From Modelica Models to Fault Diagnosis in Air Handling Units

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Heating Ventilation and Air conditioning (HVAC) systems are known for being very inefficient for different reasons, one of the most common causes being the presence of undetected failures in one or more of its components. Undetected faults can remain for long periods due to different factors: compensations made by the control algorithms of other elements belonging to the same system; lack of proper maintenance, improper timing of flow of energy to/from the building, etc. Even when systems are known to suboptimal operation, the presence of faults may be very difficult to manually localize and identify, making it a costly task for human operators who only act when indoor environmental conditions are not met. This lack of timely intervention raises the need for developing automated fault detection and diagnosis methods and technologies that assist the building operator.

Different fault detection and diagnosis (FDD) methodologies have been developed for HVAC systems, mostly based on expert knowledge to help identifying the faulty condition and its source. However, a new trend in FDD is that of using models of the HVAC systems providing a base line for optimal operation, and supporting the detection of deviation from this optimum. Model-based methods, offer the advantage of an increased flexibility to adapt to different and innovative HVAC systems. Model-based diagnosis is based on an explicit representation of the knowledge about the components and the information about the plant structure, which determines how the components interact with each other. Unlike other approaches, the development of model-based diagnosis system can be fully automated rather than hand-tailored once a suitable component library and the plant structure is place.

This paper presents an end-to-end tool chain for a model-based diagnostic solution that uses a **qualitative model** for the part of the HVAC system corresponding to the **Air Handling Unit** (AHU). This solution is derived from a general first-principle Modelica model and exploits a general diagnosis algorithm that isolates and identifies faults that occur frequently and can cause significant loss of system performance in AHUs: passing heating- and cooling-coil valves, and stuck dampers. An application example using a heating coil model is presented where the diagnosis solution is able to correctly recognise a passing heating valve. Provisions are made for the extension to other components where the same methodology can be applied only requiring first principle models that accurately represent each component behaviour.