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Design change for Thermostatic Expansion Valve Body Assembly and its Static Analysis

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Abstract:

In this piece of work, a change in design for a valve body assembly was suggested resulting in reduction of the manufacturing process and cost. Detailed study was carried out under bucket of Hydraulic Valves chosen – Thermostatic Expansion Valves (TEV) type which usually consists of three major things inlet, body and outlet under Body Assembly. Valve consists of all the controlling mechanisms in terms of push rod, springs and a diaphragm.Proposed is a change in the manufacturing process resulting in reduction of material, cost and manufacturing process. This design change is done with respect to the Body Assembly (BA) where it usually has inlet fitting, body and outlet fitting. It is suggested that these can be sent in a single go.A Static Analysis was done on both the initial and proposed. And the results were compared with that of the initial BA. The final entity (Output) is a single part unlike the initial BA, where the inlet fitting and outlet fitting are merged into the body with a different type of production methodology. Forging – using forging method the inlet and outlet fitting were designed to be merged into the body. Thus the new body that was designed consists of inlet and outlet in itself was produced using forging and thus no further operations of soldering and brazing required. And in the previous case the inlet outlet fittings were of different material whereas the proposed is same as of the body. The coming pages will discuss the details of the method, results and future scope of this project.

Keywords:

Thermostatic Expansion Valve, TEV, forged valve, design change in TEV Valves, Forged body with fittings, static analysis

1. Introduction:

Before understanding the TEV let us recap the refrigeration system, it can be defined as a closed system in which the process of absorbing and rejecting heat is performed by a flowing refrigerant in a vapor compression cycle. In its simplest form, the refrigeration system consists of five components: the compressor, condenser, evaporator, expansion device, and interconnecting piping.A thermal expansion valve (often abbreviated as TEV, TXV, or TX valve) is a component in refrigeration and air conditioning system that controls the amount of refrigerant flow into the evaporator thereby controlling the superheating at the outlet of the evaporator. Thermal expansion valves are often referred to generically as "metering devices". Would be the possible definition that is available in could. Basically these can be classified under the bucket of the check valves in Hydraulics. TEV valves can be of two types one can be mechanically controlled or electronically controlled. Usually it consists of spring and a needle/push rod operated by a diaphragm moving based on the pressure generated due to the temperature difference. Expansion valves are flow-restricting devices that cause a pressure drop of the working fluid. The valve needle remains open during steady state operation. The size of the opening or the position of the needle is related to the pressure and temperature of the evaporator. There are three main parts of the expansion valve that regulate the position of the needle/push rod. A sensor bulb, at the end of the evaporator, monitors the temperature change of the evaporator. This change in temperature creates a change in pressure on the diaphragm. An internally equalized TXV uses evaporator inlet pressure to create the 'closing' force on the valve. An externally equalized valve uses the evaporator outlet pressure' thereby compensating for any pressure drop through the evaporator.

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If an internally equalized valve is used in a system with a large pressure drop through the evaporator, the pressure below the diaphragm will be higher, causing the valve to go in a more ‘closed’ position and resulting in a superheat higher than desired (starving).The thermostatic expansion valve (TEV) controls the flow of liquid refrigerant entering the direct expansion (DX) evaporator by maintaining a constant superheat of the refrigerant vapour at the outlet of the evaporator. Superheat is the difference between the refrigerant vapour temperature and its saturation temperature.

To measure the superheat the TEV controls, the difference between the actual temperature at the sensing bulb and the saturation temperature corresponding to the suction pressure at the sensing bulb location is determined. By controlling superheat, the TEV keeps nearly the entire evaporator surface active while not permitting liquid refrigerant to return to the compressor.The ability of the TEV to match refrigerant flow to the rate at which refrigerant can be vaporized in the evaporator makes the TEV the ideal expansion device for most air conditioning and refrigeration applications.

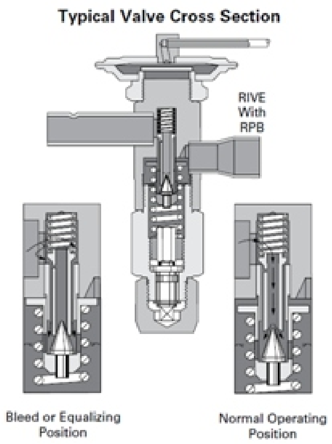
The refrigeration system can be defined as a closed system in which the process of absorbing and rejecting heat is performed by flowing a refrigerant in a vapour compression cycle. In its simplest form, the refrigeration system consists of five components: the compressor, condenser, evaporator, expansion device, and interconnecting piping. The heart of the system is the compressor since it causes the refrigerant flow. Its function is simply to receive low pressure (and temperature) refrigerant vapour from the evaporator and compress it into high pressure (and temperature) refrigerant vapour.

The high pressure vapour is then converted to a liquid phase in the condenser. The condenser performs this function by removing heat from the vapour and rejecting the heat to the air or to water in the case of water cooled condenser. The liquid, which remains at a high pressure, passes through the expansion device and becomes a low pressure two phase (liquid and vapour) mixture. This refrigerant mixture returns to its vapour phase in the evaporator by absorbing heat from the medium being cooled.

2. Inputs analysis:

In order to understand the principles of thermostatic expansion valve operation, a review of its major components is necessary. A sensing bulb is connected to the TEV by a length of capillary tubing which transmits bulb pressure to the top of valve’s diaphragm. The sensing bulb, capillary tubing, and diaphragm assembly is referred to as the thermostatic element. The diaphragm is the actuating member of the valve. Its motion is transmitted to the pin and pin carrier assembly by means of one or two pushrods, allowing the pin to move in and out of the valve port.

The superheat spring is located under the pin carrier, and a spring guide sets it in place. On externally adjustable valves, an external valve adjustment permits the spring pressure to be altered. There are three fundamental pressures acting on the valve’s diaphragm which affect its operation: sensing bulb pressure P1, equalizer pressure P2, and equivalent spring pressure P3.



Equivalent spring pressure is defined as the spring force divided by the effective area of the diaphragm. The effective area of the diaphragm is simply the portion of the total diaphragm area which is effectively used by the bulb and equalizer pressures to provide their respective opening and closing forces. Equivalent spring pressure is essentially constant once the valve has been adjusted to the desired superheat.

As a result, the TEV functions by controlling the difference between bulb and equalizer pressures by the amount of the spring pressure.Body assembly consists of two fittings and a body. The dimensional details are as given below:

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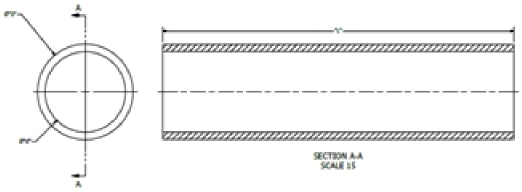


Figure 1

In the above Figure 1 “L” is the variable length of the fitting and Ø”D” and Ø”d” are the outer and inner diameters. These fittings are usually of copper material and are brought from a third party for assembling with the body. Majorly the fittings are available at various predefined sizes.Further below figure 2 shows the dimensional details of the fittings that were assumed under this project.

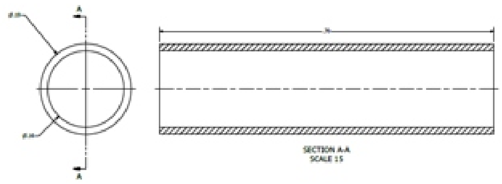


Figure 2

As per above figure, the overall length of the fitting is L=.70”, D=Ø.19” and d=Ø.16”. Figure 3 gives the details of the body design having around 14 dimensions.

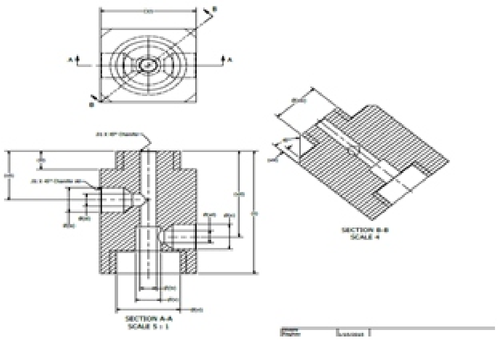
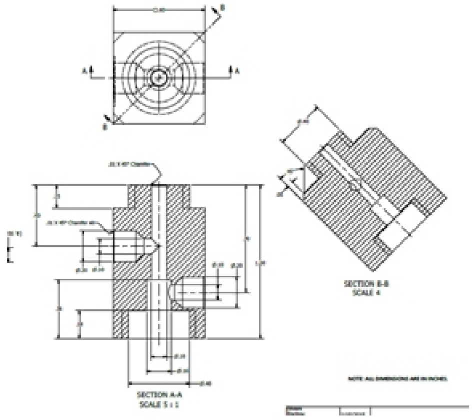


Figure 3

Assumed dimensions for the body are given in the below figure 4.



3. Design change for Thermostatic Expansion Valve Body Assembly and its Static Analysis:

The proposed valve is under forged manufacturing type.

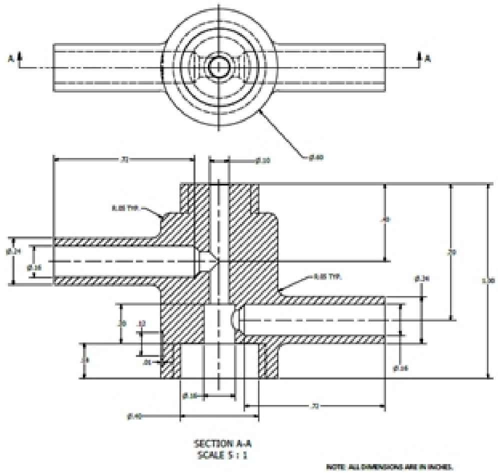
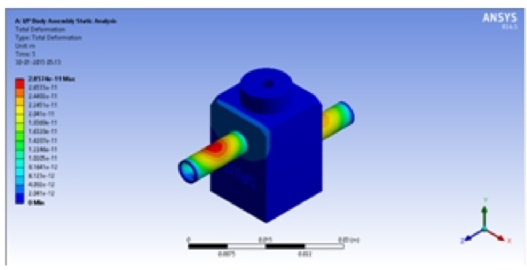


Figure 4

The inlet and out let hole are assumed to be same to have a linear results after analysis. The threads are default as per the modelling software. Below is the body assembly end to end dimension.



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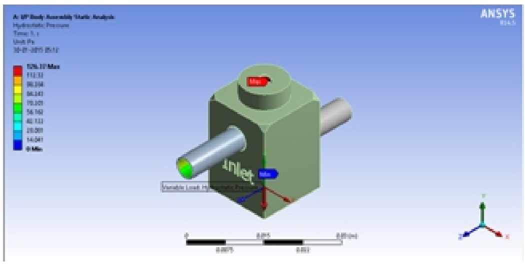
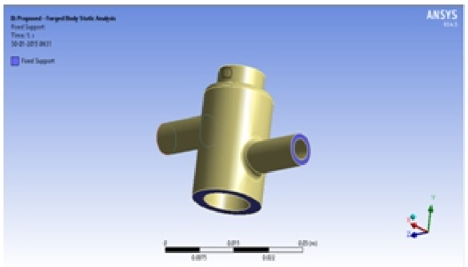
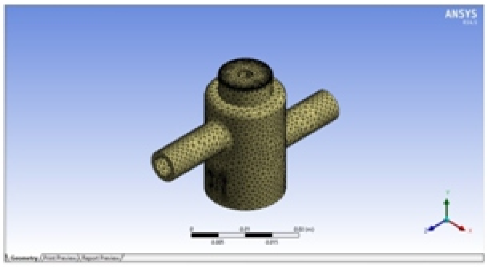
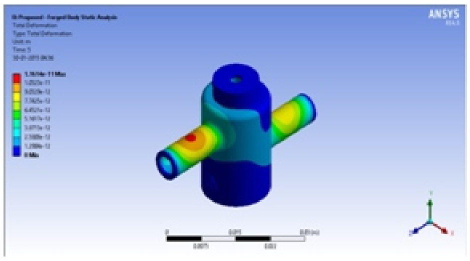
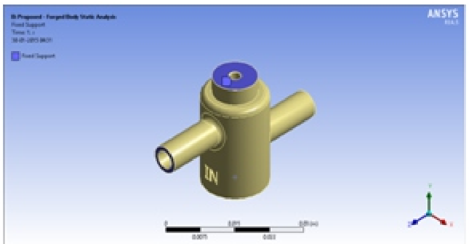


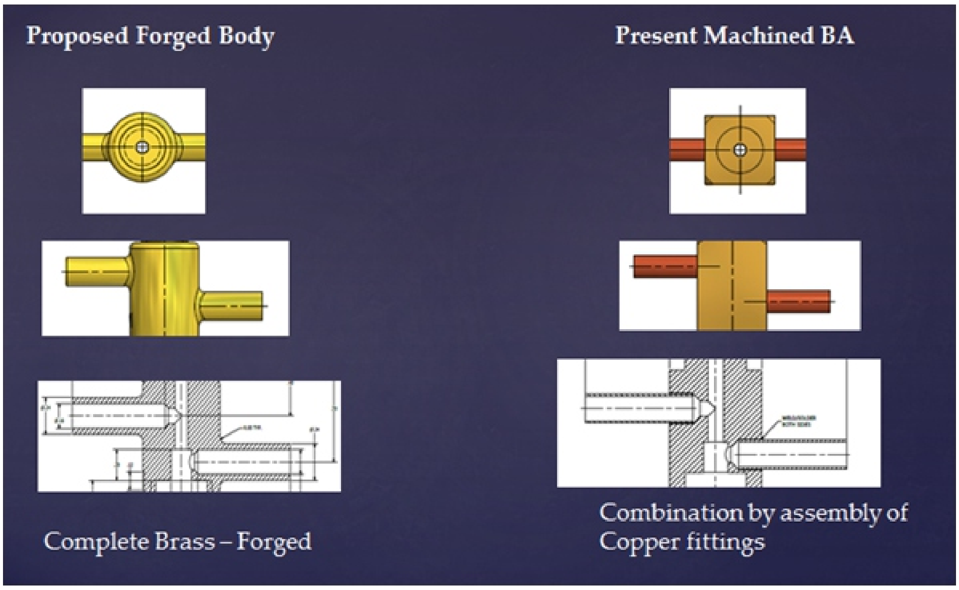








Major design changes:



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Forged Body with Fittings	Machined Body Assembly
Forging	Machining
Round Body	Square Body
No Soldering	Soldering/ Brazing
Manufacturing Time saving	Comparatively more
No more Copper (Cu)	Need copper fittings
Higher strength	Comparatively Low
Cheaper	Comparatively Costlier
Low Complexity	High Complexity
Less Labour	More Labour

4. Conclusion:

It is observed to be advantageous than the present Square Body assembly as compared with cost and deformation results. Hence it can be proposed for further manufacturing and quality analysis along with Fluid analysis based on the other components of the assembly.

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