Aerodynamic Design, Fabrication And Analysis Of Conical Probe

Dr. M. Senthil Kumar
Associate Dean,Prist University.
J.V.Murugalal Jeyan#1,Akhila Rupesh#2
Department Of Aeronautical
Satyam College Of Engineering And Technology,
Tamil Nadu,India
#1ASSISTANT PROFESSOR,
#2 UG SCHOLAR.

Abstract:A single cone probe of the yaw meter is considered and has undertaken analysis using NX NASTRAN. NASTRAN is a finite element analysis [FEA] program that was originally developed for NASA in the late 1960s under United States government funding for the Aerospace industry. The size and geometry of probes shows considerable variation according to their particular use and the number of flow quantities that are required at the same time. Fundamentally, however they all exploit the distribution of pressure which occurs over a body when it is immersed in a moving fluid. These pressure variations depend mainly on wind speed so that with suitable choice of body shape and location of perpendicular holes to serve as pressure tappings,a probe may be used to calibrate in a known wind tunnel; the relationship between pressure and wind speed can then be established over a range of speeds. The design of certain probes involving simple shapes, such as cylinders or spheres, can have some basis in theory, but the final design usually becomes a compromise aimed at minimizing the effect of factors such as de-attached waves, Mach number and stream turbulence

. ***Keywords*:**NASTRAN, Calibration, Cone Angle,Reynolds number, Conical probes

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I.Introduction

Conical probes have been used determination of the Mach number, total pressure and flow direction at supersonic speeds, their shape offering less interference to flow the hemispherical types. Although the inclusion of central pressure tapping precludes a sharp forward apex and the bow wave is detached at all times. The smaller the apex angle of the cone of the wider the range of mach over which a smooth pressure response to obtained. At the sa me time, sensitivity of the side holes to change in the flow direction increases with angle of the cone, so that some compromise is necessary.

Software Specification:

Solver:	NX NASTRAN
Analysis Type:	Structural
Solution Type:	SESTATIC 101 - Single Constraint

Linearity:Linear

The main steps followed in this analysis are as described below:

Name	Status	Environment	Description
a_catpart_sim1.sim		Default: NX NASTRAN+ Structural	-
a_catpart_fem1.fem		Default: NX NASTRAN Structural	-
CSYS	[Filter Off][Sort Off]	: :	
Groups	[Filter Off][Sort Off]	: :	
DOFSets	[Filter Off][Sort Off]	: :	
Regions	[Filter Off][Sort Off]	: :	
Fields			
Simulation Object Container	[Filter Off][Sort Off]	: :	
Load Container	[Filter Off][Sort Off]	: :	
Constraint Container	[Filter Off][Sort Off]	: :	
Solution 1	Active	NX NASTRAN Structural	-SESTATIC 101 - Single Constraint

II.MATERIAL DETAILS

The material used is Steel belonging to material category "METAL" and material type "ISOTROPIC".Intially the part is opened and meshed. The probe is meshed into 3016 elements and hence about 5760 nodes are present. After meshing the part is given constraints. For convience the cylindrical face of the probe is fixed. Then various pressures corresponding to various mach are applied individually to the pressure holes. Finally the part is solved and result is obtained.
Ratio [NU] is 0.298. Yield Strength is 129566 kPa. Ultimate Tensile Strength is 62001 kPa.

Mass Density of steel is 7.829e-006 kg/mm^3. Young's Modulus [E] is 2.0694e+008 kPa. Poisson's

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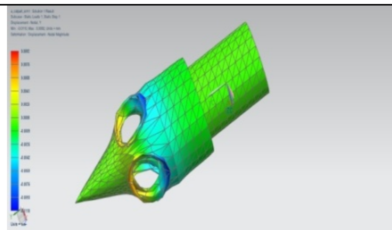
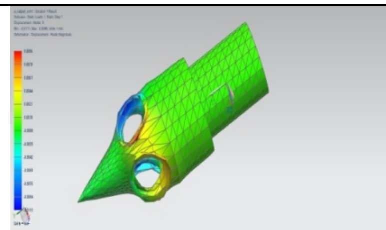
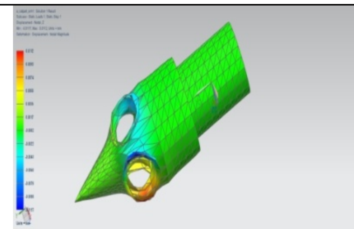
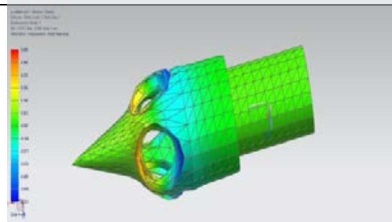
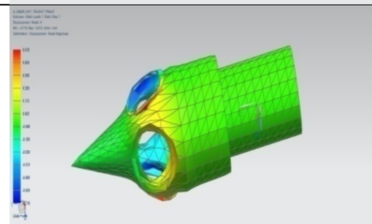
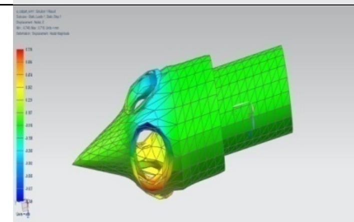
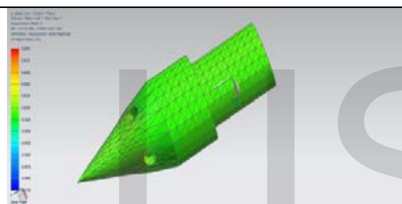
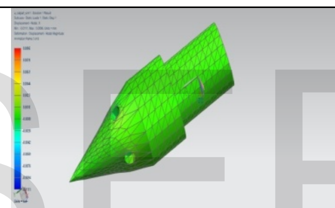
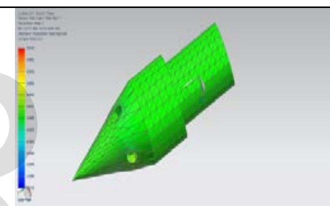
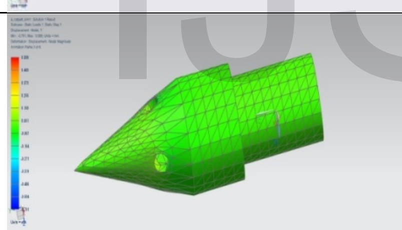
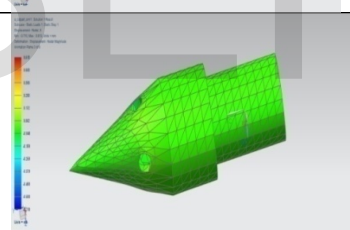
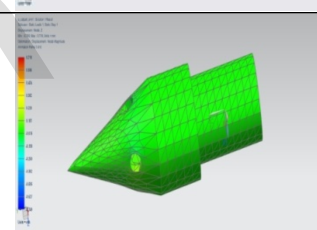
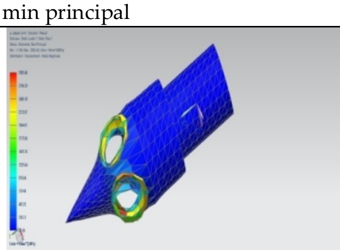
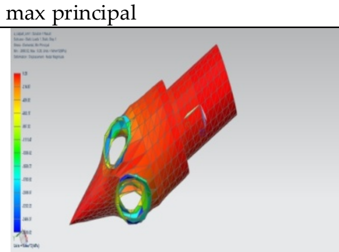
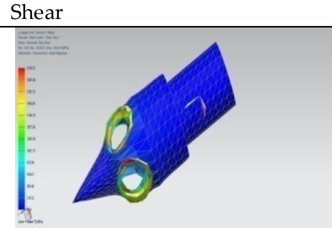
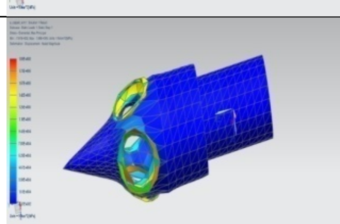
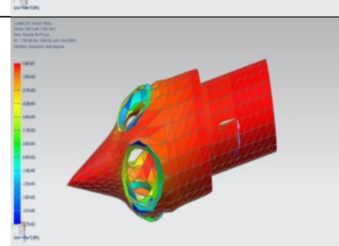
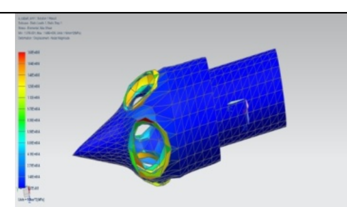
III.NASTRAN ANALYSIS SAMPLE RESULTS

TABLE I

Mach	Displacement [max][mm]		
	X	Y	Z
0.2			
1.6			
Mach	Displacement [min][mm]		
	X	Y	Z
0.2			
1.6			
Mach	Stress [max][KPa]		
	min principal	max principal	Shear
0.2			
1.6			

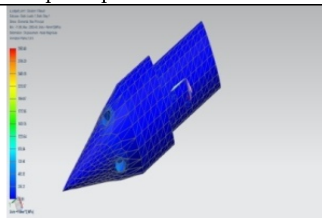
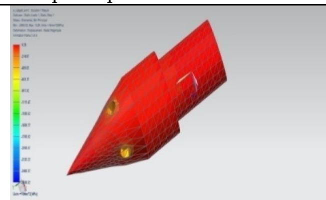
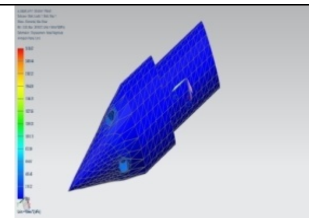
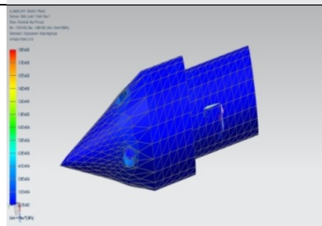
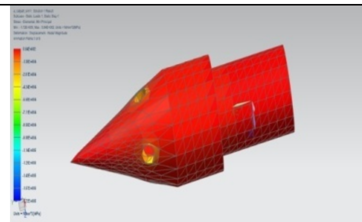
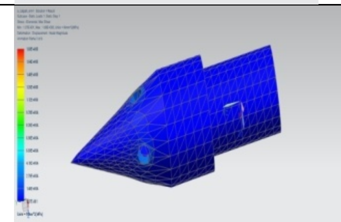
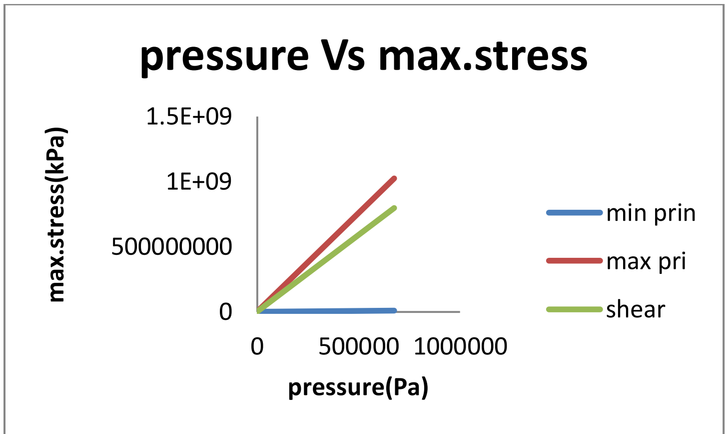
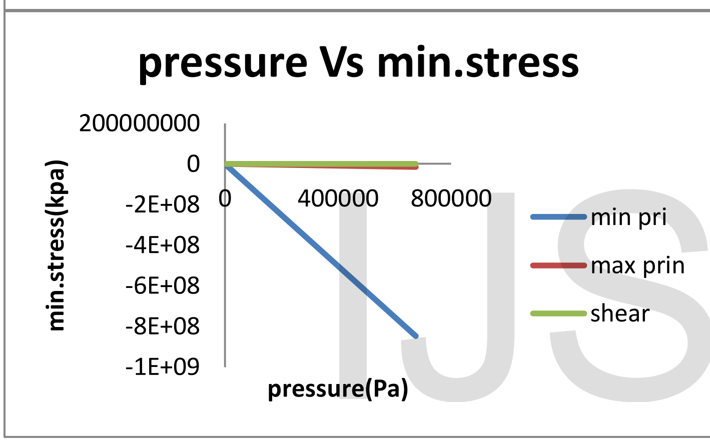
Mach	Stress [min][KPa]		
	min principal	max principal	Shear
0.2			
1.6			

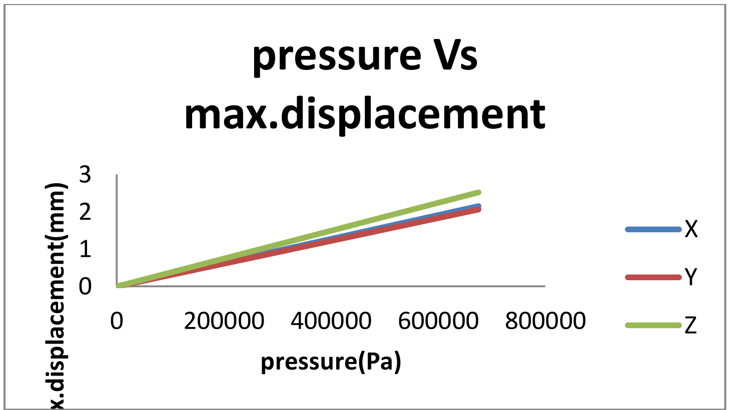
TABLE II

Mach	Pressure	Displacement [max] [mm]			Displacement[min] [mm]			stress[max] [kPa]			stress[min] [kPa]		
	Pa N/m²	X	Y	Z	X	Y	Z	min prin	max pri	shear	min pri	max prin	Shear
0.2	3002.0	9.58E-03	9.18E-03	1.12E-02	-1.11E-02	-1.10E-02	-1.17E-02	3.86E+04	4.55E+06	3.54E+06	-3.77E+06	-6.66E+04	2.35E+00
0.4	12008.2	3.83E-02	3.67E-02	4.49E-02	-4.44E-02	-4.38E-02	-4.68E-02	1.54E+05	1.82E+07	1.42E+07	-1.51E+07	-2.66E+05	9.38E+00
0.6	27018.4	8.63E-02	8.26E-02	1.01E-01	-9.99E-02	-9.86E-02	-1.05E-01	3.47E+05	4.10E+07	3.19E+07	-3.39E+07	-6.00E+05	2.11E+01
0.8	48032.8	1.53E-01	1.47E-01	1.80E-01	-1.78E-01	-1.75E-01	-1.87E-01	6.18E+05	7.28E+07	5.67E+07	-6.03E+07	-1.07E+06	3.75E+01
1	75051.2	2.40E-01	2.30E-01	2.81E-01	-2.77E-01	-2.74E-01	-2.93E-01	9.65E+05	1.14E+08	8.85E+07	-9.42E+07	-1.67E+06	5.86E+01
1.2	108073.8	3.45E-01	3.31E-01	4.04E-01	-3.99E-01	-3.94E-01	-4.21E-01	1.39E+06	1.64E+08	1.28E+08	-1.36E+08	-2.40E+06	8.44E+01
1.4	147100.4	4.70E-01	4.50E-01	5.50E-01	-5.44E-01	-5.37E-01	-5.74E-01	1.89E+06	2.23E+08	1.74E+08	-1.85E+08	-3.26E+06	1.15E+02
1.6	192131.1	6.13E-01	5.88E-01	7.19E-01	-7.10E-01	-7.01E-01	-7.49E-01	2.47E+06	2.91E+08	2.27E+08	-2.41E+08	-4.26E+06	1.50E+02
1.8	243165.9	7.76E-01	7.44E-01	9.10E-01	-8.99E-01	-8.87E-01	-9.48E-01	3.13E+06	3.69E+08	2.87E+08	-3.05E+08	-5.40E+06	1.90E+02
2	300204.9	9.58E-01	9.18E-01	1.12E+00	-1.11E+00	-1.10E+00	-1.17E+00	3.86E+06	4.55E+08	3.54E+08	-3.77E+08	-6.66E+06	2.35E+02
2.2	363247.9	1.16E+00	1.11E+00	1.36E+00	-1.34E+00	-1.33E+00	-1.42E+00	4.67E+06	5.51E+08	4.28E+08	-4.56E+08	-8.06E+06	2.84E+02
2.4	432295.0	1.38E+00	1.32E+00	1.62E+00	-1.60E+00	-1.58E+00	-1.69E+00	5.56E+06	6.55E+08	5.10E+08	-5.43E+08	-9.59E+06	3.38E+02
2.6	507346.2	1.62E+00	1.55E+00	1.90E+00	-1.88E+00	-1.85E+00	-1.98E+00	6.52E+06	7.69E+08	5.98E+08	-6.37E+08	-1.13E+07	3.96E+02
2.8	588401.5	1.88E+00	1.80E+00	2.20E+00	-2.18E+00	-2.15E+00	-2.30E+00	7.56E+06	8.92E+08	6.94E+08	-7.39E+08	-1.31E+07	4.60E+02
3	675461.0	2.16E+00	2.07E+00	2.53E+00	-2.50E+00	-2.46E+00	-2.63E+00	8.68E+06	1.02E+09	7.97E+08	-8.48E+08	-1.50E+07	5.28E+02

IV.GRAPHICAL RESULT






pressure Vs max.displacement
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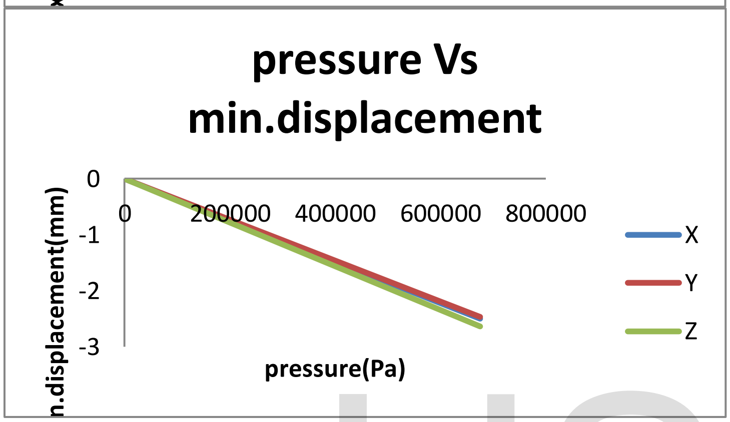
2
1
0
0
200000
400000
600000
800000
pressure(Pa)
x.displacement(mm)
X
Y
Z


pressure Vs min.displacement
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-1
-2
-3
0
200000
400000
600000
800000
pressure(Pa)
n.displacement(mm)
X
Y
Z

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V.CONCLUSION

The present design and fabrication of the conical probe setup was done successfully and the results predicted state that 1.1mm dia hole can be used up to a mach number range of 2.5. in one single probe 4 holes can be tapped for flow characteristic measures inside a tunnel test section up to a minimum of 0.1m test section to maximum of 0.6m test section The material[steel] which are used to fabricate conical probe is made by high strength high hardness metals which are heat treated. The final model is part analyzed using NASTRAN.

VI. ACKNOWLEDGMENT

Apart from the efforts from both of us, the success of this project depends largely on the encouragement and guidelines of many others.Wewould like to show our greatest appreciation to Dr.M.Chentil Kumar. Without his encouragement and guidance this project would not have materialized.We take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this project.

VII.REFERENCE

[1] A.L. Braslow and E.C. Knox, Simplified Method of Determination of Critical Height of Distributed Roughness Particles for Boundary –Layer Transition at Mach Numbers from 0 to 5, NASA TN 4363, September 1958.

[2]Kopal, Z. Tables of supersonic flow around cones. Mass. Inst. Technology Tech. Report No. 1, 1947.

[3] HESS, J.L., SMITH, A. M. O., RIVELL, T. L. Systematic design of improved static pressure sensing probes. Douglas Aircraft Co. Inc., Engineering paper No. 1181, October, 1961.

[4] SWALLEY, F. E. Measurement of RIVELL, T. L. Systematic design of improved static pressure sensing probes. Douglas Aircraft Co. Inc., Engineering paper No. 1181, October, 1961.

[4] SWALLEY, F. E. Measurement of flow angularity at supersonic and hypersonic speeds with the use of a conical probe. NASA TN D-959, 1961.

[5] ANDREWS, D. R., SAWYER, W. G.

[6] RANEY, D. J. Flow direction measurements in supersonic wind tunnels Current papers aero. Res. Coun. Lond, No. C. P. 262, 1956.

[7] BARRY, F. W. comparison of flow directions probes at supersonic speeds.J. aeronaut.Sci., 1962 [9], 750.