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Aircraft Fuel Delivery System Failure Modeling Analysis Using Maintenance Aware Design Environment Software

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1. Introduce

The MADe system modeling tool and failure knowledge-base design software aims to identify potential operational and diagnostic problems in the conceptual stages of system design. It is an enhancement to front end methodology for Prognostics and Health Management (PHM). This paper introduces the basic functions of MADe software, an aircraft case study of fuel delivery system is afforded to exhibit the main procedure of hardware system function modeling and diagnosis simulating.

2. MADe

2.1 MADe Software Introduction

The operation of complex engineered systems requires the development of diagnostic procedures. These functions provide a detailed set of instructions to help operators monitor the system's parameters and respond to potential problems by detecting and identifying faults, and guide them in performing system reconfiguration or restoration [1]. Model-based diagnostic methodologies have been shown to be useful in isolating unpredictable faults in various types of systems [2]. Accurate modeling of the behavior of complex systems is often essential for obtaining a correct diagnosis.

The concept of a Maintenance Aware Design environment (MADe) is considered to be an enhancement to and front end methodology for Prognostics and Health Management (PHM). The MADe approach is based on the application of functional analysis, failure analysis, sensor selection algorithms as well as prognostic and health monitoring tools in the early design stages.

The MADe system capabilities are shown in figure 1. The system modeling tool (Failure Knowledgebase or the FMECA Database Generation Tool) generates hardware and functional system models which can be used to predict the system response to component level faults and process their criticality. The tool aims to provide a rapid and affordable means of generating and continually updating system and failure knowledge bases.

The Advanced Fault Detection & Isolation Tool (Model Based Diagnostic [MBD]) uses the hardware system model and system monitoring design tools to generate an MBD application. This paper concentrates on the development of points 1 and 4 in figure 1, which is the generation of failure knowledge bases (1. MADe FMECA Database Generation Tool) and the fault detection & isolation design.

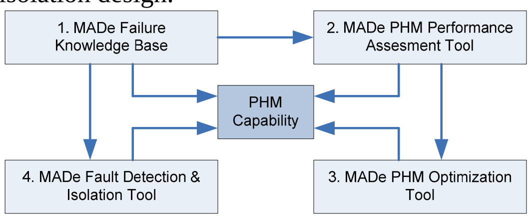

Fig. 1 MADe software capabilities

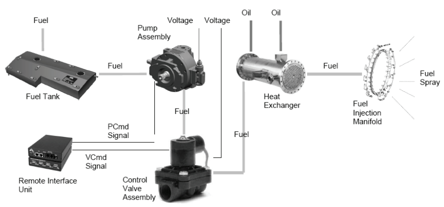

Fig. 2 FDS System schematic

2.2 FDS Case Study-Structure Function and Operating Conditions

The function of the Fuel Delivery System (FDS) is to provide a controlled supply of fuel spray to the combustion chamber at the required pressure and temperature. As figure 2, fuel is pumped from the fuel tank by a centrifugal pump which is controlled by the PCmd signal from the Remote Interface Unit (RIU). The fuel flow rate through the system is controlled by the control

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valve which consists of a solenoid-controlled valve. The cold fuel is heated by the exchange of thermal energy between the hot engine oil and the fuel, via the shell-tube type heat exchanger. Fuel spray is injected into the combustion chamber by the fuel injection manifold.

The operating mode under consideration is steady level flight at cruise altitude therefore there is no supply of fuel to the fuel tank (save for recirculated fuel which is not included in this model). It is assumed that system inputs of electrical voltage and control signals (to the Remote Interface Unit) comply with the operating requirements for the FDS. The fuel pump is set to medium speed and the control valve is set to open.

2.3 FDS Modeling and Failure Knowledge Base

The MADE system modeling tool and failure knowledge-base aims to identify potential operational and diagnostic problems in the conceptual stages of system design. System models can be generated at the conceptual design phase using functional descriptions of the components and subsystems. By including component hardware details and defining the operating modes, the model can be used to determine system monitoring requirements and to formulate Model Based Diagnostic applications for real time system Fault Detection and Isolation (FDI).

Figure 3 provides a screenshot of the MADe user interface for FDS system function modeling and failure knowledge base generation. Based on these, relationship between components and subsystem can be constructed, then system failure propagation table can be deduced and sensor set is determined. Finally, an onboard diagnosis rule is generated to detect and isolate malfunction action as shown in Figure 4.

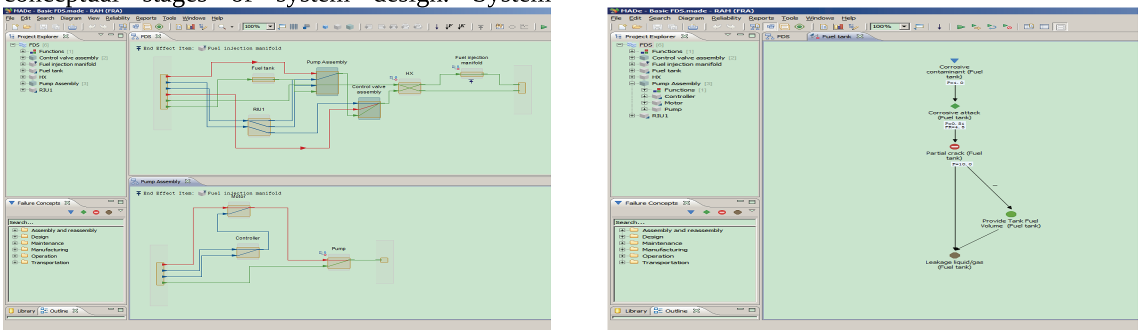

Fig. 3 FDS function modeling and fuel tank failure analysis

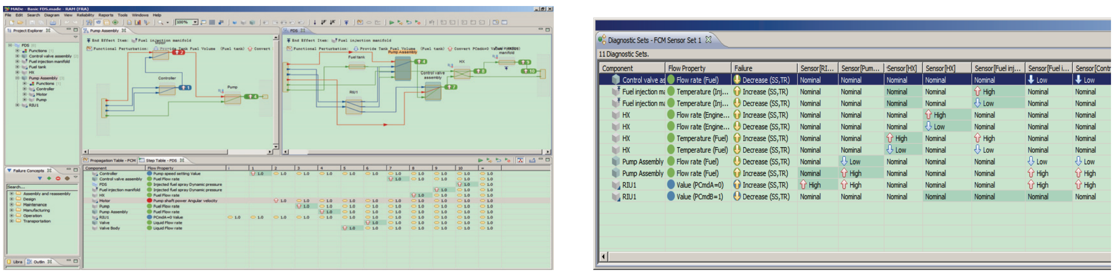

Fig. 4 FDS failure propagation table and diagnosis rule list

3. Conclusion

This paper introduce a new PHM front end developing software -MADe and its application in failure analysis and onboard diagnosis design of an aircraft fuel delivery system.

References

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[2] T. Kurtoglu, R. Butz, M.S. Feather, Model-based of diagnostic procedures for complex systems, Annual Conference of the Prognostics and Health Management Society, 2010.