ISSN: 2278-0181
COME - 2017 Conference Proceedings

Study of Improvemen to On Compensator by Thermal Expansion using Composite Materials

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Abstract Compensator is universally applicable in almost every industrial sector. Particularly in pipeline engineering, they allow space-saving pipe routing for transporting a variety of media such as hot water, steam, fuel, heat transfer fluids, hot gases and various types of chemical products. The performance of a compensator is critical, and is often judged in part by the amount of heat a unit length of the compensator can transport under a uniform heat load. The surface resistance on the exhaust section is one of the important parameters which also decide the operating temperature of the compensator. Under such circumstances, the increase in the heat transfer through an increase in the surface area, or the increase in the surface heat transfer coefficient in the exhaust section is essential to maintain the operational temperature within the constraint. The materials selection for compensator is a critical factor in the successful design and construction of each product. The materials are chosen based on the important criteria and operating conditions of the installation: chemical resistance, temperature limitations, abrasion resistance, tensile strength and susceptibility to vibration or movements are major considerations when selecting materials and designs of compensator. In this study, thermal mode analysis of the compensator is described to study the effect of the temperature acting on the internal and external wall surface of the compensator. The temperature along with the internal and external surface of the walls is noted, and its variation is investigated.

I. INTRODUCTION

A. THERMAL EXPANSION

The coefficient of thermal expansion is used to determine the rate at which a material expands as a function of temperature. Coefficient of thermal expansion is used for design purposes to determine if failure by thermal stress may occur. Understanding the relative expansion/contraction characteristics of materials is important for application success. The coefficients of thermal expansion values are of considerable interest to design engineers. Plastics tend to expand and contract anywhere from six to nine times more than metals. The thermal expansion difference develops internal stresses and in stress concentrations in the polymer, which allows premature failure to occur.

The coefficient of thermal expansion is defined as the change in length or volume of a material for a unit change in temperature. The overall coefficient is the linear thermal expansion (in.) per degree Fahrenheit or Celsius. The coefficient of thermal expansion data is calculated by the change in length divided by the quantity of the length at room temperature, multiplied by the change of temperature

B. BASIC PRINCIPLES OF EXPANSION COMPENSATOR

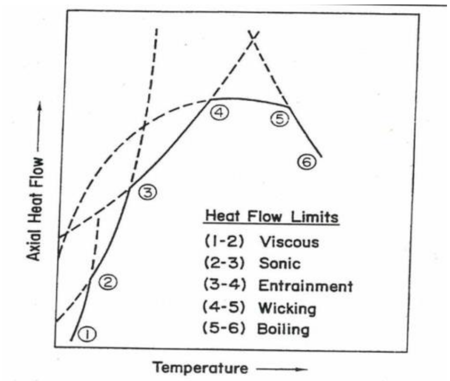
Expansion compensators are used in piping systems to absorb thermal expansion or terminal movement where the use of expansion loops is undesirable or impractical. Expansion compensators are available in many different shapes and materials. Bellow you will find a short description of Metallic, Rubber and Teflon compensators.

II. TYPES OF THERMAL EXPANSION COMPENSATORS

Metal pipe expansion compensators can withstand the design temperatures, pressures, as well as, provide the capacity necessary to absorb thermal growth of the piping system. The thermal movement required can be axial, lateral or angular. In some cases, the pressure thrust of a pipe expansion compensator must be restrained by the use of tie rods, hinges or gimbal while allowing the bellows to move through its design deflections. There are various types of thermal expansion compensator is available

A. OPERATING LIMITS

A compensator behaves like a structure of very high thermal conductance, but is constrained by the principles of fluid dynamics and heat transfer. These operating constraints depend additionally on the thermo physical properties of the working fluid, container and design configuration, and the coupling of the compensator to the environment for heat addition and removal. The commonly accepted limits discussed in the literature are 1. The viscous Limit 2. The sonic Limit compensator Operating limits with heat pipe



Compensator in Spacecraft

Compensator, at vapor temperatures up to 2000 C, have probably gained more from developments, associated with spacecraft applications than from any other area. Details about the following types of applications can be found in the literature.

1 Spacecraft temperature equalization
2 Component cooling, temperature control and radiator design
3 Space nuclear power sources
4 Moderatorcooling
5 Removal of the heat from the reactor at emitter temperature. (Each fuel rod would consist of a heat pipe with externally attached fuel).
6 Elimination of troublesome thermal gradients along the emitter and collector.

B. OBJECTIVE OF THE PRESENT WORK

S	ITEM DESCRIPTION	OPERATING RANGI
1	Loose/swivel flange thickne	30 mm
2	Loose/swivel flange heigh	400 mm
3	Flange diameter	4065 mm
4	Bellow base diameter	4185 mm
5	Operating Temperature	300^{0}c (572^{0}F)
6	Operating Pressure	3.5 Par (50 PSIG)

The study of our project is to find out the performance of a compensator depends on several factors, such as the radial and axial thermal resistances at inside the compensators.

The surface resistance is one of the important parameters which also decide the operating temperature of the compensator.

The objective of the present study is the thermal investigation of the transient operation of a compensator under different materials used in order to determine the surface resistance and to determine the effective thermal conductivity of the compensator, which is being used as an important parameter in commercial software, to analyze the performance of many metal compositions using compensators.

In the present work, a Universal compensators made up of three composites of the same dimensions were constructed with some modifications, in order to provide three different materials.

The results obtained from the above investigation are compared and presented in this work. In addition, the effective thermal conductivity of the compensator will determine and reported

4.ASSEMBLY DESIGN OF COMPONSATER

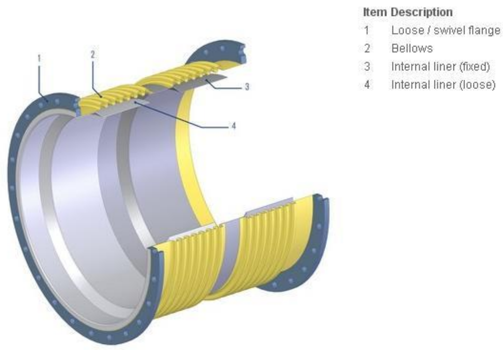
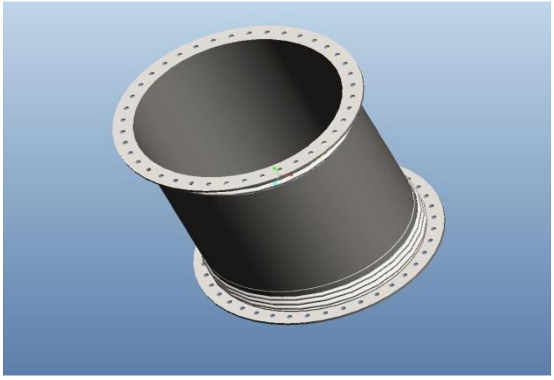


Table 3.1: Operating Range of Compensator

S.	BELLOW	WELD ENDS	FLANGES
1	AISI 321	1.0038-S235JRG2	1.0038-S235JRG2
2	AISI 304	1.0425-P265GH	1.0425-P265GH
3	AISI 316	AISI 316L	AISI 316L

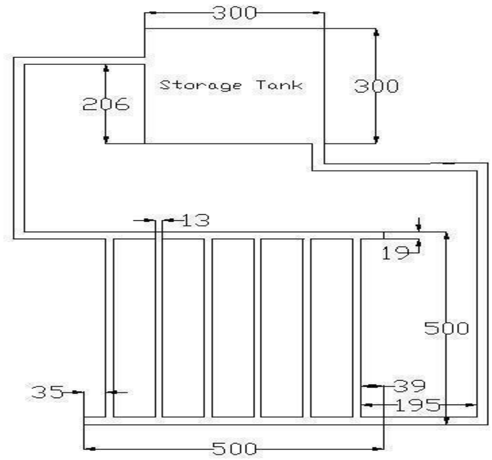
Table 3.2: Material Used for Compensator

3.2 THERMAL EXPANSION COMPENSATOR 3D MODEL



inside the slab. Inlet and outlet pipes were provided for all the collector slabs. PV cells were pasted on the surface of the collector .the rating of the PV cells are 4 volts each .the inlet of the collector slab is now connected to the outlet of the water storage tank . The water storage tank used here is a rectangular one made of

Stainless steel with dimensions of 300*300*300 mm3. The outlet of the collector is in this case an open system the outlet of the collector is open free and the temperature of the heated water from the collector is noted down. The collectors' slabs are placed in the north south direction to have maximum exposure to sunlight throughout the testing period. The angle of inclination used here is 45 degree. As the collector starts to give out hot



Water the temperature of the inlet normal water and the outlet hot water are noted down for every one hour once. Two thermometers are fixed in the outlet of the storage tank and at the outlet of the Collector. A ball valve is used to adjust the flow rate of water to the inlet of the collector and another ball valve is used to control the outlet flow rate. The Concrete PV/T collectors are rested on a sand bag used as a support as well as an insulating medium therefore by not allowing heat to dissipate on the unexposed side of the collector. The complete Concrete PV/T water collector experimental setup was installed at THURAIYUR Trichy (11.107° N, 78.3716° E) TamilNadu, India. The experiments were conducted during the month of February–March, 2017. The readings were taken from morning 10 AM to5.00PM.

2.1 HEADER AND RISER TUBES

The header and riser tubes are placed inside the Concrete PV/T collector. The riser tubes are vertically arranged between the two header tubes. The water flows inside the header and riser tubes. During a day time the collective tubes absorbs the heat from the sunlight and transfer to the water flows inside the tube. The thermometers are placed at the inlet and outlet of the concrete PV/T to measure the inlet and outlet temperature of the water.

2.2HEADER TUBE

- Material : Copper, PVC, Brass
- Length : 500 mm
- Diameter: 19.05 mm
- Distance between header tubes : 461.9 mm

2.3RISER TUBE

- Material : Copper, PVC, Brass
- Length : 461.9 mm
- No. of tubes : 6
- Distance between each tubes : 84.76 mm
- Diameter : 12.7 mm

2.1 ABSORBER / COLLECTOR

The concrete used as the absorber and collector with the basic ratio of 2:2:1 of cement , sand and water content with gravels size ranging from 2.5mm to 3 mm.The dimension of the concrete slab is 600mm × 600mm×50mm. Flat surface area is 600mm×600mm. The thickness of the concrete slab is 50mm.

2.3 STORAGE TANK

Storage tank is made up of stainless steel and the tank is insulated inside with the foam sheet. The size of the storage tank is 300*300*300 mm3. It has the inlet hole at the bottom. Then it is connected to the header tube inlet by copper tube. Initially the storage tank contains cooled water.

2.4 PV CELL

The PV cell is pasted on the surface of the Concrete PV/T collector. Here the monocrystalline silicon cell is used.

The number cells used in this project is 10.

2.5 ASSUMPTIONS

Flow inside tube is viscous. One dimensional flow. Heat transfer between storage tank & surroundings are negligible.

3. WORKING PRINCIPLE

Concrete PV/T collectors are the combined arrangement solar flat plate collector and PV cell in a single system simultaneously produce the thermal energy as well electrical energy. In principle, a PV/T module is similar to a solar thermal collector in term of heat Generation. The surface of the collector absorbs the heat from the sun rays and transfers it to the water passing through the pipes of the collector. Hot Water being lighter rises to the insulated storage tank and an equal amount of cold water replaces this hot water by the thermosyphon effect. This cycle repeats as long as the sun shines, resulting in all the water getting heated for distribution through pipes to the required usage points. The principle of the thermosyphon system is that cold water has a higher specific density than warm water, and so being heavier will sink down. Due to higher temperature differences at higher solar irradiances, warm water rises faster than it does at lower irradiances. Simultaneously PV cell is formed over the flat plate collector consists of "P" type silicon. This time a small amount of phosphorous is added to the mixture. The phosphorous mixture creates a negative characteristic and thus is referred to as "N" type silicon. When light penetrates to the junction of the "N" and "P" type silicon layers it creates a flow of electrons throughout the crystal structure. This flow of electrons occurs because sunlight is composed of photons, or particles of solar energy. When sunlight strikes a PV cell, some photons are absorbed. When enough sunlight (energy) is absorbed by the material (called a semiconductor), electrons are dislodged from the materials' atoms. A crystal structure of silicon contains empty areas which accept the electrons. As one electron moves to fill a hole, it created another hole. It is the flow of these electrons that produces electricity.

4. READINGS AND OBSERVATIONS

TABLE 1: READINGS OF CONCRETE PVC PV/T WATER COLLECTOR AT A MASS FLOW RATE OF 1 Kg/min

Time	Solar intensity	Outlet temperature
IST (Hrs)	*I (w/m2)*	˚C
10	720.6	39.5
11	861.4	42.2
12	935.5	46.4
13	919.9	53.5
14	818.3	50.3
15	763.7	47.1
16	603.5	41.2
17	561.6	37.1

TABLE 2: READINGS OF CONCRETE COPPER PV/T WATER COLLECTOR AT A MASS FLOW RATE OF 1 Kg/min

Time	Solar intensity	Outlet temperature
IST (Hrs)	*I (w/m2*	˚C
10	720.6	43.1
11	861.4	47.3
12	935.5	51.3
13	919.9	56.5
14	818.3	53.2
15	763.7	49.4
16	603.5	43.1
17	561.6	40.2

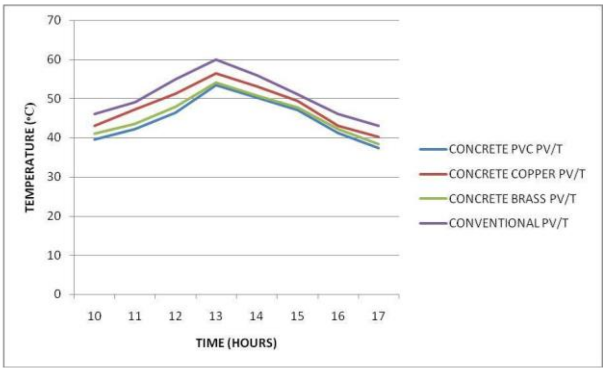
READINGS OF CONCRETE BRASS PV/T WATER COLLECTOR AT A MASS FLOW RATE OF 1Kg/min

Time	Solar intensity	Outlet temperature
IST (Hrs)	*I (w/m2*	˚C
10	720.6	41
11	861.4	43.5
12	935.5	47.8
13	919.9	54.1
14	818.3	50.8
15	763.7	47.7
16	603.5	42.1
17	561.6	38.3

TABLE 4: READINGS OF CONVENTIONAL PV/T WATER COLLECTOR AT A MASS FLOW RATE OF 1 Kg/min

Time	Solar intensity	Outlet temperature
IST (Hrs)	*I (w/m2*	˚C
10	720.6	46
11	861.4	49
12	935.5	55
13	919.9	60
14	818.3	56
15	763.7	51
16	603.5	46
17	561.6	43

GRAPH 1: COMPARISON OF OUTLET TEMPERATURE BY DIFFERENT PV/T SYSTEMS



5. CONCLUSION

Hence the analysis of different PV/T water collector has been carried out and compared with conventional PV/T water collectors. From the experiment it is clear that the performance of the conventional PV/T is comparable with Concrete Copper PV/T. The order of performance is conventional PV/T , Concrete Copper PV/T, Concrete Brass PV/T and Concrete PVC PV/T. Thus Concrete PV/T is suitable for residential purpose as it is a cheap system when compared to Conventional PV/T.

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