DESIGN AND ANALYSIS OF A FIVE HOLE PRESSURE PROBE USING DIFFERENT MATERIALS

[1]G.V.Saikiran, [2]Dr.N.Seshaiah
[1]PG Scholar,[2]Professor ,Dept. Of Mechanical Engineering
[1,2]PBR Visvodaya Institute Of Technology And Science, Kavali, Nellore (Dt),A.P

ABSTRACT:

Five-hole pneumatic pressure probes are utilized to do the enduring state measurements of three parts, for example, velocity, inflow angles, static and all out pressures all the while for a point in a flow field. Flow measurement is significant. The nature of the flow impacts the plan and execution of the different streamlined parts like blowers, blowers, fans and turbines and so forth. Increasingly more research work is accessible in the field of flow measurement. Numerous procedures had been produced for measurement of flow like LDV, PIV and Hot wire anemometry. Every one of these systems are viable yet are expensive. In the present work, alignment of five hole pressure test is done. Writing survey uncovers that the flow measurement by test is extremely compelling since it can quantify flow parameters, for example, static and stagnation pressure, velocity of liquid stream. The test is exposed to realize flow field for adjustment. The velocity of the liquid stream is kept up at 25 m/sec and the test is adjusted for various yaw and pitch angles. In this work, planning of test withstanding pressure esteems, misshapenness, stress and strains are broke down for various composite materials in ANSYS. Looking at the aftereffects of every material settle better withstand materials .

I.INTRODUCTION

Pressure probes can be utilized to quantify the stagnation pressure, static pressure, and the flow point inside a liquid stream. When planning a pneumatic test that will be utilized in flow measurements, the impacts of blockage, recurrence reaction, pressure hole size and geometry, the nearby Mach and Reynolds numbers and the general size of the wonders under scrutiny must be tended to. All in all, better precision is reachable if littler probes and transducers are utilized. In spite of the fact that this generally implies the mechanical respectability might be undermined, the reaction times are longer and that there are more prominent issues with sullying in messy conditions. The impacts of blockage become most noteworthy when the flow is compressible. For instance, embeddings a test into a gas stream where the undisturbed Mach number is 0.9 will make the flow gag if the flow zone is decreased by even 1 percent. In supersonic flow, a test stem can make a withdrew flow stun that lies far upstream of the test tip.

a. Static Pressure Probes

Static pressure probes are at times used to get static-pressure measurements in the flow instead of at the limits. A static pressure test may essentially be a round and hollow cylinder put parallel to the flow with static tappings situated on its body. An assortment of nose setups can be utilized on the static cylinders. A portion of these probes are known as wedge probes, cone probes, plate probes, and Prandtl cylinder probes. For these, the static pressure readings acquired are affected by various factors similarly as on account of the divider static tapings.

Since the exact utilization of static pressure probes necessitates that the flow is parallel to the hub of the test, their utilization is best confined to flow fields where the angles and disturbance are little. These conditions are once in a while satisfied in turbo hardware research apparatuses aside from at the bay to the test areas.

Here, the static cylinders are regularly joined with stagnation pressure tubes all together that the stagnation pressure and flow velocity can be resolved.

b. Stagnation Pressure Probes

On the off chance that a half-open cylinder is put with the goal that its open end faces the up and coming flow stream, at that point the stagnation pressure of the flow stream can be estimated by then (Pitot, 1732). Definitely, the test will bother the flow close to the measurement point yet in uniform unfaltering flow, the stagnation happens quickly in the region of the nose so warmth move and frictional impacts (Hurd et al) can be overlooked and practically any size and type of cylinder will effectively gauge the stagnation pressure furnishing its hub is lined up with the flow bearing. Be that as it may, if the test is in a precarious stagnation-pressure slope field, for example, happens inside the limit layer then the streamlines are avoided toward the locale of lower velocity. This avoidance makes the test demonstrate a stagnation pressure higher than that at the test focus area.

At the point when the stagnation-pressure test pivot isn't parallel to the flow course a blunder in the measurement will result. The level of mistake is dictated by the nose state of the test. Chamber type probes have almost no resistance to misalignment. Kiel probes can endure varieties in flow point to 45 degrees. A profoundly inclined Pitot test can stay harsh toward inside one percent of the dynamic pressure over a point of as much as 25 degrees.

Pitot probes, alongside being impacted by a variety in flow edge, disturbance, pressure inclinations, and test nose geometry are likewise influenced by Mach number and by test bolster body geometry and by changes in the flow field (Grant).

c. Flow Direction Measurement

Alters in flow course in turbo machines are straightforwardly identified with the work trade. Precise information of the flow bearing is consequently significant. Pressure probes are delicate to flow course are utilized for this reason. The probes are generally adjusted to decide the impact of their direction to the flow on the measurement. The alignment is regularly performed in a free-fly framed by setting a spout at the exit of a huge plenum chamber. To decide the impacts of pitch and yaw, the test is pivoted about its tomahawks. The pitch and yaw angles are characterized in the figures (beneath).

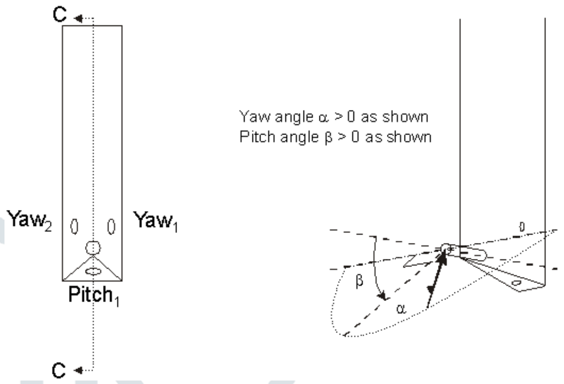

Fig 1: Pitch and Yaw Angles

The most widely recognized of the pressure touchy direction probes are the cobra, the wedge, the five-hole and round and hollow probes some of which are demonstrated as follows. In these plans a couple of sets of evenly built pressure tapings are slanted as for the flow stream. At the point when just one sets of pressure tappings is utilized, two-dimensional flow direction measurements are obtained. Two sets are utilized for three-dimensional measurements.

Flow direction can be dictated by both of two techniques. The first is the invalid technique. With this technique, the test is mounted in an actuator, and the flow edge dictated by adjusting the pressure perusing acquired on the two inverse static tappings. With the subsequent strategy, the test is mounted in a fixed position and the individual static pressures estimated. By methods for earlier alignment, the flow direction can be derived. The last strategy must be utilized when the test can't be pivoted while keeping up the tip at a fixed spatial area.

The cobra test is normally developed with three cylinders patched together one next to the other, looking into the gas stream. It is in this way used to decide just one flow point (regularly the yaw edge). The middle cylinder is utilized for stagnation pressure measurement; the two outside cylinders have their forward warns cut at 45 degrees. Each of the three cylinders lie in single plane. The cobra test is generally utilized for flow point examines in view of its low blockage and relative simplicity of assembling. It ought not be utilized to quantify the dynamic pressure or to surmise the static pressure, principally in light of the fact that the distinction in pressure between both of the side holes and the middle hole is a generally little part of the dynamic head.

The wedge test (see beneath) is a straightforward, tough, a few dimensional test that comprises of a triangular, kaleidoscopic test. Dissimilar to the cobra test, the wedge test can be utilized to gauge the static pressure. It has been made with different angles, the most prominent being between 8 deg. to30 deg. As far as possible to the helpful working scope of Mach numbers is a component of the point and the flow pitch edge. It is lower for probes with more prominent included angles. Smaller wedges are, anyway less delicate to flow point yet they improve exactness as far as static pressure measurement.

Five-hole probes are an advancement of the two-hole Conrad and three-hole Cobra probes. They are utilized to gauge the pitch and yaw angles of the flow, the stagnation pressure or static pressure. Thusly, they give adequate information to completely indicate the velocity and pressure fields giving that the stagnation temperature thus, the thickness, is known. Not many turbo machine flow fields are not three-dimensional.

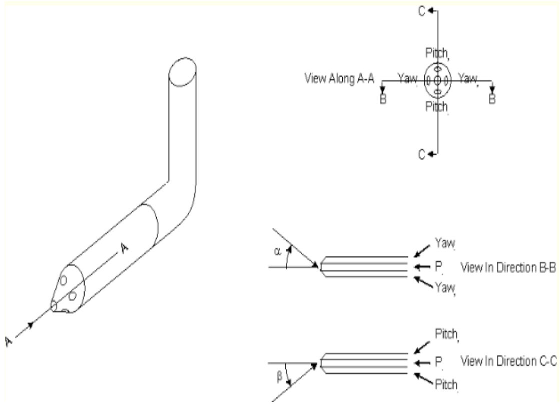

Fig 2: A 5-hole truncated cone probe

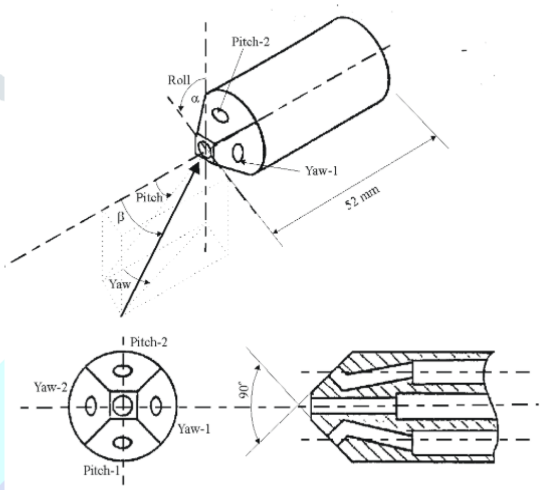

Fig 3: A 5-Hole Truncated Pyramid Probe

The figures above show typical five-hole probe geometries. Typically, the included angle of the probe nose varies between 60° and 120° . The greater the included angle, the less sensitive the probes are to the dynamic pressure but the more sensitive they are to changes in flow angle. In practice, an angle of 90° provides a reasonable compromise. All of these probes are remarkably insensitive to the effects of Mach number but some are sensitive to Reynolds number changes. The 5-hole truncated pyramid probe is least sensitive to changes in Reynolds number.

II.SELECTION OF COMPOSITE MATERIALS:

Now-a-days, composite materials are used in large volume in various engineering structures. Wide spread use of composite materials in industry is due to the good characteristics of its strength to density and hardness to density. The possibility of increase in these characteristics using the latest technology and various manufacturing methods has raised application range of these materials. We selected material and analyzed with these materials are mentioned below.

1. AISI 1065 Carbon Steel
2. Aluminum Silicon Carbide
3. Carbon Epoxy

a. AISI 1065 Carbon Steel:

Steels containing carbon as the major alloying element are called carbon steels. They may also contain up to 1.2% manganese and 0.4% silicon. Residual elements such as copper, molybdenum, aluminum, chromium and nickel are also present in these steels.AISI 1065 carbon steel is a high-carbon steel, which has high tensile strength and heat treatable.

b. Aluminum Silicon Carbide:

AlSiC-12, containing 63 vol.% of A 356.2 aluminum alloy and 37 vol.% silicon carbide. Its thermal conductivity is 170–180 W/m K. It is compatible with generally the same materials as AlSiC-10. Its density at 25 °C is 2.89 g/cm The aluminum matrix contains high amount of dislocations, responsible for the strength of the material. The dislocations are introduced during cooling by the SiC particles, due to their different thermal expansion coefficient.

c. Carbon Epoxy:

Carbon fiber fortified composites have remarkable mechanical properties. These solid, firm and lightweight materials are a perfect decision for applications where lightweight and predominant execution are significant, for example, segments for flying machine, car, rail and excellent buyer items. Composite materials are delivered by joining a fortifying fiber with a sap framework, for example, epoxy. This mix of fiber and pitch gives qualities better than both of the materials alone and are progressively being utilized as swaps for moderately overwhelming metallic materials. In a composite material, the fiber conveys most of the heap and is the significant supporter of the composite material properties. The sap moves load between strands, keeps them from clasping and ties the materials together. The range offered depends on composite sheets created by stacking carbon fiber textures one upon another and after that injecting the stack with gum under vacuum.

This process produces sheets with one smooth glossy resin rich side and the other rougher side showing the fabric weave detail. Carbon fibres are produced from polymer fibres such as polyacrylonitrile and from pitch. The initial fibre material is drawn under tension whilst it is heated to around 1000°C causing 2 dimensional carbon-carbon crystals (graphite) to be formed when hydrogen is driven out. The carbon-carbon chain has extremely strong molecular bonds and this is what gives the fibres their high strength.

III.MODELING:

A. Design Of Pressure Probes Using CATIA:

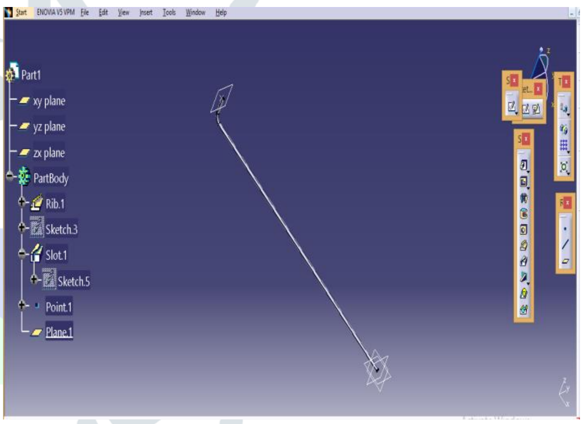

Fig 3. Design of Pressure Probes in CATIA

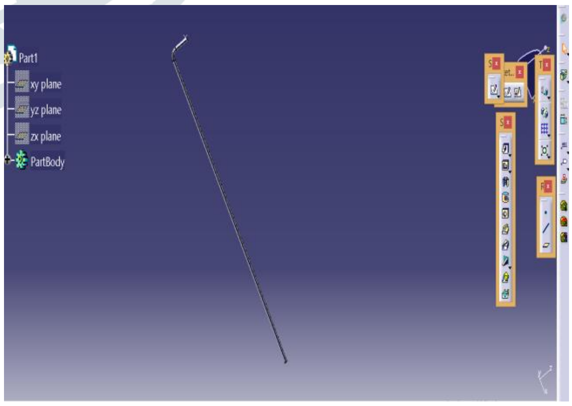

Fig 4: Final design of pressure probes in CATIA

B. ANALYSIS OF PRESSURE PROBES USING ANSYS:

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of userdesignated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand.

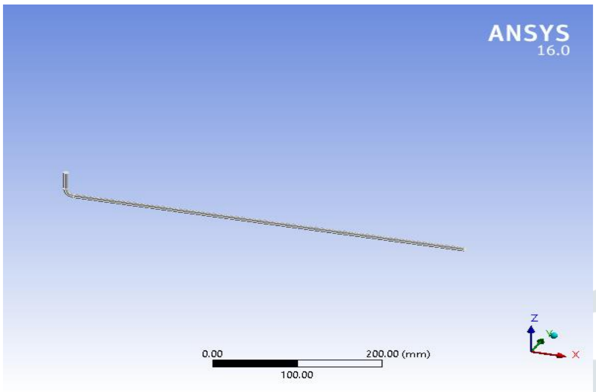

Fig 5.:Structural analysis in AISI 1065 Carbon Steel

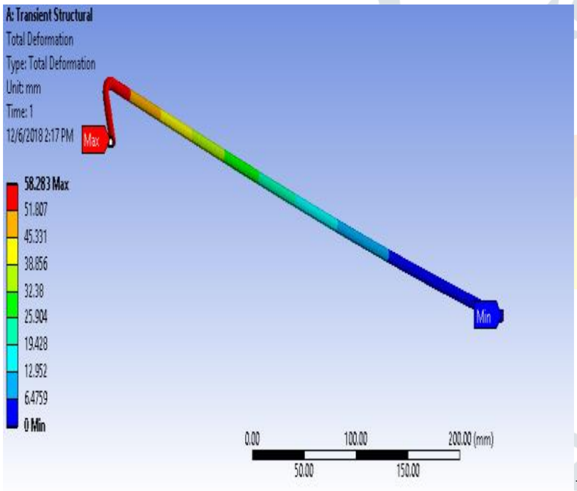

Fig 6:Total Deformation of Pressure Probe in :AISI 1065 Carbon Steel

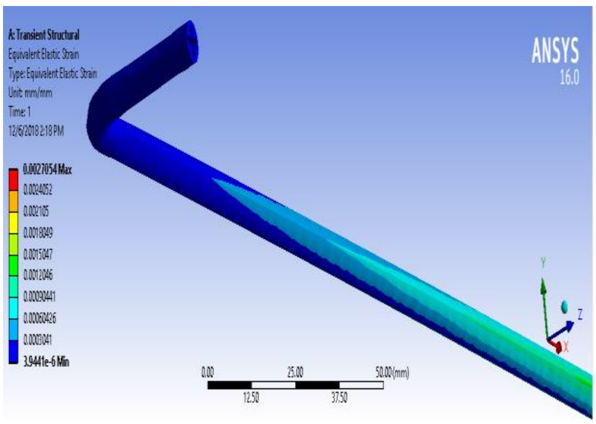

Fig 7: Equivalent Elastic Strain in AISI 1065 Carbon Steel

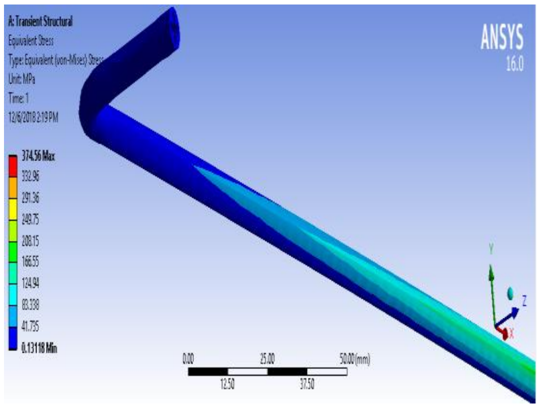

Fig 8: Equivalent Stress in AISI 1065 Carbon Steel

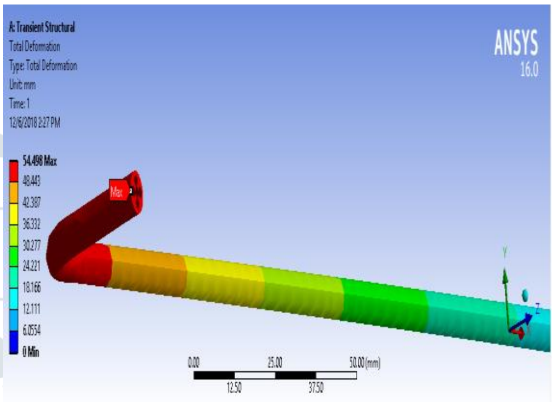

Fig 9: Total Deformation in ALUMINIUM SILICON CARBIDE

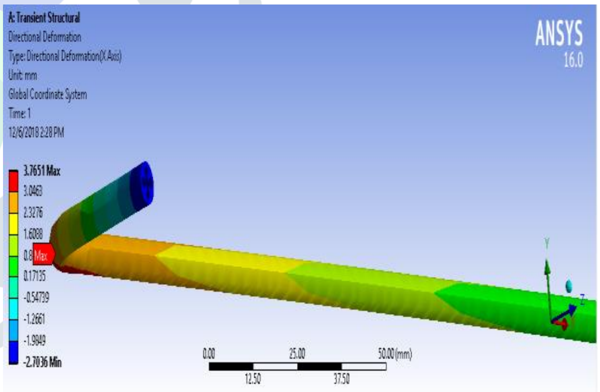

Fig 10: Direct Deformation in ALUMINIUM SILICON CARBIDE

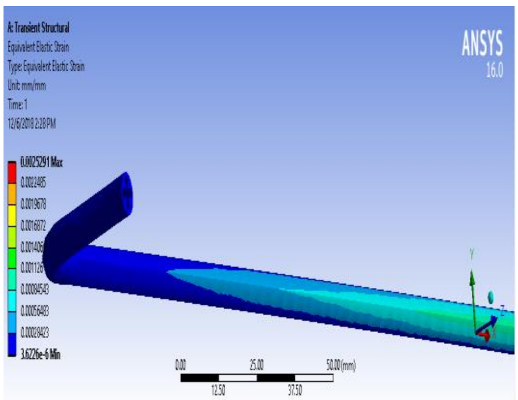

Fig 11: Equivalent Elastic Strain in ALUMINIUM SILICON CARBIDE

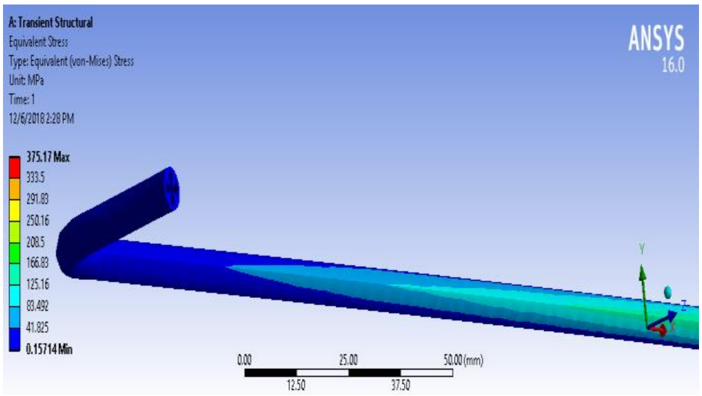

Fig 12: Equivalent Stress in ALUMINIUM SILICON CARBIDE

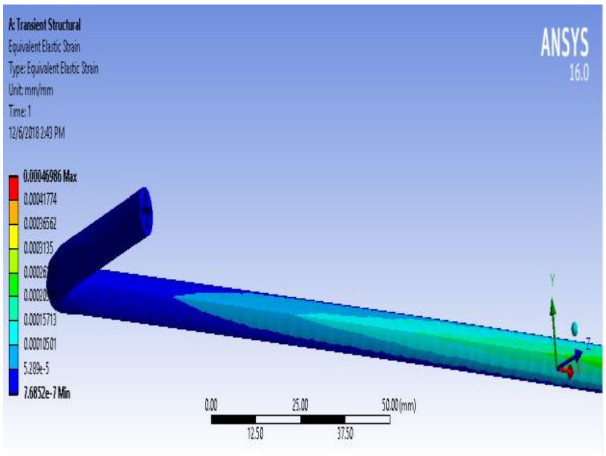

Fig 15: Equivalent Elastic Strain in CARBON EPOXY

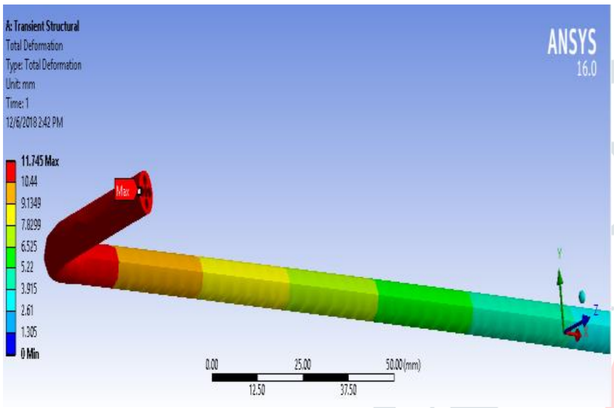

Fig 13. Total Deformation in CARBON EPOXY

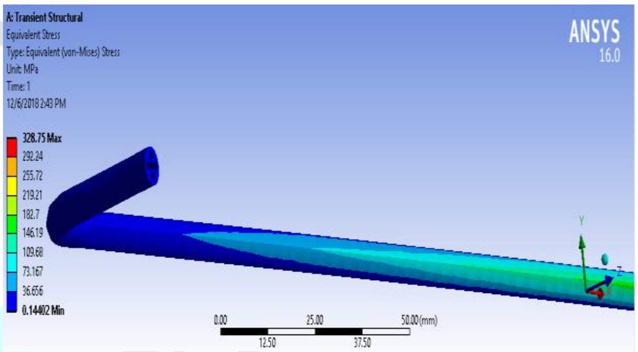

Fig 16: Equivalent Stress in CARBON FIBR

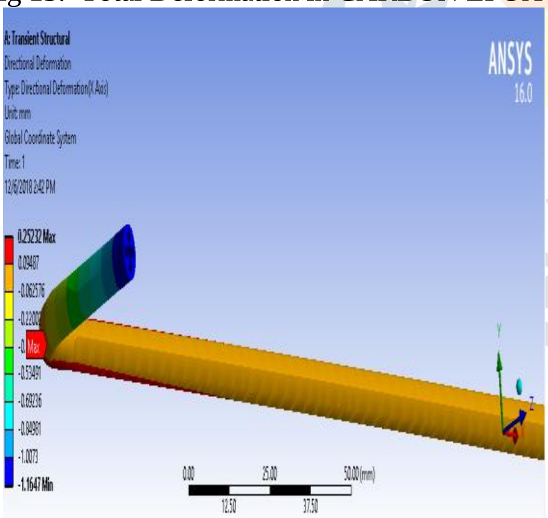

Fig 14 Directional Deformation in CARBON EPOXY

IV. RESULTS AND COMPARISON:

In we designed and analyse the Pressure probe by using the different materials we get the Total Deformation, Direct Deformation , Equivalent Elastic Strain , Equivalent Stress.

AISI 1065 carbon steel

AISI 1065 carbon steel	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*
Results				
Minimum	0. mm	-2.6342 mm	3.9441e-006 mm/mm	0.13118 MPa
Maximum	58.283 mm	4.2715 mm	2.7054e-003 mm/mm	374.56 MPa

Aluminum silicon carbide

Aluminum silicon carbide	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*
Results				
Minimum	0. mm	-2.7036 mm	3.6226e-006 mm/mm	0.15714 MPa
Maximum	54.498 mm	3.7651 mm	2.5291e-003 mm/mm	375.17 MPa

Carbon epoxy

Aluminum silicon carbide	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*
Minimum	0. mm	-1.1647 mm	7.6852e-007 mm/mm	0.14402 MPa
Maximum	11.745 mm	0.25232 mm	4.6986e-004 mm/mm	328.75 MPa

By observing above results:

- Modeling and analysis of pressure probes has been done in catia software.
- Simulation has carried out on pressure probes, with different materials respectively.
- Highest deformation is obtained for 58.283 mm AISI 1065 carbon steel, lowest deformation for 11.745 mm Carbon epoxy.
- High Equivalent Elastic Strain is obtained 2.7054e-003 mm/mm for obtained for AISI 1065 carbon steel, lowest deformation for 4.6986e-004 mm/mm Carbon epoxy
- For 375.17 MPa High Equivalent Stress is obtained Aluminum silicon carbide . lowest Equivalent Stress is 328.75 MPa Carbon epoxy .

V.CONCLUSION:

The paper attempts to investigate a five hole pressure normalization techniques in combination with three data reduction techniques reported in the multi-hole pressure probe literatures. A particular set of calibration data for a five-hole probe was generated experimentally and used the same data set for analyzing the every possible combination of pressure normalization and data reduction techniques. An additional pressure reduction technique is also proposed in this paper, where the effect of centre-hole pressure is included in all defining pressure normalization parameters. The conclusion may be written as under:

- Modeling and analysis of pressure probes has been done in catia software.
- Simulation has carried out on pressure probes, with different materials respectively.
- Highest deformation is obtained for 58.283 mm AISI 1065 carbon steel, lowest deformation for 11.745 mm Carbon epoxy.
- High Equivalent Elastic Strain is obtained 2.7054e-003 mm/mm for obtained for AISI 1065 carbon steel, lowest deformation for 4.6986e-004 mm/mm Carbon epoxy
- For 375.17 MPa High Equivalent Stress is obtained Aluminum silicon carbide . lowest Equivalent Stress is 328.75 MPa Carbon epoxy .

REFERENCES

[1] S.J. Lien, N.A. Ahmed “An examination of suitability of multi-hole pressure probe technique for skin friction measurement in turbulent flow”, Journal of Flow Measurement and Instrumentation, Vol. 22, p 153–164, 2011.

[2] M. Yasar , O. C.Melda “A multi-tube pressure probe calibration method for measurements of mean flow parameters in swirling flows”, Journal of Flow

Measurement and Instrumentation, Vol. 9, p 243–248, 1998.

[3] “Wind Tunnel Calibration of 5-Hole Pressure Probes for Application to Wind Turbines”, National Renewable Energy Laboratory National Wind Technology

Center Golden, Colorado, U.S., May 1998.

[4] A. R. Paul, R.R. Upadhyay, A. Jain , “A novel calibration algorithm for five-hole pressure probe”, International Journal of Engineering, Science and Technology, Vol. 3, p. 89-95. 2011.

[5] Demetri Telionis, Yihong Yang , “Recent Developments in Multi-Hole Probe (MHP) Technology” , 20th International Congress of Mechanical Engineering

November 15-20, 2009, Gramado.

[6] A. J. Main, C. R. B. Day, G. D. Lock, M. L. G. Oldfield, “Calibration of a four-hole pyramid probe and area traverse measurements in a short-duration

transonic turbine cascade tunnel”, Experiments in Fluids Vol. l, p 302-311, 1996.

[7] .B. O. Johnson, “A Multi-Holed Pressure Probe Accuracy Analysis” Thesis report, University Of Florida, 2012.

[8] A.J. Pisasale, N.A. Ahmed , “A novel method for extending the calibration range of five-hole probe for highly three-dimensional flows”, Journal of Flow

Measurement and Instrumentation Vol. 13, p 23–30, 2002.

[9] H.K. Sung, J.K. Young, “Calibration of a Five-Hole Multi-Function Probe for Helicopter Air Data Sensors”, Journal of Aeronautical & Space Sciences, Vol.

10, Nov, 2009.

[10] C. Ostowari, W. H. Wentz , “Modified Calibration Technique of a Five-Hole Probe for High Flow Angles” Technical notes Experiments in Fluids, 1983.

[11] T. Jason, C. Cengiz , “Sub-Miniature Five-Hole Probe Calibration Using A Time Efficient Pitch And Yaw Mechanism And Accuracy Improvements”,

Proceedings of ASME Turbo Expo Turbine Technical Conference IGTI, Vancouver, Canada, June 6-10, 2011.

[12] T. Yasa, G. Paniagua, “Robust procedure for multi-hole probe data processing”, Journal of Flow Measurement and Instrumentation, Vol. 26, p46–54, 2012.

[13] S. Pezzotti, I. D. Juan, N.M. Vicente, P. Alejandro, “A wind tunnel for anemometer

calibration in the range of 0.2–1.25 m/s", Journal of Flow Measurement

and Instrumentation Vol.22, p 338–342, 2011.

[14] M.C. Gameiro, C.A.C. Pereira, J.M.S. Cruz , "On the use of a linear interpolation method in the measurement procedure of a seven-hole pressure probe",

Journal of Thermal and Fluid Science Vol. 28, p 1–8, 2003.

[15] F. Kevin, K. O Andrew, "Measurement and assessment of wind tunnel flow quality", Journal of Aerospace Sciences Vol. 44, p 315– 348, 2008.

[16] K.M. Arguelles Diaz , J.M. Fernandez, E. Blanco Marigorta, R. Barrio Perotti, "Head Geometry Effects on Pneumatic Three-Hole Pressure Probes For Wide

Angular Range" under Journal Flow Measurement and Instrumentation Vol. 21, p 330-339, 2010.

[17] Campbell J. F, Brandon J.M, "Calibration and flight results for the Ares I-X 5-hole probe", Journal of Acta Astronautica Vol. 68, p 1219–1227, 2011.

[18] Chue S. H, "Pressure Probes For Fluid Measurement", Prog. Aerospace Sci, Vol. 16, No. 2, p. 147-223, 1975.

[19] Dr.Louis, "A Multi Holed Pressure Probe Accuracy Analysis", University of Florida, spring, 2012.

[20] A.M.Yacom, "The Calibration and Application of Five Hole Probe", technical Memorandum, January 18, 1978.