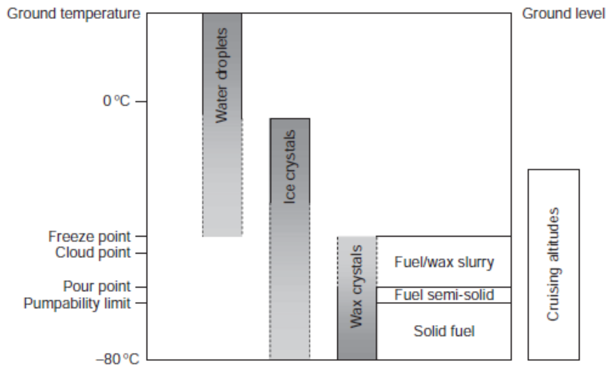


Fig.3 The Dependence of fuel temperature on vapor pressure

3. MODELING & SIMULATION

Change in density of the fuel, depending on the temperature and the change of flow is the easiest show at the one branch of the fuel system, which is between two tanks.

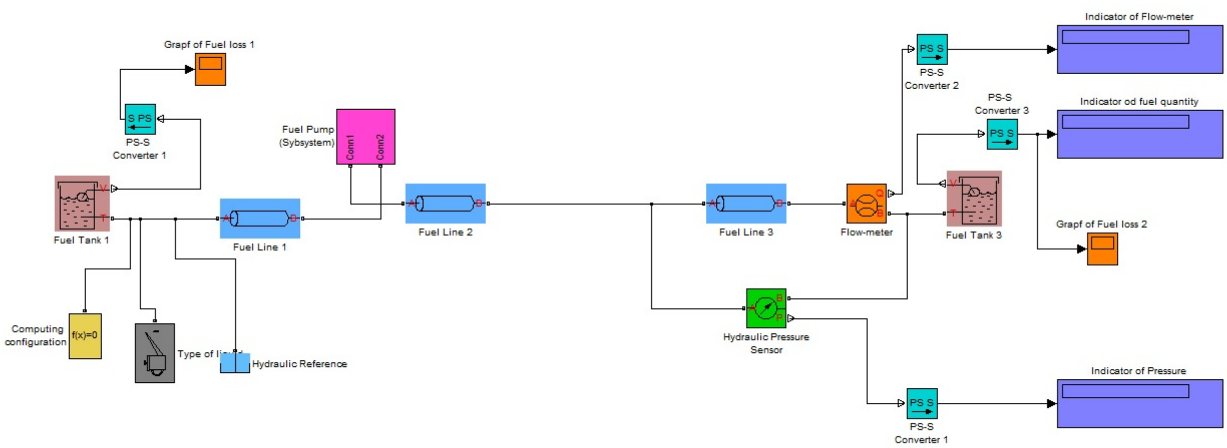
The length of fuel line between the fuel tanks is 10m, internal diameter of the fuel line is 10mm. Fuel pump is set at 6000ot/min and time of flow is always 60s. Is used aircraft fuel JET A. There have been 10 simulations for changing the temperature from -40°C to +50°C, each graded after 10° degrees Celsius.

Temp. (°C)	Fuel Flow (m^3/s)	Pressure (Pa)
-40	0,00302145	1590486,861
-30	0,00306727	1573107,298
-20	0,00310032	1556506,468
-10	0,00312447	1540455,109
0	0,00314237	1524789,293
10	0,00315585	1509397,169
20	0,00316617	1494201,231
30	0,00317419	1479148,232
40	0,00318051	1464200,179
50	0,00318555	1449330,631

Fig.4 Table of measure values

Of these 10 simulations, we have compiled a table of 10 measured values the fuel temperature depending on variation in density and thus also change the fuel flow.

It is possible also simulate the change in fuel pressure in the fuel line. Based on these measured values was compiled graph of fuel flow depending to his temperature, as shown in Figure 4 As seen in this graph the flow rate is increased exponentially. The greatest increase of flow was observed in the temperature range from -40°C to + 30°C. At higher temperatures, flow with increasing temperature to grow only slightly. Of course, as already mentioned, value of density change with temperature is given by a specific type of



aircraft fuel, thus liquid.

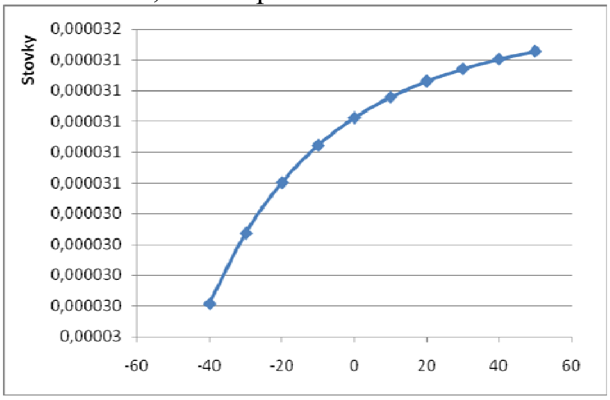


Fig.5 The Graph dependence of fuel flow on temperature

The second graph shows the change in pressure in the fuel line in the temperature dependence pumped fuel.

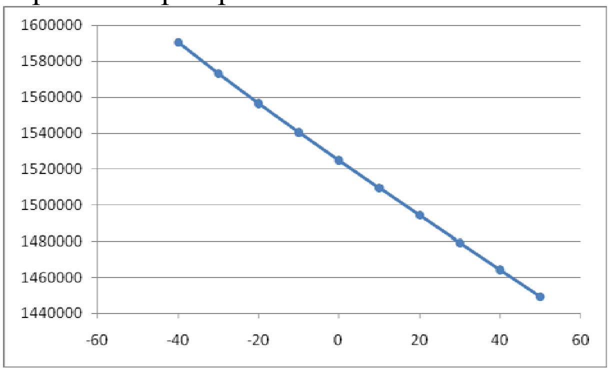


Fig.6 The Graph dependence of fuel pressure on temperature

On the graph is to see the exponential decrease in pressure with increasing temperature of the fuel. This decrease is almost directly-proportional to the increasing temperature.

3. CONCLUSIONS

As shown in the waveform obtained dependence of, in the change in temperature ranging from -40°C to +60°C (which is a total change of 100°C), occurs an increase in fuel flow rate by approximately 5%. This increase can be documented as an error that occurs by changing the fuel temperature. This value is relatively high, at concrete an increase in flow rate of 0.18 dm^3/s, respectively 0.18 l/s. On this example can illustrate the importance of maintaining thermal stability of aviation fuel. Described change of raises change flow fuel in operation of aircraft in flight. This change of flow could cause such large changes in fuel supply and thus the loss of the required thrust. The benefit of this method of modeling and simulation of aircraft systems in the software Matlab-Simulink is also concluded that in this way can make the analysis and synthesis of the fuel system before its actual design and verify its functionality and the eventual operational problems.

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