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Contents

OPTIMIZATION OF PIPING EXPANSION LOOP IN PROCESS PLANT

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Abstract--- **In a process Plant, Pipes are used to transport fluid from one point to another or one equipment to another. When the fluid temperature is above the atmospheric temperature, the pipe will expand. If this expansion is restricted by means of a support or equipment, it will induce some forces and moment or stress in the piping and connected equipment. These thermal stresses and its allowable limits are calculated as per ASME (American Society of Mechanical Engineers) B31.3 code. This code also specifies the allowable limit for other type of stresses developed in the piping (For e.g.: stresses due to pressure, weight, wind etc.) and its allowable value. When the connecting equipment are far away, it will be routed through pipe rack which will provide more accessibility around the process plant. Pipe rack loops are employed for absorbing the thermal expansion of the pipes. In this project, dimensions of pipe rack loops for a process plant are optimized based on temperature, pipe size, pressure etc. The guidelines mentioned in ASME B 31.3 are used for designing the loops using Caesar II Software which is based on FEM. The analysis is carried out by assuming anchors at both the sides of the pipe rack loop which is a common practice in a process plant.**

Key words--- ASME, Pipe rack, Pipe rack loops, FEM, Caesar II

I. INTRODUCTION

Pipe is a hollow cylindrical object which is having outside diameter and thickness defined as per ASME (American Society of Mechanical Engineers) B 36.10[10]/ 36.19[11] standards. In order to get a desired output/ product from a process plant, fluids are to be circulated between processing equipments. Pipes are used to transport these fluids. When the connecting equipments are far away, these pipes will be routed through pipe rack. Pipe rack will provide more accessibility around the plant. Pipe rack is "Π "shaped structure for supporting pipes, usually fabricated from steel or concrete. In order to maintain the safety of a process plant, the piping system has to be designed properly so that it will not collapse under the action of the loads due to weight, pressure, temperature and other occasional conditions. ASME provides guidelines to be followed in order to maintain safety of a process plant. This guideline is published as ASME B 31.3 code [7].

During the design phase of a pipe rack for petrochemical plant which consists of thousands of piping systems, approximating these loop dimensions are a major concern for the designers. A combination of different design cases has to be considered while optimizing the loop dimensions. The design will have an impact on the design, material cost and safety of the plant. In this project, dimensions of pipe rack loops for a process plant are optimized based on temperature, pipe size, pressure etc. The guidelines mentioned in ASME B 31.3 [7] are used for designing the loops using Caesar II Software which is based on FEM. The analysis is carried out by assuming anchors at both the sides of the pipe rack loop which is a common practice in process plant.

II. EXPERIMENTAL METHODOLOGY

A. Pipe rack and expansion loop

When the pipe is to be connected between two equipment which are far away, it will be routed through Pipe rack. Pipe rack will provide more accessibility around the plant. Pipe rack is " Π " shaped structure for supporting pipes, usually fabricated from Steel or Concrete. Fig 1.3 show an actual picture of the Pipe rack under construction. It depends on the number of lines to be routed through pipe rack, it will be constructed in one or more levels which are called tiers of pipe rack. Generally Process lines are routed through Lower or middle tier of the pipe rack and utility lines will be routed through Upper tier. The minimum height of the pipe rack (Lower tier) is generally restricted to 4.5m as small vehicles can easily pass through under these pipe racks. The spacing between pipe racks depends on average size of the pipe routed through the pipe rack. Most commonly used Pipe racks will be having a span of 6 to 8 m. There will be two tie beams at both the ends of the pipe rack which will connect between two pipe rack. These tie beams will provide more stability to the Pipe rack structure. This can also be used for supporting the pipes that are coming into or out of the pipe rack.

When the carrying fluid is at high temperature, the pipe will expand depends on the Thermal Coefficient of Expansion of the material, Length of Pipe and

Temperature of the fluid. This expansion increases linearly with all the parameters. As the lines in Pipe rack generally travel a long distance, the length of the pipe is more in pipe rack which produces more expansion. These expansions to be restricted to keep the piping system in designed position. But when pipe supports are employed to reduce these displacements, it will induce some stresses on the piping system. These are called thermal stresses which are to be optimized for the safe operation of the plant.

Pipe rack loops are employed to reduce these thermal stresses. It is characterized by pipes routed perpendicular to the actual direction of the pipe. If the pipes are routed in both the perpendicular directions, it is called a three dimensional loop (6 elbows) and if it is only in one direction, it is called a two dimensional loop (4 elbows). Three dimensional loops are the most commonly used as it gives more flexibility compared to the two dimensional loops. Two dimensional loops will also obstruct the routing of other pipes which doesn't have high temperature. So the two dimensional loops are employed when three dimensional loops are not possible by some process constraints. A three dimensional loop is shown in Fig 1

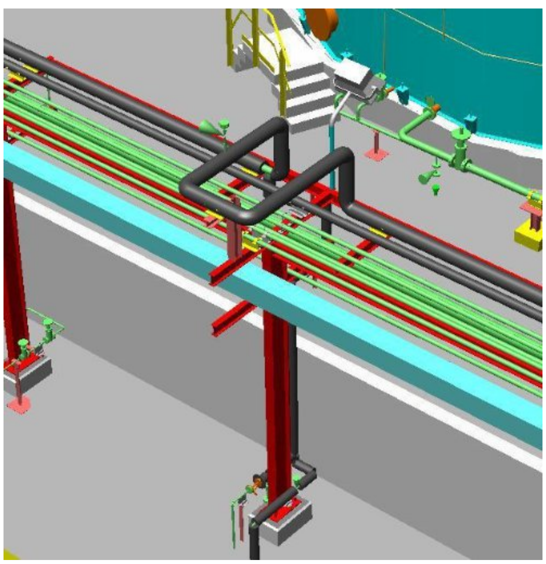


Figure 1: Computer (PDS) Model of 3 dimensional expansion loop

The vertical leg of the three dimensional loop will be having limitations as it cannot move beyond the next level (tier) of the pipe rack. Generally the length of loop in vertical direction is taken as the half of the distance between two levels of the pipe rack. At these levels, there will be tie beams on both sides of the pipe rack from where we can get the supports if required. The horizontal leg required for the expansion loop plays an important role in placing the pipe in Pipe rack. If the horizontal leg required is more it should be placed in such a way that loop should not extend more distance from the pipe rack.

Expansion loops are erected approximately at the centre of total length of the pipe rack. Anchors are placed on both sides of the expansion loop so that the complete expansion is absorbed by this loop and it will not reach to the equipment.

B. Design Procedure

A sample three dimensional expansion loop is created in this project. Anchor is assumed at both ends of the pipe rack. The distance between anchors is calculated based on maximum possible distance, a shoe support (support used for an insulated pipe) can travel. The length of the shoe support generally varies from 200 to 400 mm in length. In order to keep the support in the structure of Pipe rack, the maximum possible distance travel is restricted to 100mm. This is on one side of the expansion loop. On the other side of the pipe rack also 100 mm expansion is possible. So the distance between anchors is calculated based on the length required for 200mm thermal displacements.

Piping Isometrics are created using AutoCAD. The piping system is divided into finite elements by putting node numbers at different points as shown in Figure 2.

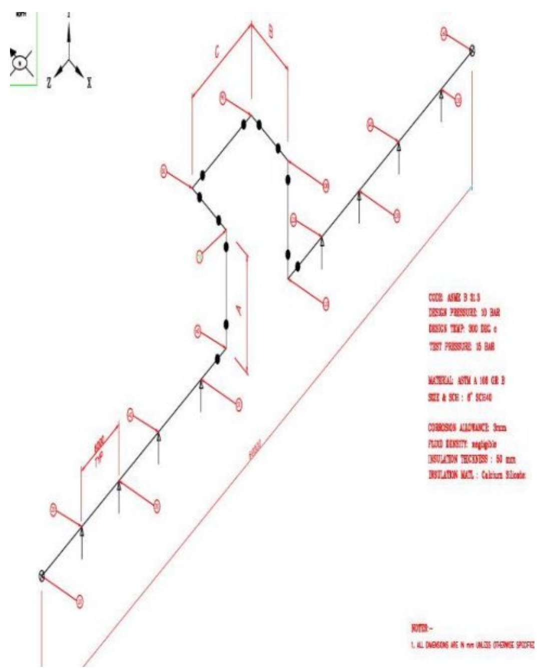


Figure 2: Isometric Drawing of Piping system to be analyzed

The piping system is modeled in Caesar II software. Loads due to Weight, Pressure, Temperature and Wind are imposed on the system. The atmospheric temperature is assumed as 21^0C.

The parameters in table 1 are used for th e first model of the ex ercise

Table 1. In put parameters for modelling [10, 11, 12]

Sr. No.	INPU T PARAME ERS	
01	Pressur e	10 BAR
02	Temperature	300 ^{0}C
03	Pipe size	6” NPS
04	Schedu le	SCH40
05	Pipe material	AS TM A 106 Gr. B
06	ASME Code	AS ME B 31.3 [1]
07	Supports	6m span
08	Fluid density	Negligible
09	Hydro test pressure	15BAR
10	Insulation thickness	50mm
11	Insulation material	C alcium Silicate
12	Wind v elocity	45 m/sec at all eleva tions
13	Shape factor	0.65

Typical load combinations as mention ed in Figure 3 is created and a nalyzed. The dimensions A is fix ed as 1 500mm. The system is analyzed to find out the optimum dimension B and C so that piping syste m is safe in a ll the load combinations. The system is optimized to get a thermal stress ratio of around 80% and there is n o heavier loa ds on Anchors on both sides of the loop. An a pproximate ra tio of 2:1 is adopted when changin g the dimens ion of B and C for o ptimization.

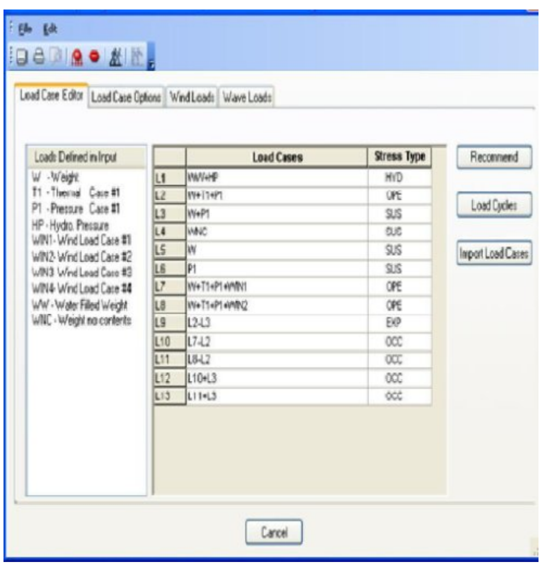


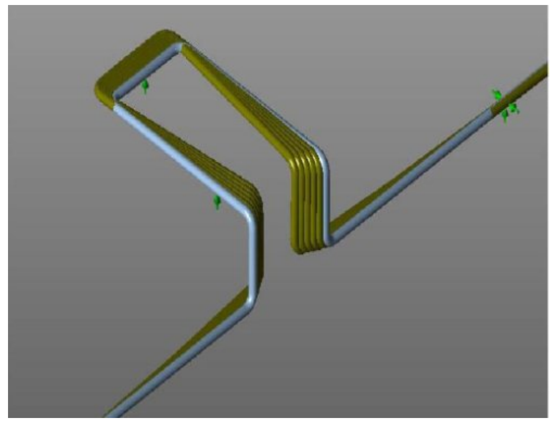
Fig ure 3: Load co mbination for design

III RESULTS A ND DISCUS SION

The piping system is analyze d between tw o anchors placed b etween 60 m apart. The dim ensions A, B and C required for the safe desig n of the piping system as pe r ASME B 3 1.3 [7] is obtained an d is given bel ow.

A = 1.5m, B = 4m, C = 2m

T he movement of the pipes near expansi on loop is plo tted in the Figure 4.



F igure 4: Movement of Exp ansion loop at Operating condition

T he optimum loop dimensi ons are obtained by evaluating the following three results from Caesar II rep ort

(1) Stress Su mmary Report shown in tab le 2
(2) Displace ment Report s hown in table 3 & 4
(3) Restraint Summary Re port shown in table 5

Table 2. Stre ss summary report

CODE STR ESS CHEC K PASSED : LOADCA SE 1 (HYD) WW+HP	
	Kpa
Code Stress Ratio (%)	10.3 @ Node 75
Code Stress	24934.4 Allowable: 241311.0
Axial Stress	13512.4 @Node 68
Bending Stre ss	11812.7 @Node 75
Torsion Stre ss	196.3 @Node 70
Hoop Stress	27455.0 @Node 15
CODE STR ESS CHEC K PASSED : LOADCA SE 3 (SUS) W+P1	
Code Stress Ratio (%)	23.3 @ Node 75
Code Stress	28497.8 Allowable: 122370.4
Axial Stress	14719.4 @Node 68
Bending Stre ss	14267.3 @Node 75
Torsion Stre ss	237.1 @Node 70
Hoop Stress	29192.2 @Node 15
CODE STR ESS CHEC K PASSED : LOADCA SE 4 (SUS) WNC	
Code Stress Ratio (%)	11.7 @ Node 75
Code Stress	14267.3 Allowable:

	122370.4
Axial Stress	488.9 @Node 68
Bending Stress	14267.3 @Node 75
Torsion Stress	237.1 @Node 70
Hoop Stress	0.0 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 5 (SUS) W	
Code Stress Ratio (%)	11.7 @Node 75
Code Stress	14267.3 Allowable: 122370.4
Axial Stress	488.9 @Node 68
Bending Stress	14267.3 @Node 75
Torsion Stress	237.1 @Node 70
Hoop Stress	0.0 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 6 (SUS) P1	
Code Stress Ratio (%)	11.6 @Node 15
Code Stress	14230.5 Allowable: 122370.4
Axial Stress	14230.5 @Node 15
Bending Stress	0.0 @Node 15
Torsion Stress	0.0 @Node 15
Hoop Stress	29192.2 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 9 (EXP) L9=L2-L3	
Code Stress Ratio (%)	78.7 @Node 80
Code Stress	243425.7 Allowable: 309285.9
Axial Stress	1417.3 @Node 15
Bending Stress	243425.7 @Node 80
Torsion Stress	19000.5 @Node 60
Hoop Stress	0.0 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 10 (OCC) L10=L7-L2	
Code Stress Ratio (%)	27.6 @Node 50
Code Stress	44948.2 Allowable: 162752.6
Axial Stress	209.9 @Node 79
Bending Stress	44746.5 @Node 50
Torsion Stress	8940.1 @Node 60
Hoop Stress	0.0 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 11 (OCC) L11=L8-L2	
Code Stress Ratio (%)	26.0 @Node 110
Code Stress	42338.5 Allowable: 162752.6
Axial Stress	552.7 @Node 15
Bending Stress	41785.8 @Node 58
Torsion Stress	8045.7 @Node 60
Hoop Stress	0.0 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 12 (OCC) L12=L10+L3	
Code Stress Ratio (%)	44.3 @Node 50
Code Stress	72054.5 Allowable: 162752.6
Axial Stress	14671.3 @Node 68
Bending Stress	57615.7 @Node 50
Torsion Stress	8870.2 @Node 60
Hoop Stress	29192.2 @Node 15
CODE STRESS CHECK PASSED : LOADCASE 13 (OCC) L13=L11+L3	
Code Stress Ratio (%)	36.0 @Node 58
Code Stress	58613.9 Allowable: 162752.6
Axial Stress	14929.0 @Node 109
Bending Stress	43824.2 @Node 110
Torsion Stress	8115.5 @Node 100
Hoop Stress	29192.2 @Node 15

This shows ratio of the maximum stress produced in the piping system to allowable stress ratio as per ASME B 31.3 [7] (for different combination of the cases defined).

Table 3. Displacement report at sustained condition

NODE	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
10	0.000	-0.000	-0.000	-0.0000	-0.0000	-0.0000
15	0.002	-0.491	-0.000	-0.0000	-0.0001	-0.0034
20	0.006	-0.000	-0.000	0.0001	-0.0001	-0.0069
25	0.007	-0.487	-0.000	0.0000	0.0000	-0.0103
30	-0.000	-0.000	-0.000	-0.0002	0.0002	-0.0138
35	-0.017	-0.505	-0.000	-0.0002	0.0004	-0.0172
40	-0.032	-0.000	-0.000	0.0009	0.0002	-0.0207
45	-0.031	-0.437	-0.000	0.0006	-0.0003	-0.0241
50	0.000	-0.000	-0.000	-0.0032	-0.0010	-0.0275

The displacement Report will show the movements of the pipe at different node numbers. This movement will vary from Case to case. Displacement report in Case 3: W+P1 (Sustained) was instrumental in deciding the supporting span to avoid excessive sagging as shown in table 3.

Table 4. Displacement report at operating condition

NODE	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
10	-0.000	-0.000	0.000	-0.000	0.0000	-0.0000
15	-1.069	-0.510	-10.782	-0.0004	0.0339	-0.0039
20	-2.848	-0.000	-21.563	0.0015	0.0271	-0.0077
25	-3.202	-0.393	-32.345	0.0011	-0.0205	-0.0116
30	0.000	-0.000	-43.126	-0.0059	-0.1088	-0.0154
35	7.484	-0.861	-53.908	-0.0040	-0.1563	-0.0193
40	14.251	-0.000	-64.690	0.0224	-0.0814	-0.0232
45	13.892	0.902	-75.471	0.0151	0.1159	-0.0270
50	-0.000	-0.000	-86.253	-0.0840	0.4356	-0.0309

Similarly the displacements report in Operating condition Case 2: W+P1+T1 was helpful to check the movements of the pipe at plant operating conditions as shown in table 4. It is restricted to 5mm in vertical, 25 mm horizontal and 100mm axial so that practical inconvenience is avoided. We could see the displacement report of different nodes in the X, Y and Z direction in tables 3 and 4 and can be seen in the restricted limits.

Table 5. Restraint summary report

Node	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10		Rigid ANC					
	1(HYD)	1	-1378	-19	-1379	-2	-50
	2(OPE)	-188	-1026	5090	-1036	752	-41
	3(SUS)	0	-1016	-14	-1016	-2	-37
	4(SUS)	0	-1016	-14	-1016	-2	-37
	5(SUS)	0	-1016	-14	-1016	-2	-37
	6(SUS)	0	0	0	0	0	0
	7(OPE)	1152	-1026	5517	-1037	-2014	-119
	8(OPE)	-172	-1027	6262	-1038	688	-66
	MAX	1152/L7	-1378/L1	6262/L8	-1379/L1	-2014/L7	-119/L7

The Restraint Summary Report will show the loads on different types of pipe supports with their node numbers. The loads will vary with respect to different load cases. Summary of the load on support at a node number (for different load cases) are shown in table 5**.** The load limit is considered at 10000N which will help designing different types of supports for the Civil Engineers.

IV Conclusion

In this project, a pipe rack expansion loop is designed in the piping system as per ASME B 31.3 [7] code with different load and boundary conditions. There after the dimensions of the expansion loop are optimized for the given input parameters. The dimensions A, B and C required for the safe design of the piping system as per ASME B 31.3 [7] is obtained and is given below.

A = 1.5m, B = 4m, C = 2m

- Isometric drawing with support and loop dimensions are drawn.
- Movements of the pipe at different points are evaluated
- Pipe Supports location, its types and the forces acting on it are found out for optimum design of pipe rack and support.

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SOLAR PAVEMENT

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***Abstract*— A solar pavement is a series of structurally engineered solar panels that are driven upon. The idea is to replace current petroleum-based asphalt roads, parking lots, and driveways with solar road panels and piezoelectric crystals that collect energy to be used by homes and businesses purposes, and ultimately to be able to store excess energy in alongside the solar pavement. Thus renewable energy replaces the need for the current fossil fuels used for the generation of electricity, which cuts greenhouse gases and helps in sustainable development. Years ago, when the phrase "Global Warming" began gaining popularity, we started batting around the idea of replacing asphalt and concrete surfaces with solar panels that could be driven upon. Our current power grid is based on centralized power stations. Distribution of power is handled through transmission lines(overhead and underground), relay stations, and transformers. When a line goes down (lighting, wind, tress, utility pole hit by car, etc.), everyone on the wrong end of the line loses power until the damage is repaired. If a power station goes down, an entire section of the country goes dark. The Solar pavement on the other hand, replaces all current centralized power stations including coal- and nuclear-powered electricity generation plants. Also in india road accidents are increassing day by day. As a solution for this we are introducing solar pavement. Our long range goal is to cover all concrete and asphalt surfaces that are exposed to the sun with Solar Road Panels. This will lead to the end of our dependency on fossil fuels of any kind. We're aware that this won't happen overnight. We'll need to start off small: driveways, bike paths, sidewalks, parking lots, playgrounds, etc.**

Keywords: Solar energy, photoelectric effect.

I. INTRODUCTION

Elimination of internal combustion engines, which would now be feasible with the Solar Pavement, would wipe out most of the rest of the causes of greenhouse gases. There are many other features, including wildlife preservation, the elimination of impervious surfaces, law enforcement, DUI detection, counter-terrorism, etc. An intelligent highway infrastructure and a self-healing decentralized power grid that will eliminate our need for fossil fuels and also it will lead to less invest in antiquated technology viz asphalt and overhead power lines. As the day by day the price of petroleum products are getting huge hike & resources are very less there will be no longer feasible material such as asphalt for our road surfaces. When Solar Pavement Panels are refurnished, the solar cells will be upgraded to newest technology, which will allow keeping up with population growth and increased energy needs. The Solar pavement helps to increase the electric energy generation as well as the make the nation pollution free. We can increase the use of battery vehicles instead of petrol and diesel vehicles. The Solar Pavement produces clean, renewable energy. Thus we can save this world, for our next generation. technologies than conventional petroleum reserves, but may become economically visible in the near future. The concept of compressed air vehicle (CAV) will definitely give a solution to problems that are en-countered by using fossil fuels. Developing an engine using this technology would give technical as well as economic benefits.

II. COMPONENTS USED

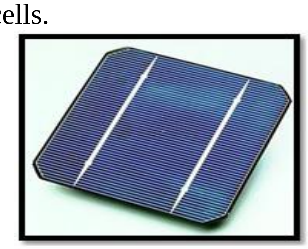
2.1 SOLAR CELL

A solar cell or photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels. Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photodetector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity. Solar panel refers either to a photovoltaicmodule, a solar hot water panel, or to a set of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure. A PVmodule is a packaged, connected assembly of solar cells. Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

The operation of a photovoltaic (PV) cell requires 3 basic attributes:

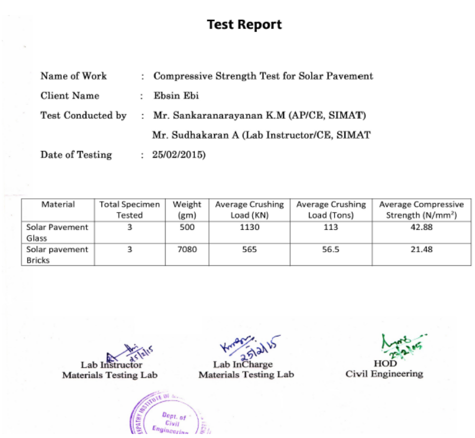
1. The absorption of light, generating either electron-hole pairs.
2. The separation of charge carriers of opposite types.
3. The separate extraction of those carriers to an external circuit.

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Mainstream materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Due to the increased demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.A photovoltaic system (informally, PV system) is an arrangement of such cells designed to supply usable electric power for a variety of purposes, using the Sun (or, less commonly, other light sources) as the power source. Multiple solar cells in an integrated group, all oriented in one plane, constitute a solar photovoltaic panel or solar photovoltaic module. Photovoltaic modules often have a sheet of glass on the sun-facing side, allowing light to pass while protecting the semiconductor wafers. Solar cells are usually connected in series in modules, creating an additive voltage. Solar cells are typically named after the semiconducting material they are made of. These materials must have certain characteristics in order to absorb sunlight. Some cells are designed to handle sunlight that reaches the Earth's surface, while others are optimized for use in space. Solar cells can be made of only one single layer of light-absorbing material or use multiple physical configurations to take advantage of various absorption and charge separation mechanisms. Solar cells can be classified into first, second and third generation cells.



III. RESULTS AND DISCUSSIONS

We're aware that this won't happen overnight. We'll need to start off small driveways, bike paths, patios, sidewalks, parking lots, playgrounds, etc. This is where we'll learn our lessons and perfect our system. Once the lessons have been learned and the bugs have all been resolved, we'll plan to move out onto public roads. Many things have changed since then including the size of our panels. Our initial panels were 280 x 160mm. We made the solar pavement bricks and done the Compressive strength test. The result shows that an load up to 110 tons can be passed over the brick. We can use M80 concrete mix to get maximum load capacity. We are using toughed glass to get its maximum strength, also the glass is shatter proof. So we can directly use the solar pavement bricks for the road construction.



Test Report

Name of Work : Compressive Strength Test for Solar Pavement
Client Name : Ebsin Ebi
Test Conducted by : Mr. Sankaranarayanan K.M (AP/CE, SIMAT)
Mr. Sudhakaran A (Lab Instructor/CE, SIMAT
Date of Testing : 25/02/2015)

Material	Total Specimen Tested	Weight (gm)	Average Crushing Load (KN)	Average Crushing Load (Tons)	Average Compressive Strength (N/mm^2)
Solar Pavement Glass	3	500	1130	113	42.88
Solar pavement Bricks	3	7080	565	56.5	21.48

Lab Instructor
Materials Testing Lab

Lab InCharge
Materials Testing Lab

HOD
Civil Engineering

Tested Specimen after compression test

IV. CONCLUSIONS

We can't wait any longer to find a replacement for oil, which is rapidly disappearing. Our dependency on oil has long been a matter of national security and we don't want to wait until it's gone to decide what to do next. We have the technology to solve this Problem in a relatively short period of time, which may be all we have left. In developing counties the major part of the geographical area is to be explored in terms of road connectivity. So instead of implementing the higher targets roads to be developed per day such countries can reduce the target and develop solar pavement so they could improve economy with infrastructure. One of the great features of the Solar pavement Panel is that much of it can be reused. Some components like the solar cells, capacitors, and LEDs will wear out and have to be replaced, but much of the panel is reusable. If we began manufacturing today with 18.5%efficient solar cells, and the panels lasted 20 years before the need for refurbishing, the latest (20 years from now) efficiency solar cells would be installed and the same Solar pavement Panel would produce even more power than before. This will allow the Solar pavement to keep up with the increase in electricity demand over the years. In addition, the Solar pavement replaces our current aging power grid. The Solar pavement carry power - not froma centralized point like a power station, but from the power-producing grid itself along with data signals (cable TV, telephone, high-speed internet, etc.) to every home and business connected to the grid via their driveways and parking lots. In essence, the Solar pavement becomes a conduit for all power and data signals. Final thoughts: elimination of the fossil fuel plants will take away about half of the CO_2 emissions that are known to be contributing to the climate crisis. Providing a means to recharge all-electric cars anywhere along the roadside or even while driving will open the door for the elimination of the internal combustion engines, which account for most of the other half of the CO_2 emissions. With internal combustion engines now obsolete, our dependency on oil - foreign or domestic - will finally be over with.

IV ADVANTAGES

Create an intelligent, secure highway infrastructure that pays for itself.
Create an intelligent, secure, decentralized, self-healing power grid.
Eliminate the need for coal-fired or nuclear power plants.
End our dependency on oil and other fossil fuels (oil, coal and natural gas).
Cut our nation's greenhouse gas emissions by over 50%.
Provide safer driving conditions.
Snow & ice management.
Traffic management.
Wild life protection.
National security.
Usage of recycled material

V CONCLUSIONS

The technology of compressed air engine is not new. In fact, it has been around for years. Compressed air technology allows for engines that are both non-polluting and economical is still our project compressed air powered engine may not be the first of its kind. It certainly needs refinements. Though poor in efficient is still attractive as renewable source of energy is the power source. It is a viable option for clean and efficient local transportation.

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FLUID DYNAMICS CHARACTERISTICS OF NANOFLUIDS IN A RECTANGULAR DUCT

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***Abstract*--- This paper is a numerical investigation of fluid dynamics characteristics of nanofluids in a rectangular duct. Al_2O_3 and CuO are used as nanoparticles while water has been used as base fluid. The analysis is being carried out with three different diameters – 10nm, 50nm and 100 nm, particle volume concentrations of 0% to 5% and Reynolds number Re = 500. The variation of physical properties of base fluid is taken as temperature dependent. The velocity of nanofluids increases as the diameter is increased. The effect of nanoparticle volume concentration and size on wall shear stress is also analysed. This shows that wall shear stress increases with increase in particle volume concentration as well as particle size.**

Key words--- Nanofluids, Laminar flow, Rectangular duct, Numerical, Control volume, Two-phase, Convective heat transfer

I. INTRODUCTION

Cooling is one of the most important technical challenges industry faces today. With the demand for faster and smaller devices thermal loads increase and conventional cooling methods that use extended surfaces (fins, micro channels, etc.) are reaching their limits. Therefore there exists a pressing need to improve heat removal technologies. Convective heat transfer can be enhanced passively by changing flow geometry, boundary conditions or by enhancing thermal conductivity of fluid. Various techniques have been proposed to enhance the heat transfer performance of fluids. Researchers have also tried to increase the thermal conductivity of base fluid by suspending milli or micro sized solid particles in fluids, since the thermal conductivity of solid is two to three orders of magnitude higher than that of the liquids. However, adding micrometer size particles cause several problems arising out of sedimentation, clogging, pressure drop and erosion of channels, pipes and conduits. Modern nanotechnology provides new opportunities to process and produce materials with crystal sizes on the order of nanometers. Fluids with nanoparticles suspended in them are called nanofluids. Nanofluid can be defined as engineered colloids made of a base fluid and nanoparticles (1-100 nm). The term was proposed in 1995 by Choi of the Argonne National Laboratory; U.S.A. Compared with suspended conventional particles of milli or micro meter dimensions, nano fluids show better stability, high thermal conductivity with negligible pressure drop Successful applications of nanofluids would support the current trend toward component miniaturization by enabling the design of smaller but higher-power heat exchanger systems.

The heat transfer enhancement using nanofluids has been proved by most of the literatures even though the increase in heat removal rate varies from study to study. A 15% increase in Nusselt number Nu by using CuO–water nanofluid with particle volume concentration of $\varphi = 1\%$ has been reported by [2] while an increase of 4.57% with Reynolds number Re = 100 has been reported by [1]. When Re is increased from 100 to 1500, percentage increase in Nu increased to 5.92%. They have identified a maximum of 34.83% increase in Nu by using CuO–water nanofluid with $\varphi = 5\%$ and Re = 500. They have used homogeneous model for their study. While modeling the same nanofluid by two phase method increased Nu from 34.83% to 67.76% with $\varphi = 5\%$ and Re = 500. This has been reported by [3]. They have also identified an increase of 30% in heat transfer coefficient when particle diameter decreased from 100 nm to 30 nm. These results show that modeling nanofluid as a single phase fluid lead to lower increase in heat transfer. This study aims to formulate the transport equations considering nanofluid as a homogeneous fluid using two - dimensional finite volume method. By using the formulated equations, the laminar flow characteristics of different nanofluids through a rectangular duct are analysed. The nanofluid is a mixture of water as the base fluid and Al2O3 and CuO as nanoparticles with different volume concentrations and particle sizes. The variation of physical properties of base fluid is taken as temperature dependent.

II. RESULTS AND DISCUSSIONS

Results are presented for Reynolds number Re = 500, φ varying from 0% to 5% and three different particle diameters of 10 nm, 50 nm and 100 nm. The nanofluid has been considered as a homogenous mixture which enters the duct with uniform temperature and velocity.

A grid independence study has been carried out and the result is shown in Fig. 2. From this 40x40 grid structure has been adopted.

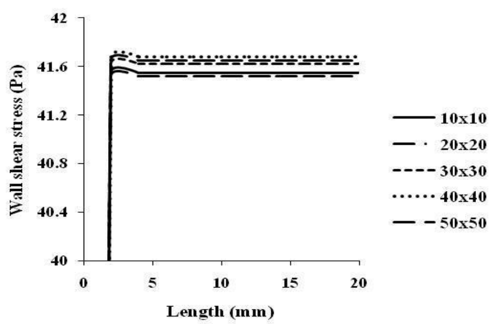

Fig. 1 Grid independence study

The velocity profile for pure water flow obtained in this study and the developing flow profile given by Shirley et al. (2006) are compared in Fig. 3. This shows that the velocity profile obtained by coding is in accordance with standard profile.

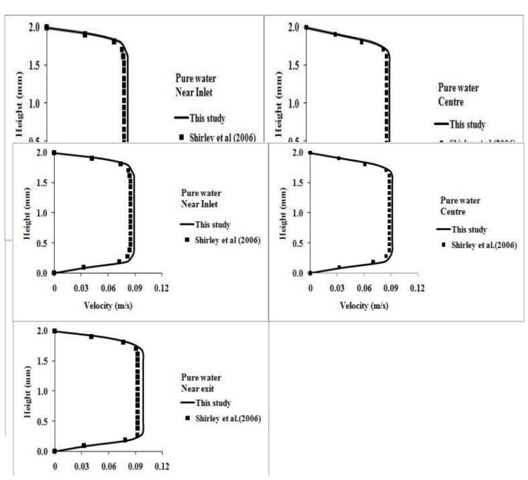

Fig. 2 Comparison of velocity profile for pure water with available literature

The effect of nanoparticle diameter on velocity profile for alumina-water nanofluid is shown in Fig. 4. This shows that the velocity is increasing as the diameter is increased since the larger particles offer less resistance to flow.

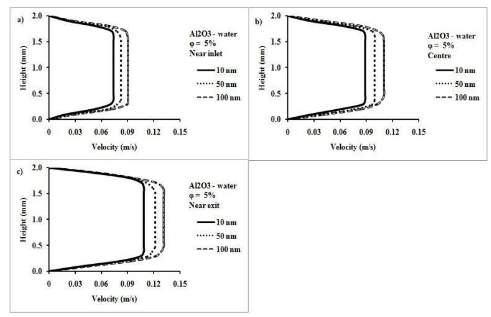

Fig. 3 Velocity profile for Alumina-water nanofluid

The effect of nanoparticle volume concentration and diameter on wall shear stress has been analysed and the result shows that wall shear stress increases with the increase in volume concentration and decrease in particle diameter

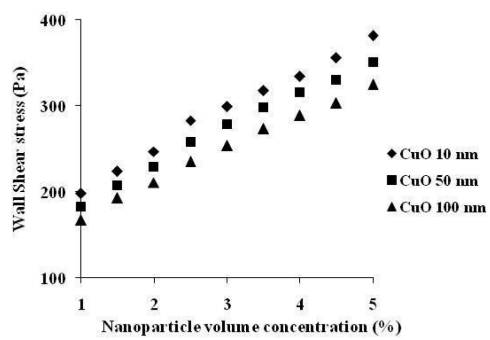

Fig. 4 The effect of nanoparticle volume concentration and diameter on wall shear stress for CuO-water nanofluid

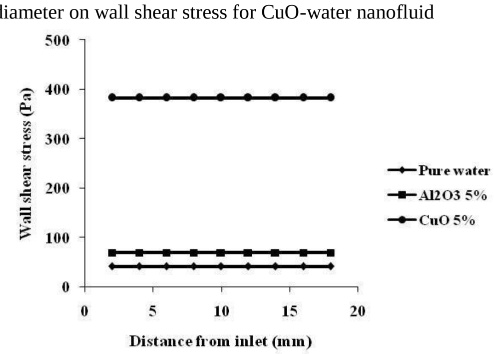

Fig. 5 Comparison of different nanofluids with pure water

III. CONCLUSION

The velocity profiles for nanofluids flow with particle diameters of 10 nm, 50 nm and 100 nm, particle volume concentration ϕ = 5% and Re = 500 are analysed at near inlet portion, at the centre portion of the duct and at near exit portion. The velocity of nanofluids increases as the diameter is increased. At near inlet portion of the duct, velocity increases by 22.22% for alumina-water nanofluid by increasing particle diameter from 10 nm to 100 nm. The effect of nanoparticle volume concentration and size on wall shear stress is also analysed. This shows that wall shear stress increases with increase in particle volume concentration as well as particle size. The CuO-water nanofluid has higher value of shear stress than Al2O3-water nanofluid since CuO has high viscosity than Al2O3.The percentage increase in wall shear stress when concentration is changed from 0% to 5% is 75% for Al2O3-water nanofluid with particle size 10nm. For CuO-water very high increase is noticed due to high viscosity of CuO. The percentage increase in wall shear stress when the diameter is reduced from 100 nm to 10 nm is 17.53% with particle volume concentration 5% for CuO-water nanofluid.

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“FLAPPING WING MAV (FWMAV)”

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Abstract— **The growing importance of Flapping Wing MAV Aerial Vehicle design has kindled research interests in developing countries around the world. The aim was to build an Flapping Wing Micro Air Vehicle “FWMAV” with very less wing loading which can be used for surveillance purposes. An experimental approach adopting trial and error method was used in fabrication. The weight factor plays a major role and wing loading needs to be as low as possible. The FWMAV involved a tail rotor for controlling the yawing moments. The FWMAV achieved commendable flight and endurance after few trials. Here we explain how flapping micro air vehicles (MAVs) can be designed at from bird to insect size. The common believe is that micro fixed wing airplanes and helicopters outperform FWMAV at bird scale, Here we present our experience with designing and building micro flapping air vehicles that can fly both fast and slow, hover, and take-off , and we present the scaling laws and structural wing designs to miniaturize these designs to insect size. Next we compare flapping, spinning and translating wing performance to determine which wing motion results in the highest aerodynamic performance at the scale of hummingbirds, house flies and fruit flies. Based on this comparison of hovering performance, and our experience with our flapping wing MAV, we find that flapping MAVs are fundamentally much less energy efficient than helicopters, even at the scale of a fruit fly.**

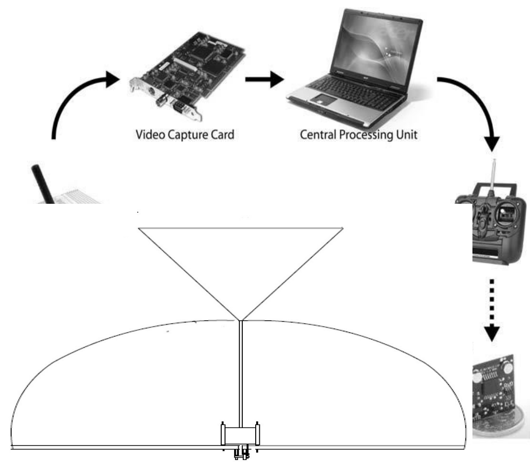
Keywords: Micro Air vehicles, Aerodynamics.

I. Introduction

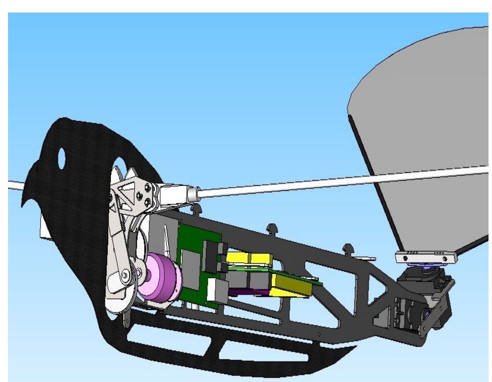
Natural fliers like birds and insects have captivated the minds of human inventors through history. The ease and grace with which they take to the air vastly surpasses the state of the art in aircraft and their control systems. This is not to say that modern aircraft designs are ineffective, they are excellent in many respects. Propellers and turbines are very efficient methods of producing thrust and airfoils efficiently produce lift. A Boeing 747 achieves a dimensionless cost of transport (energy used divided by weight times distance) of 0.1, equivalent to a soaring albatross, and does it with amazing reliability, but it will never match the maneuver ability of the albatross.

The problem mirrors legged versus wheeled locomotion well. Wheels provide a stable, easy to analyze, and very efficient way of getting around with the sacrifice of a large amount of agility. Legs are notoriously difficult to control and current implementations are energy inefficient [2] and flapping wing flight parallels this well. The unsteady fluid dynamics of flapping wings are poorly understood and it’s difficult to get an ornithopter (the term used henceforth to refer to a flapping wing vehicle) to maneuver as desired. Interest in the design and control of ornithopters has grown in recent years as interest has grown in the area of Micro Aerial Vehicles or MAVs. These small flying machines have struck the imaginations of many as ideal platforms for a variety of tasks including systems monitoring and surveillance where a swarm of tiny agents would be unobtrusive and have better access to confined areas than larger flying vehicles . This thesis covers two years of work on the Phoenix ornithopter project, a 1.8 meter wingspan flapping wing flying robot, picking up from just after proof of concept work performed at the lab. From that point on two hardware revisions were produced of the Phoenix, one in summer 2007 and one in summer 2008. In the time between these summers flight testing and analysis was performed. Sustained steady level flight under computer control was finally achieved in August 2008.

II FLAPPING FLIGHT RESEARECH REVIEW



Previous to MAV research, biologists have devoted tremendous effort to understand how animals fly by flapping wings. Insects, birds and bats represent three distinct groups of natural fliers. Insects are the most abundant in nature: there are more than one million different species estimated and over 9000 new species are discovered each year..Their flight performance has been proven by natural selection :their capabilities to escape from predators, to search and hunt for food and to successfully reproduce. Their flight with complicated kinematics and thin Birds, on the other hand, represent the evolved reptile descendents from dinosaurs.



2.2 SCHEMATIC REPRESENATION

I. CONCLUSIONS

In this project the case for the construction of a large scale or helicopter suitable for control systems research is motivated. Performance and weight constraints imposed by the computers and sensors desired onboard make it difficult to work with the smaller platforms currently available, let alone micro UAVs currently in development. In order to work with the dynamics and controls of a flapping wing flying vehicle while these future targets are currently in development as called up version has been designed and constructed. With its larger payload capacity it's capable of carrying a fully equipped computer and high-end inertial measurement unit with the option of future additions of GPS or other more exotic sensors.

The ornithopter was designed from the ground up with the needs of researching mind. All components have been designed to be as light weight and high performance as possible so as to maximize payload capacity and are intended to fail inpredicable and field repairableways.

Manual and initial autonomous flight tests have been conducted and show that the ornithopter is capable of sustained flight with a full load of electronics and can be stabilized by simple controllers in common use in aircraft. Flight tests have also shown that the planned points of failure work as expected and allow repairs to be quickly accomplished in the field.

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