Abstract

Investigating the dynamics of any multi-physical non-linear system has always received an extra attention in research sector. It becomes more challenging when investigation is performed on such multi-physical system under thermal condition. This thesis will reflect the importance of the investigation for modelling multi-physical interactive structural-dilation and property- changing behaviours of the system under severe thermal conditions. Through this project, the dynamic behaviour of the proposed pressure control valve is investigated under thermal conditions by means of Bond-graph technique. At first, a significant modification of the existing pressure control valve is done where the adjusting part of the valve is simplified in order to avoid the complexities related to interaction with moving elements and to achieve a much simple Bond-graph representation of the valve. Initially this pressure control valve had three moving elements (as shown in Fig.16). They are: control spool (spindle), adjusting spool and adjusting plate or placoid. The simplification is performed based on the scenario where the displacement of the adjusting spool and plate were happening concurrently. The resultant simplified Bond-graph model of the pressure control valve is more effective than the existing one with less number of state variables to be used to carry out the thermal investigation. Then a nonlinear mathematical model of that specific SLV (space launch vehicle) pressure control valve is built with respect to the simplified Bond-graph model. At this stage, different operating conditions that involve various inlet pressures is dynamically simulated. The obtained results are similar as the original ones which indicates that the pressure control regulator is working as per expectation with its simplified version. After this simplification, the Bond-graph models of both the elastic control and adjusting spool is developed. Then, the existing rigid adjusting spool of the control valve is replaced with the elastic one as the thermal conditions cannot be investigated with the rigid spool configuration. The characteristics of dilation and shrinking of the elastic spool can reveal the thermal impact precisely. Then the mathematical model of the control valve with elastic adjusting spool has been derived from the respective Bond-graph model and the obtained results reveal that the control valve is still working properly with the elastic adjusting spool. The simulation result which represents the deformation of each element of the elastic adjusting spool proves that the adjusting spool is now an elastic adjusting spool. Finally, thermal strain equivalent source is added to the Bond-graph model of elastic adjusting spool to develop a thermos-mechanically enhanced one. Then, thermal condition is introduced to the system. At this final stage, the final simulation result represents how the entire system's dynamics is affected due to adding this thermal condition where the control valve is not able to regulate the pressure anymore.