Demonstration of Actuator Coil Dry Heating test

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Abstract

Actuator plays vital role in fluid control requirements. In an actuator, it is important to have large electromagnetic force through a relatively short stroke. This may be achieved by better design of electromagnetic circuit and also by reducing the mass of the moving parts. The focus was given to realise solenoid type design actuator to provide fast response. The actuator is normally closed and electro-mechanically actuated with hard on soft seat configuration. Actuator coil is designed to have operating capability between 28V to 42V DC. Actuator has to be continuously on for maximum requirement of 3 minutes. The proto hardware was tested for varying current inputs and the corresponding temperatures of the actuator were measured. Coil health like resistance and insulation were tested and found satisfactory after coil dry heating test. This paper describes the actuator coil details, dry heating test methodology on proto hardware and salient test results.

1. Introduction

The design and utilization of flow control components necessitate a wide variety of operational and environmental considerations related to each intended application. Actuators are basically shut off valves which feed gas or liquid at constant flow rates. These are remotely operated type, capable of actuating either continuously or in pulse mode on electrical command. Functional requirements for actuators include leak tight, cycle life and low power consumption. The design and selection criteria for actuator are type of actuation, actuation time, power, operating pressure, leakage requirements, flow, pressure drop, flow medium and operating life. Major evaluation criteria are mass, size, cost, reliability and performance [1].

2. Working Mechanism

Electrical command to the actuator coil opens actuator, which meters gas or liquid flow required to any of the control systems. Over the past decade, there has been wide variety of actuation mechanisms and methods employed for construction of actuators including electro-static, electro-magnetic and piezo-electric actuation [2]. The actuator has an actuating mechanism and sealing mechanism in one unit within a small envelope. When the actuator coil is energized, the coil builds up magnetic field and as a result armature is attracted towards the stationary stop, thus opening the actuator outlet port. On de-energizing the coil, the magnetic field disappears, the armature moves back and closes the actuator port.

Simplified construction reduces the valve manufacturing cost and no dynamic seals are used [3]. The materials chosen for the actuator are stainless steel material (magnetic & non-magnetic), rubber and insulated copper coil.

3. Characterisation for coil dry heating

Actuator coil dry heating test is carried out on proto hardware. On command to actuator coil, it actuates and opens the fluid path. In flow condition, fluid takes certain amount of heat by convection. Heat dissipates through conduction from the body and radiates annularly outside. In non-flow condition, heat dissipates through conduction from the body and radiates. Coil dry heating test was carried out for the actuator in no flow condition, which is severe from the actuator coil insulation resistance point of view. Basic electrical tests like coil resistance, insulation resistance are conducted for actuator.

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4. Test set-up

Actuator coil has been connected to power supply. Two numbers of K-type thermocouples are bonded to inlet (180° apart) and one more K-type thermocouple is bonded to outlet of the actuator. All three thermocouples are connected to three independent multi meters respectively. Actuator coil dry heating test set up is shown in Fig-1.

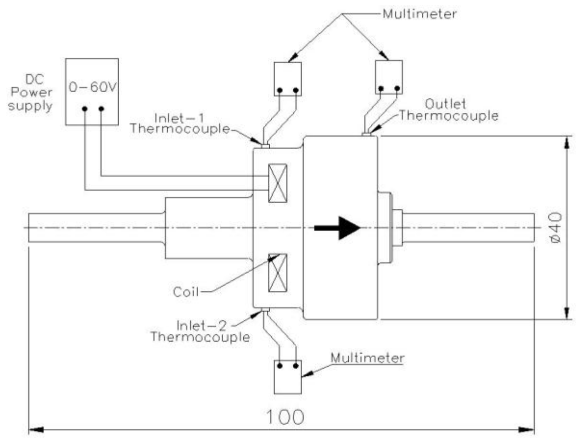

Figure 1, Actuator coil dry heating test set up

5. Test methodology

The Resistance of the actuator coil used is around 34 ohms for the selected gauge of 35.5 AWG and number of turns are 800. Actuator was tested for its functionality and found satisfactory. Initial coil resistance and actuator insulation resistances are measured before dry heating test. Following are six cases, where in which the current pumping to coil varied from 0.25 amps to 1.50 amps insteps of 0.25 amps.

Table 1, Coil input current for various cases

Case	Coil input voltage (V DC)	Current (amps)	Power (Watts)
1	8.5	0.25	2.125
2	17	0.50	8.500
3	25.5	0.75	19.125
4	34	1.00	34.000
5	42.5	1.25	53.125
6	51	1.50	76.500

6. Test Results

Coil Resistance measured is 34 ohms and actuator insulation resistance measured is 6×10^4 Mega ohms. By applying 8.5VDC input to actuator coil, 0.25 amps current pumped to coil. With 0.25 amps current for 180sec, three thermocouples (bonded at inlet and outlet) output is measured in terms of volts in multi meter. Even though current input is for 180sec, multi meter output was observed up to 360sec. The corresponding temperatures for K-type thermocouple are plotted with respect to time and shown in Figure.2. Coil resistance, actuator insulation resistances are measured after the test and found values repeatable.

The same test is repeated with coil input current of 0.50, 0.75, 1.00, 1.25, 1.50 and corresponding temperature graphs with time is shown in Figure.3, 4, 5, 6 and 7 respectively.

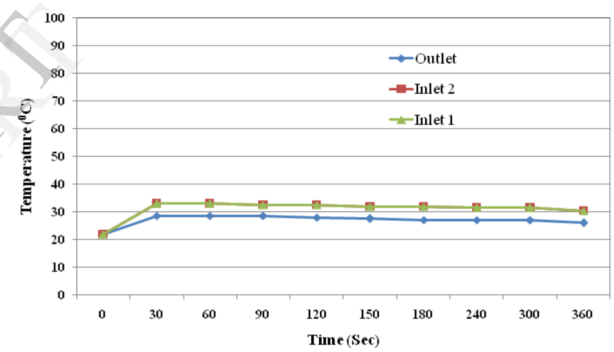

Figure 2. Actuator Temperatures for 0.25 amp coil current

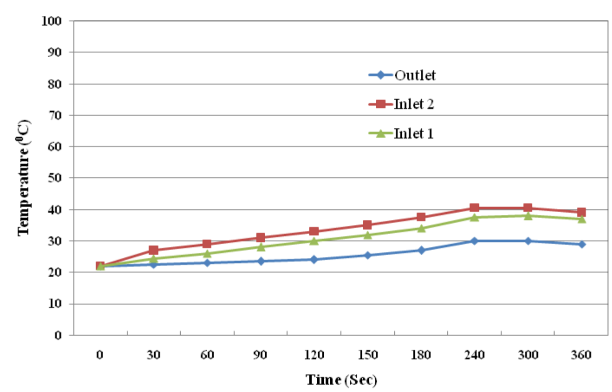

Figure 3. Actuator Temperatures for 0.50 amp coil current

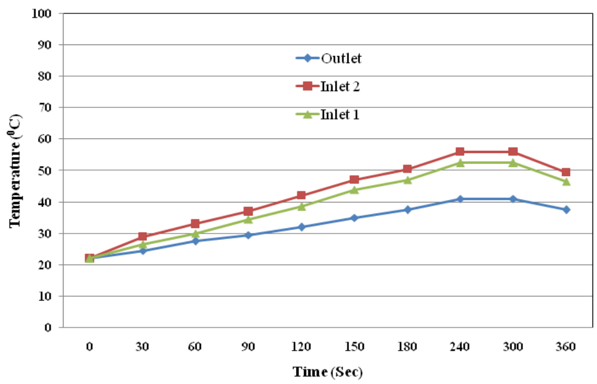

Figure 4. Actuator Temperatures for 0.75 amp coil current

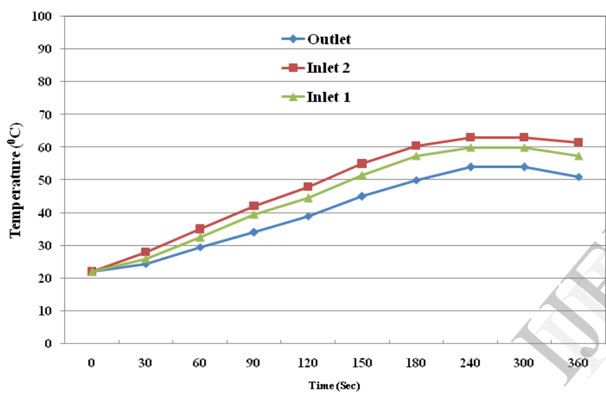

Figure 5. Actuator Temperatures for 1.00 amp coil current

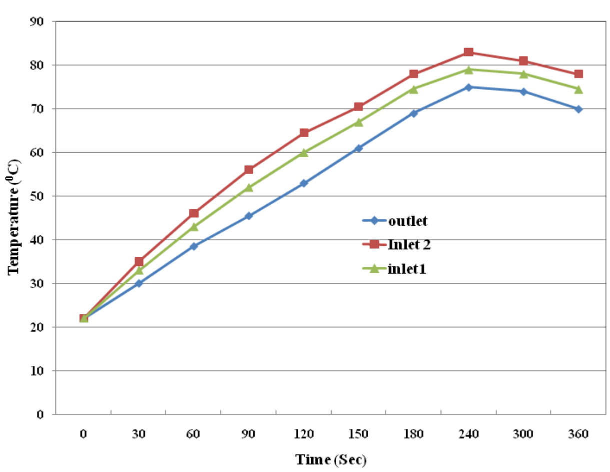

Figure 6. Actuator Temperatures for 1.25 amp coil current

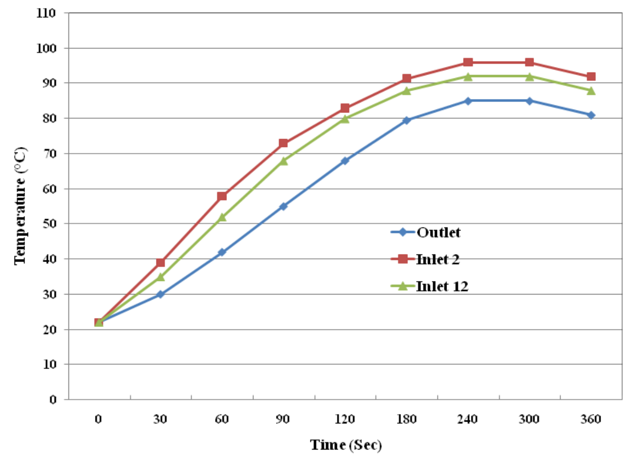

Figure 7. Actuator Temperatures for 1.50 amp coil current

7. Conclusion

Actuator proto hardware made and coil dry heating test is carried out in no flow condition, which is severe than flow condition. Basic electrical tests like coil resistance, insulation resistance are conducted for actuator. Coil input current is varied from 0.25 amps to 1.50 amps in steps of 0.25 amps for 180sec and monitored the actuator inlet & outlet temperatures through K-type thermocouples for 360sec. Also the coil resistance, actuator insulation resistances are measured after each test and measured resistance values are repetitive in nature, by which it was concluded that actuator coil health is good. The maximum temperature observed is well below 100°C, which is very benign from actuator materials point of view. However coil dry heating test demonstrated that the coil is intact and could able to demonstrate continuous operation of actuator to meet the specific requirement of 180sec. The test results of actuator coil dry heating test are satisfactory.

8. References

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