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Performance Evaluation of Yaw Meter With the Aid of Computational Fluid Dynamic

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Abstract: *A multi-hole conical probe is employed to determine the velocity of the air flow, total and static pressures of the wind tunnel, wave angle in addition to estimating the noise of the test segment. It twinkles with the unique qualities of being trouble-free, vigorous with the flexibility to be applied even in ruthless situations. Our innovative conical wedge type probe is launched by means of AUTOCAD and engineered by exploiting the stain less steel material. The pressure holes are situated at the end of the conical probe which is applied to calculate the pressure and flow velocity of the atmosphere. The novel probe is performed at supersonic settings by the effective use of the proficient Computational Fluid Dynamic Analysis (CFD analysis) software. It discharges the task of assessing the enduring competence of the projected probe under a variety of situations like fixed pressure and temperature along with the velocity of the air flow at different mach-numbers. This sample fashioned blueprint built up in CFD is estimated under supersonic backdrops up to mach 3. Thus, it is crystal clear that that our well-conceived sample developed with semi nose angle 20º ushers in a sterling performance in mach 2.8 triggering an incredible shock wave of 29.3º*

Key words: *Multi-hole probe, wedge type probe, shock wave angle, Mach number, CFD analysis,*

I. Introduction

The pressure along pressure ports assembled on their tips is measured by fluid flow instruments also called multi-hole probes. These tidings can come back in to three components fluid velocity along with static and dynamic pressure [1]. Total pressure, static pressure, flow velocity (and Mach number) and flow direction (yaw and pitch angles with respect to the probe head) are theoretically measured by calibrated Probes with several sensors under well controlled flow conditions [2]. On the similar measurement plane the static pressure (Ps) is absorbed from the either side of the wind tunnel and the total pressure (Pt) is absorbed from a Pitot Static probe accumulate through the sidewall of the tunnel [3] Pitch angles, stagnation and static pressures by using an interpolation algorithm and an iterative loop, the relative axial, radial and tangential flow velocities are determined from the above flow parameters [4]. It is generally used to attain the scalar and vector properties of complicated flow fields like those encountered around complex bodies or turbo machines in terms of static and total pressure and three-dimensional (3D) velocity components respectively [5]. Metal matrix composites (MMCs) have become attractive in a variety of applications due to its advantage of having intermediate properties between metal and ceramic [15]. To obtain the transient flow field pressure data and establish local transient Mach number, Dynamic pitot and static pressure probes were designed; and to establish the local transient flow angle a dynamic four-hole conical pressure probe was designed [6]. The calibration surface split into numerous zones by edge of the probe relative to the probe axis. In each zone distinct combination of pressure coefficients are used [7]. A further advantage of using the pressure transducers remote from the pressure taps is that are mechanically shielded. So is used in a robust measurement system capable of function in industrial and laboratory flows [8]. In a four-holed probe the top and bottom holes will imply a pitch angle and the left and right holes imply of yaw. A calibration map is produced by rotating the probe through a range of pitch and yaw angles [9]. In a closed wind tunnel or a free jet at various flow directions, the probe is to be measured. When the probe is kept stationary the pressure level of each hole is recorded; while the probe is be rotated to vary the flow incidence [10].To measure the angle of attack and Mach number by direct measurement of the calibrated pressures at the 5 ports, static ring, and plenum are the main functions of probes. By employing a combination of wind tunnel, CFD, and other numerical modeling techniques the probe is to be calibrated [11]. The contingency transmitted from the measurements to the effective output the flow variables has been noticed. The measurement of multi-hole pressure probe can be pursued on the pipe wall, where the wall is expected to considerably damp out the cause of turbulence on pressure probe readings. The turbulence be produced the fluctuation of static pressure and it is important in

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conventional Pitot static probe [12].The standard Pitot static tubes, S-probes and multi-hole pitot tubes are the examples of 2 and 3 dimensional static differential pressure devices. For calibrating 2-D and 3-D airspeed instruments in its low-turbulence wind tunnel and the air-speed calibration in unerring yaw and pitch angles, the NIST has been layout. And also it is depend up on the intensity of turbulent [13]. The resultant of the local velocity by employing a bi-directional probe needs the measurement of pressure difference between the front and back sides of the probe and the local gas density. In order to improve the accuracy of the velocity measurement by bi-directional probe, the measurement contingency should be calibrated for various flow circumstances like range of Reynolds number, flow approaching angle, temperature variation etc. [14] The experimental results then were numerically validated with the help of Fluent, which shows a good agreement between the experimental and predicted results[16]. Tunnel blockage, model size, model design and shock waves are the different parameters for the probe designs. By using these parameters conical probe is to be constructed and, if the conical four-hole probe is being constructed AUTOCAD is be used. The manufacturing material of the conical probe be the hardness and temperature withstanding capacity and the conical four-hole probe is manufactured by employing Stain less steel. It is perfectly welded, long enduring, easily annealed and be strong. An adapter, cone probe, probe adapter, small adapter and wedge are the five parts of yaw meter and these dimensions are adapter (ϕ30×130), cone probe (ϕ10×30), probe adapter (ϕ10×70), small adapter (ϕ10×55) and wedge (20×60×140).The adapter is to be coupled with the wedge which had three conical probes with similar distances. . The conical probe has the nose angle 40º(nose semi angle=20º). The conical probe is coupled by using probe adapter. During fabrication method various machine progressions are made. The main functions are CNC milling, CNC grinding, shaping, Buffing and so on. Also all the materials are heated and oil bath for clean-up functions. By using MS steel conical probe is being developed and its ability is evaluated by using CFD software.

II. Designing methodology for evaluating the performance of wedge type four hole conical probe

The wedge type four-hole conical probe is an innovative technique designed for finding specific shock wave angle with the help of the AUTOCAD algorithm. The designed probe is fabricated as per the specified dimensions by using stainless steel and thereafter tested for its durability at supersonic condition in various types of mach numbers. At supersonic condition, various parameters such as the static pressure and temperature in addition to the velocity of the air flow are tested for evaluating the innovative probe. In the supersonic condition, the Mach number is in the range of 1.2 to 3 and the probe is checked up to the maximum Mach number 3.The modus operandi of the proposed methodology is explained as follows:

II.1 DESIGN

The conical four-hole probe is designed before fabrication with the aid of AUTOCAD. The kinds of factors involved in the probe design are 1.Tunnel Blockage 2.Model size 3.Model Design 4.Shock wave. Here, tunnel blockage factor is utilized to calculate the supersonic flow of the system the model size is the significant factor in probe design for efficient utilization of probe to calibrate system flow speed with the minimum error disturbances, this leads towards shock waves. The Shock wave is a type of propagating disturbance and the formation of Shocks Pressure waves will build up then adding towards each other to form a shock wave at the boundary between supersonic and subsonic flow. The probe is designed on basis of theoretical analysis, the considerable theoretical analysis factor are 1.nose angle 2.shock wave angle 3.Mach number. Fig.1 shows the conical four-hole probe (yaw meter).

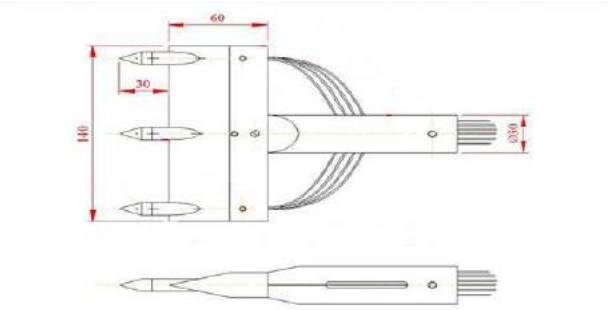
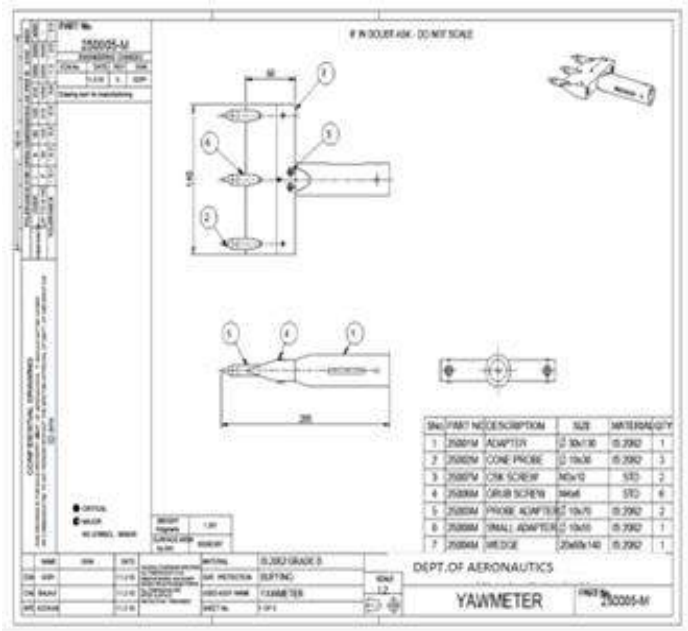


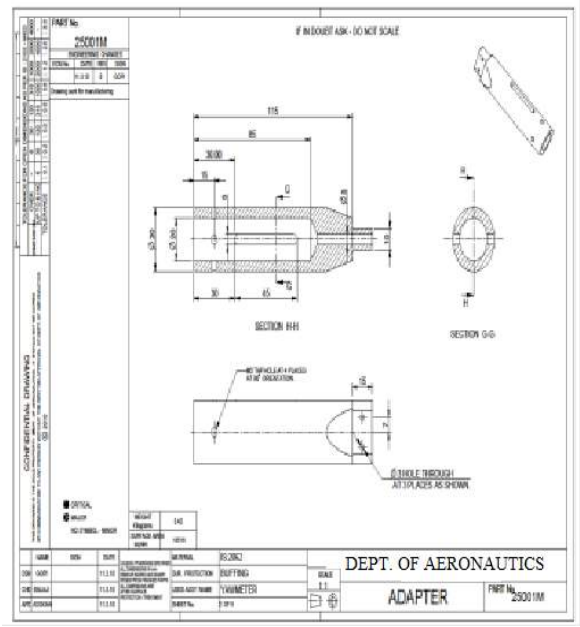
Fig.1. Yaw meter

The following Fig.2 shows the full design of conical four-hole probe or yaw meter arrangements of the probe with its dimensions. The conical four-hole probe (yaw meter) is designed in Department of Aeronautics using AUTOCAD. It consists of the following elements: 1.Adapter 2.Cone probe 3.Probe adapter 4.Wedge

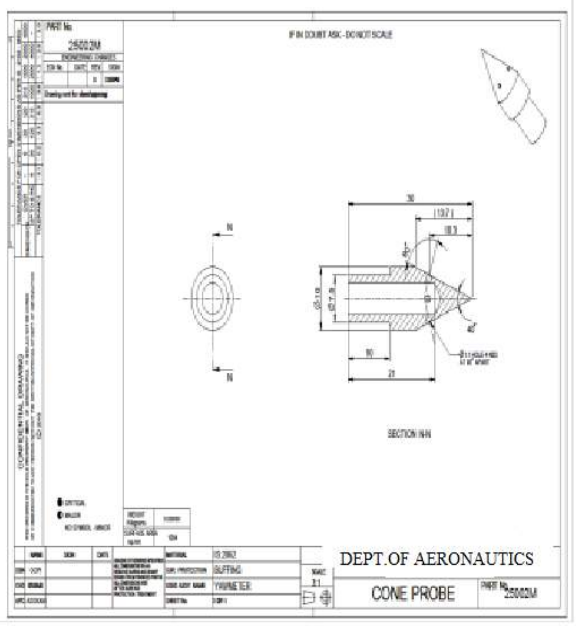
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(a) Over all Design of Overall Design of aw meter

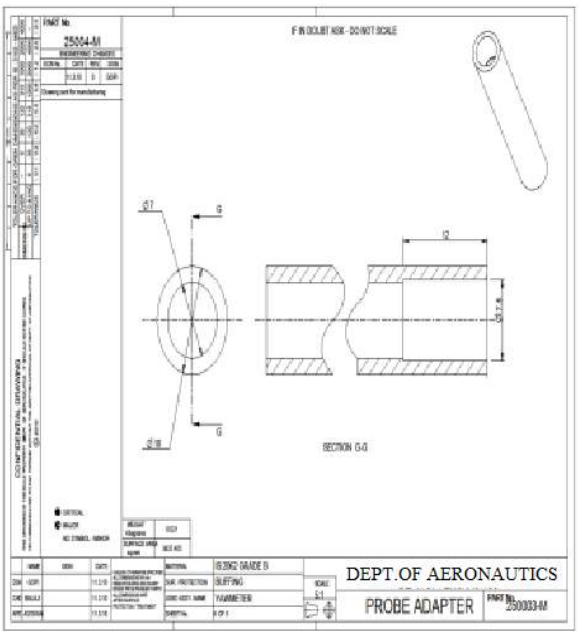


(b) Adapter of the Yaw meter

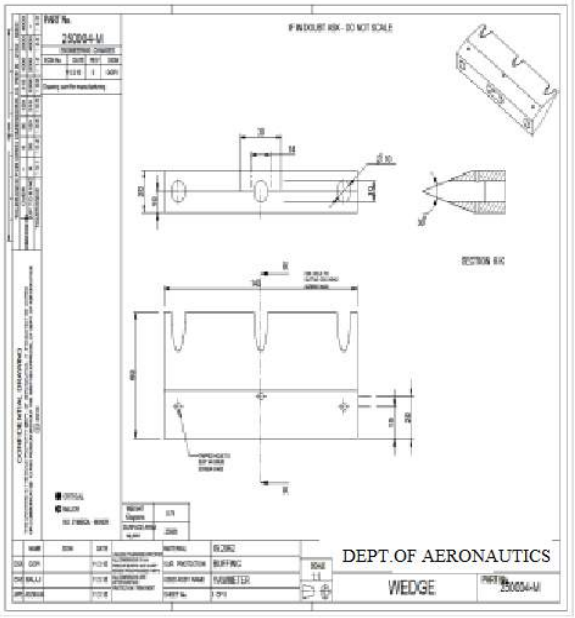


(c) Cone probe of the Yaw meter

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(d) Probe adapter of the Yaw meter



(e) Wedge of the yaw meter

Fig.2. Yaw meter and its elements of the Yaw meter

The Fig (a) shows the conical four-hole probe or Yaw meter with full components. The Adapter is connected with the wedge which comprises the cone probe with the cone adapter. The Figs (b), (c), (d) and (e) show Adapter, Cone probe, probe adapter and wedge. The components are explained below:

II.1.1 Adapter

Considering, the Fig (b) adapter connected with the wedge is shown having length of 115mm and diameter of ⌀30 mm also having the small hole with the diameter of 10mm which is inserted into the wedge of the probe. The adapter consists of the small tubes that are connected with the holes of the conical probe and the section H-H shows the cross section of the Adapter. The total length of the adapter is divided into 115mm and 15mm then the 115 mm length section has ⌀ 10 mm diameter hole with length of 45 mm.The section G-G shows the cross section of H-H and its shows the diameter of the adapter which is ⌀ 30 mm and the inner diameter is ⌀20mm. The length of 15 mm projection is used to insert the adapter with the wedge of the yaw meter.

II.1.2 Cone Probe

Fig(c) shows the cone probe for yaw meter length and diameter are 30mm and ⌀10 mm respectively. The section N-N shows the cross section of the cone probe then the conical section of the cone probe length is 13.7mm.The nose angle of the conical section is 40º and the semi nose angle is 20º. The four holes are made at the conical section and the diameter of the hole is ⌀ 1.1 mm.The centre point of the hole and conical section starting point makes the angle of 90º.The outer diameter of the probe is ⌀10mm and the inner diameter of the probe is ⌀7.5mm with the length of 21mm and is used to insert the probe adapter. The small holes are connected with pressure sensors for measuring the pressure co-efficient.

II.1.3 Probe Adapter

Fig (d) shows the probe adapter of the yaw meter, it has the length of 70mm and the diameter of ⌀ 10 mm.It is used to connect with the conical probe. The section G-G shows the cross section of the probe adapter. It has outer diameter of 10mm and inner diameter of 7.5mm and it is used to connect with the conical probe.

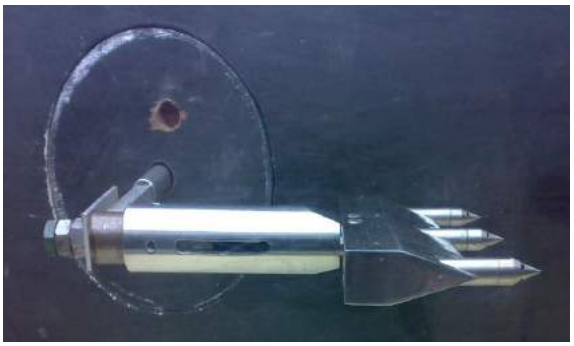
II.1.4 Wedge

Fig (e) shows the wedge of the yaw meter. It has three holes for inserting three conical probes with diameter of ⌀ 10 mm.It has the length of 140mm and width of 60mm.The wedge is connected with the probe. The section K-K shows the cross section of the wedge and shows the conical projection with the angle of 30º.Because the conical probe with cone adapter is fixed with this point. The 20mm thickness of the wedge backside is 30mm width hole with the length of 15mm which is used to fix the probe adapter.

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II.2 Fabrication

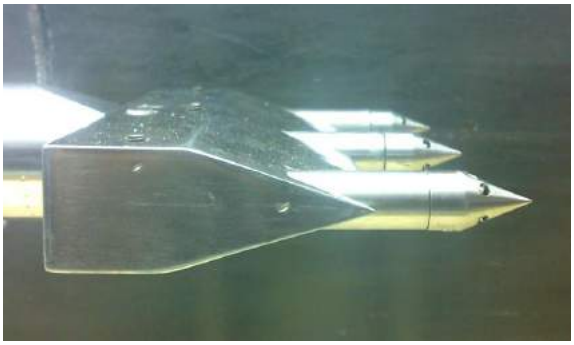
It is pertinent to note here that material choice for fabrication plays a very significant role in this regard. The material for fabrication has to be chosen in such a way that it possess appreciable rigidity and potency. It is the stainless steel material which is exploited for production of yaw meter, which, in turn, is employed to estimate the flow velocity, overall pressure and fixed pressure of moving flow field. The yaw meter is conceived here with the help of the wind tunnel. And the yaw meter is employed to estimate the velocity, overall pressure and fixed pressure of the wind at supersonic stage, in which the pressure and temperature are enhanced. Hence the material employed for yaw meter fabrication, for all practical purposes, very stiff and sturdy. Thus the Stain less steel (IS: 2062) is made use of for producing the yaw meter. And the material is fabricated in accordance with the desirable dimensions. Each and every segment of the yaw meter is planned and produced according to the pre-determined dimensions. The yaw meter is devised by means of AUTOCAD and the ensuing figures illustrate the fabricated yaw meter. Fig (a) depicts the stage after the fabrication of the yaw meter. A close observation of the Yaw meter reveals that it is comprised of an adapter, cone probe, probe adapter and wedge.



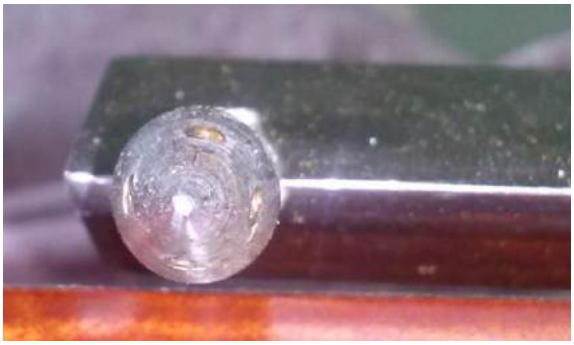
(a)Yaw meter set up



(b) Components of Yaw meter



(c)Cone probe with probe adapter of Yaw meter



(d) Cone probe with holes



(e)Wedge of the yaw meter



(f)Yaw meter

Fig.3. Fabricated Yaw meter

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Each and every module of the probe is illustrated in the Fig (b), with a detailed description on them as given below.

II.2.1 Adapter

From Fig (b) which illustrates the main adapter of the probe of the yaw meter, we can see that it has a length of 130mm and diameter of ⌀30mm.The material employed for the adapter is Stain less steel. Processes such as MITR, Jig boring, cylindrical grinding and CNC lathe are utilized to produce the adapter of the yaw meter. The s adapter is entrusted with the task of inserting the wedge module of the yaw meter.

II.2.2 Probe Adapter

Fig (b) also reveals the probe adapter of the conical probe of the yaw meter, which is fabricated by means of the maching procedures such as MITR, Jig boring, cylindrical grinding and CNC lathe. In this case, the length of the probe adapter is shown to be 70mm and diameter ⌀10mm. The central function of the probe adapter is concentrated in linking the conical probe with the wedge of the yaw meter

II.2.3 Cone probe

Fig (c) vividly illustrates the cone probe of the yaw meter, which is devised as per the premeditated dimensions. It is observed that it consists of four holes to estimate the pressure of the wind tunnel. Fig (e), on the other hand, depicts the conical probe holes. In this connection, the whole diameter of the probe is found to be ⌀1.1 mm, and the conical nose angle of the cone probe is 40^o and semi nose angle is 20^o. Maching processes like cylindrical grinding and CNC wire cut are efficiently carried out to produce the cone probe in accordance with the pre-defined dimensions.

II.2.4 Wedge

From Fig (e), which demonstrates the wedge of the yaw meter it is found that the length. Width and rear side thickness of the wedge are 140mm, 60mm and 20mm respectively. Two significant processes such as CNC Milling and shaping are carried out in the wedge maching task. It is also found that the adapter of the yaw meter is produced in line with the prescribed dimensions.

Fig (f), we get an overall picture of the fabricated yaw meter in accordance with the pre-determined dimensions. It is also observed that once the fabrication of the yaw meter is complete, all modules are integrated into the system as shown in the diagram and, thus, finally the full-fledged yaw meter is made

III. Results and Discussions

The wedge type four-hole conical probe is designed and fabricated as per the specified dimensions. Its performance is evaluated by using Computational Fluid Dynamic analysis software in 2D and 3D analysis method. The results are discussed and explained following:

III.1 CFD analysis

The Computational Fluid Dynamics simulation is employed to simulate the model by using the CFD analysis software. It is targeted at attaining the accurate result of the designed model with real time environmental conditions. Though the nose semi angle which furnishes the shock wave angle is 20^o, it zooms to 29.3^o in the case of the innovatively designed model. When the semi-nose angle is decreased, though we are able to measure the pressure, the accuracy of the result obtained from the probe is not up to the expected level. Then, we resort to increasing the Mach number gradually. When the Mach number reaches 3, the maximum for the supersonic condition, the semi-nose angle 20^o is selected which ushers in the desired accurate result. The theoretical Table 1, shown below, furnishes the shock wave angles of the probe for different Mach numbers and nose-semi angles selected for the analysis.

TABLE I
SHOCK WAVE ANGLE FOR VARIOUS Θ-SEMI-NOSE ANGLES

Mach no.	Shock wave angle θ= 5	10	15	20	25	30
1.05	72.4	--	--	--	--	--
1.1	65.6	67.0	--	--	--	--
1.2	56.4	57.5	60.6	72.5	--	--
1.3	50.5	51.4	53.4	58.0	--	--
1.4	45.5	46.3	48.3	52.8	59.3	--
1.6	39.0	39.4	41.6	46.2	52.2	59.1
1.8	34.0	34.6	37.1	41.6	46.7	52.6
2	30.1	31.3	33.7	38.0	43.0	48.3
2.5	23.8	24.8	27.8	32.2	37.1	42.6
3.0	20.0	21.3	24.7	29.3	34.2	39.5
3.5	16.9	19.4	23.4	27.7	32.7	38.3

The following parameters are employed to derive the real time conditions of the CFD computational analysis. The Mach number is varied with constant ambient temperature and pressure. The outputs of the CFD include static pressure and temperature, together with turbulence viscosity and velocity. In this regard, there are two types of analysis methods available such as 2D analysis and 3D analysis methods.

III.1.2 2D analysis method:

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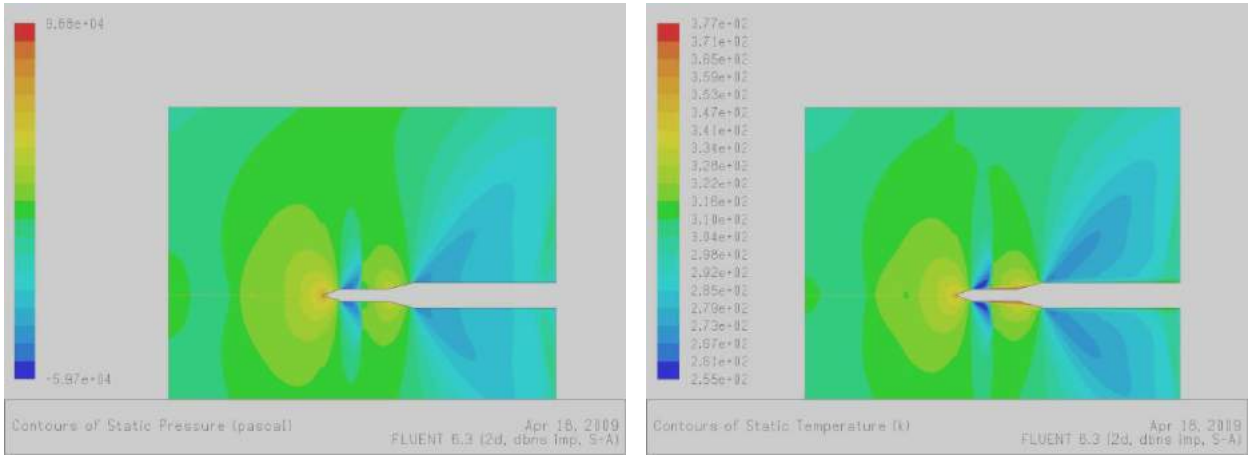
In the case of 2D analysis, a single conical four-hole probe is analyzed in the CFD method in real time environmental conditions. Table 1 shows the various Mach numbers with constant ambient pressure and temperature. The output of the probe is plotted as CFD graphical method.

TABLE II
2D ANALYSIS FOR VARIOUS MACH NUMBERS

S.NO	VELOCITY	AMBIENT PRESSURE	AMBIENT TEMPERATURE
1	Mach 1	1.01325 bar	288 K
2	Mach 2	1.01325 bar	288 K
3	Mach 2.5	1.01325 bar	288 K
4	Mach 3	1.01325 bar	288 K

III.1.2.1 MACH 1

In the case of MACH 1, the ambient pressure and temperature are observed to be 1.01325 bar and 288K respectively. The Fig.4 (a), (b), (c) and (d) show the static pressure, static temperature, turbulent viscosity and velocity magnitude of the probe respectively



(a)Static pressure (b) Static Temperature

(c)Turbulent Viscosity (d) Velocity Magnitude

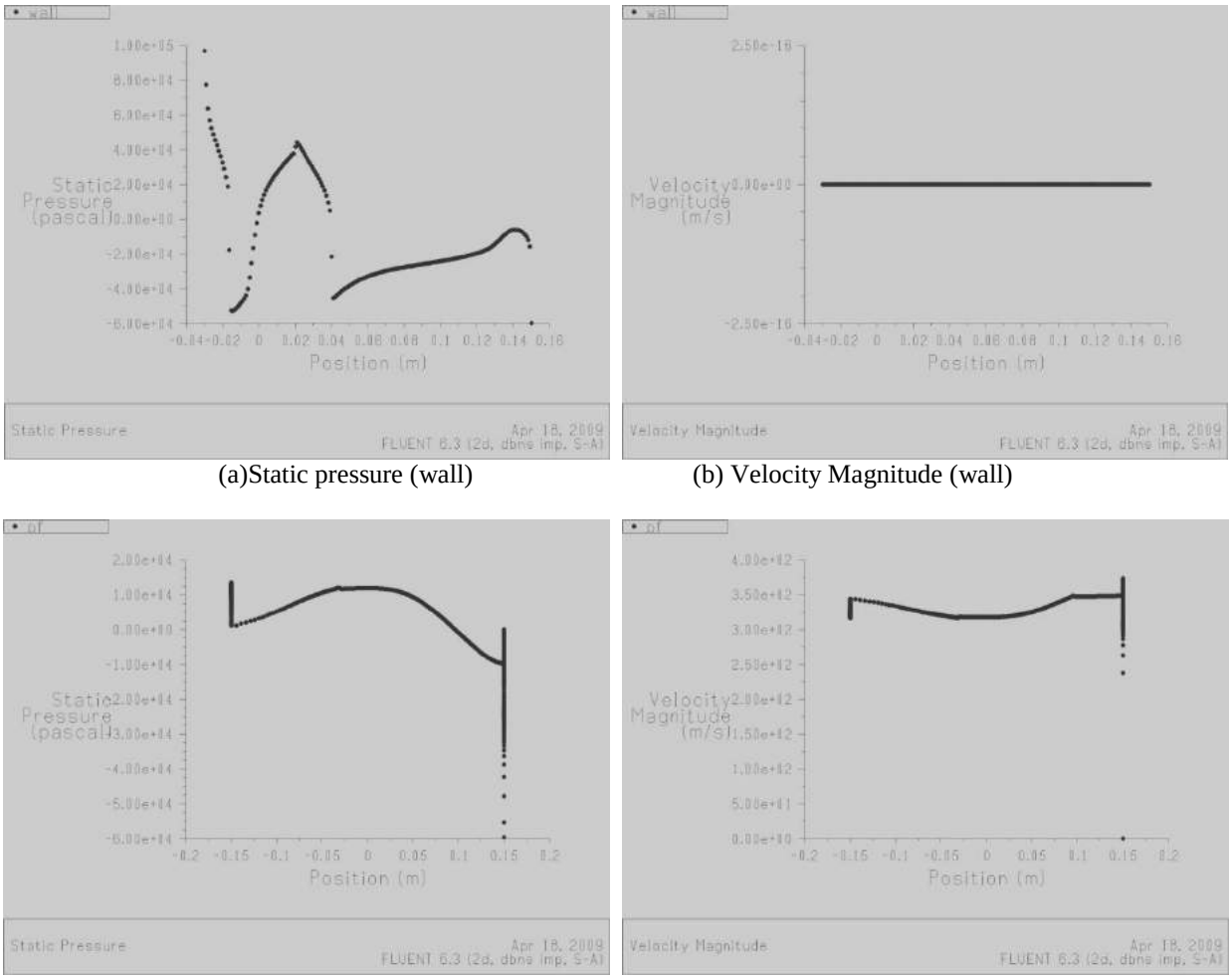
Fig.4. 2D Graphical output of the conical four-hole probe

Fig (a) shows the static pressure output of the probe along with the detached wave formed by the shock wave. As it is not fitted with the pressure, it gets accumulated in front of the probe tip in the case of Mach 1, as clearly shown in Fig (a) by the yellow color. On the other hand, Fig (b) depicts the static temperature which is identical to that of the static pressure as shown by the yellow color on the tip of the probe. As the velocity of the air is blocked by the detached wave, it gets reduced as illustrated by the green color in Fig (d).

Shadow graph

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Fig.5 shows the shadow graph of the static pressure and the velocity of the probe in the wall side. In fact, it is the optimal method that reveals the non-uniformities in the air medium.



(a)Static pressure (wall) (b) Velocity Magnitude (wall)

(c)Static Pressure (pf) (d) Velocity Magnitude (pf)

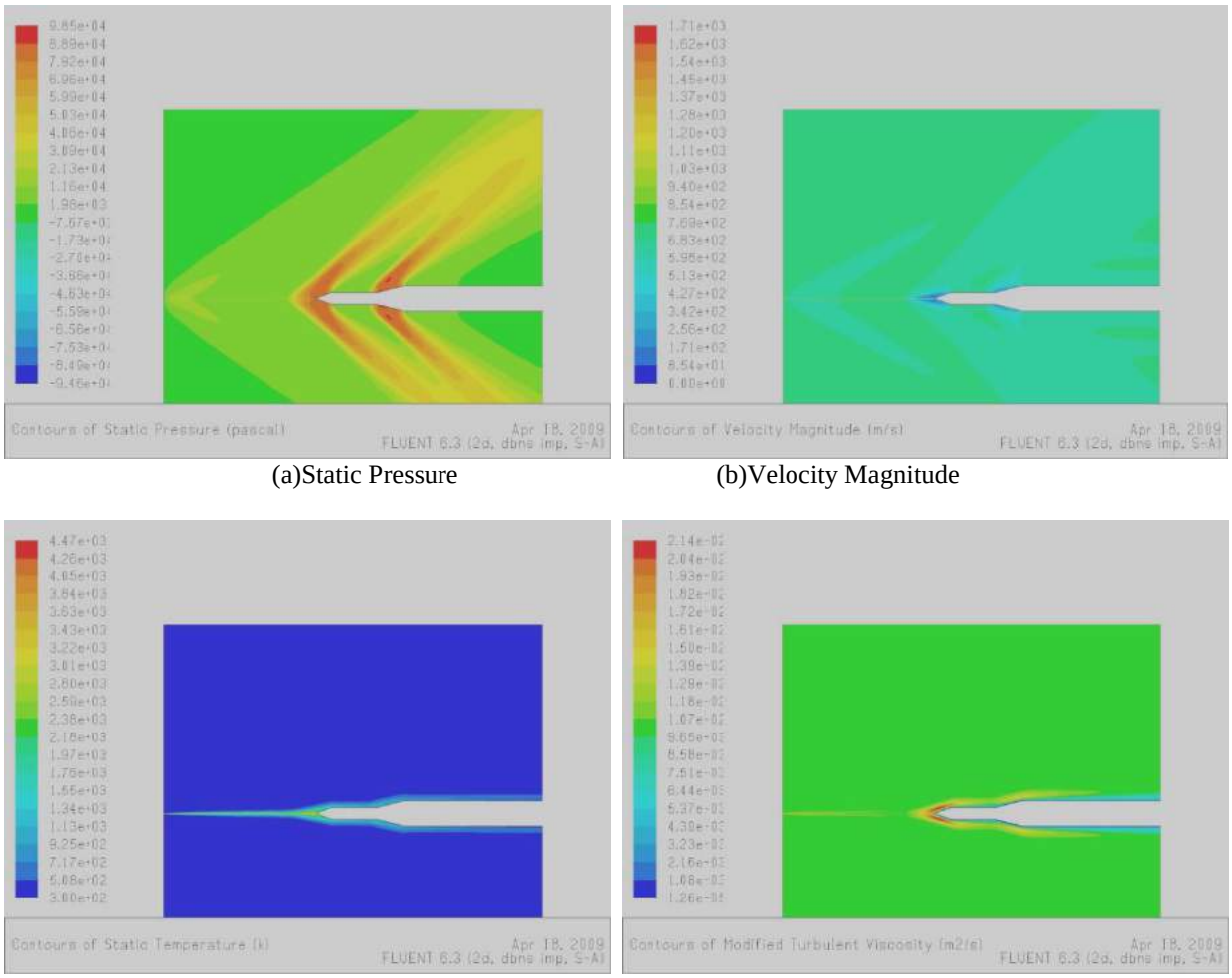
Fig.5. Shadow graph of the probe in different positions

In Fig (a), the static pressure of the probe wall sides is shown and it appears even when the pressure is discontinued. The Fig (b), on the other hand, illustrates the velocity magnitude of the probe wall side which shows continuity with minimum variations. The Figures (c) and (d) show the static pressure flow and the velocity of the pressure of the probe respectively.

III.1.2.2 MACH 2

In the case of MACH 2, the detached wave gets reduced, when Mach number is increased. Fig 6 shows the values of parameters such as static pressure, velocity magnitude, static pressure and turbulence viscosity of the probe.

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(a)Static Pressure (b)Velocity Magnitude

(c) Static Temperature (d) Turbulent Viscosity

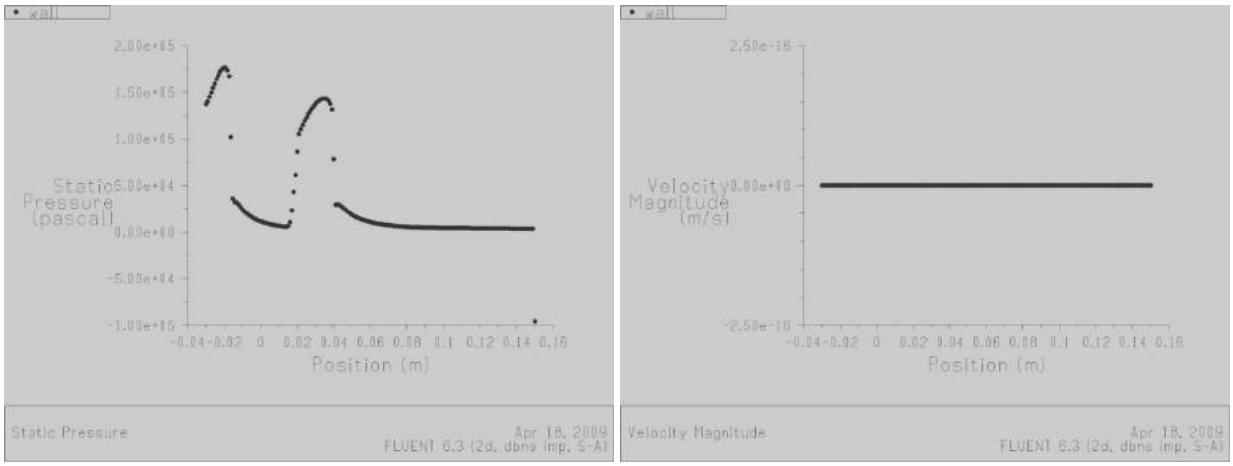
Fig.6 MACH 2 output responses of the probe

When the Mach number increases, the shock wave coupled with the air pressure creates the shock wave angle with the probe. The Fig (a) clearly shows the pressure fitted with the probe tip and gives the angle of shock wave. The maximum static pressure of the probe is represented by the red color. The static temperature which varies in accordance with variation in velocity is shown by the blue color. Fig (c) shows the variation of the static temperature with the minimum value as blue color. The turbulent viscosity furnished in Fig (d) with minimal range of variation is illustrated by light green color.

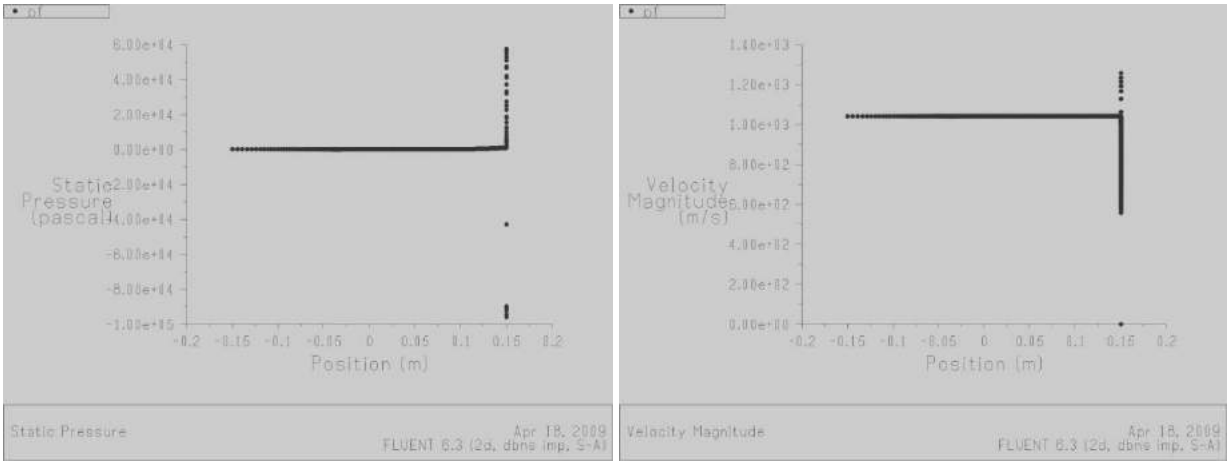
Shadow graph

Fig 7 shows the shadow graph of the yaw meter, with the static pressure of the probe system depicted in Fig (a).

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(a) Static Pressure (wall) (b) Velocity Magnitude (wall)



(c)Static Pressure (pf) (d) Velocity Magnitude (pf)

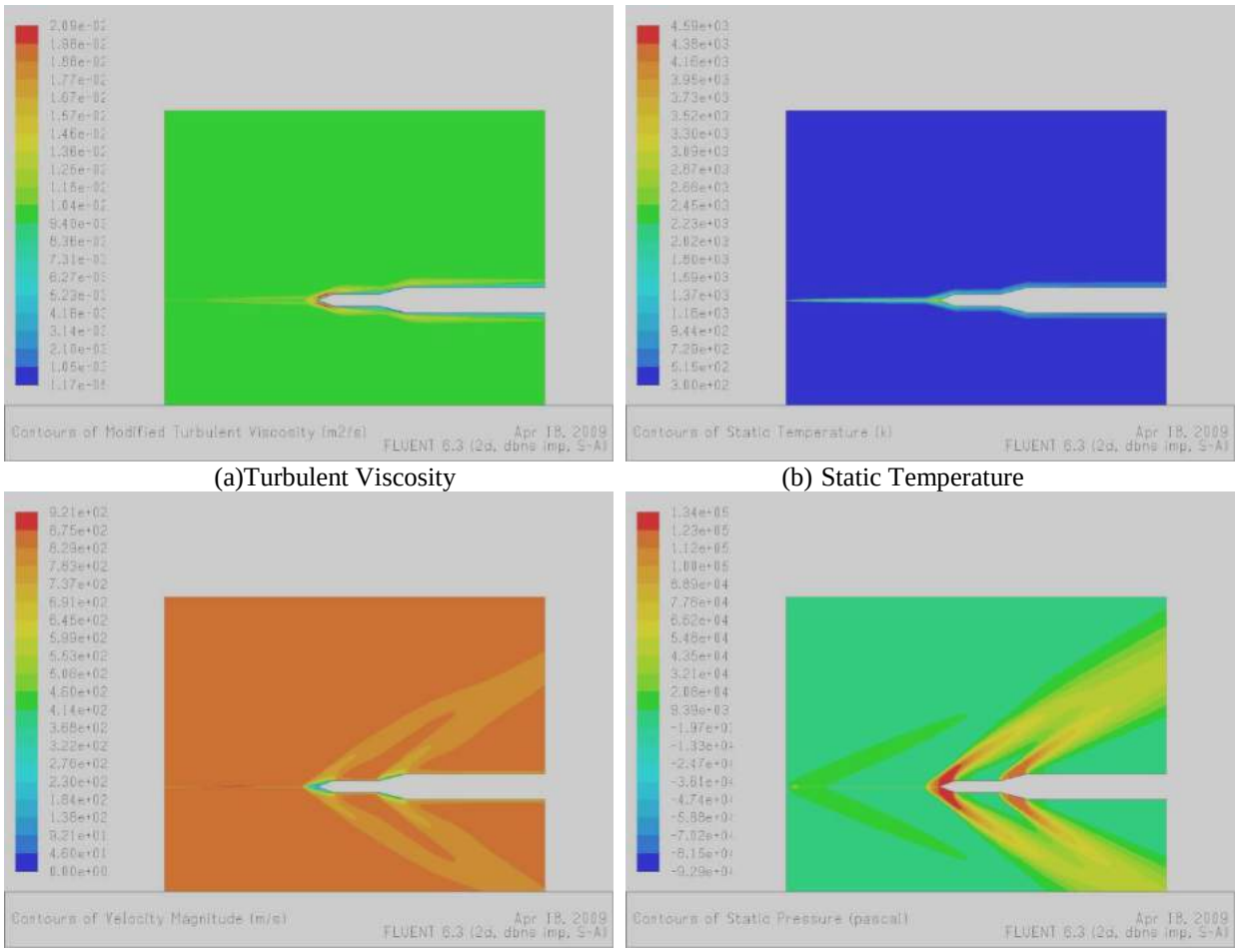
Fig.7 Output of the Probe in different positions in MACH 2

The flow direction of the air as well as its velocity is illustrated in Fig (b). When the Mach number increases, the pressure flowing through the wall side continues to some extent. While Fig (c) shows the static pressure of the probe wall side, the velocity of the probe gets illustrated in Fig (d).

III.1.2.3 MACH 2.5

Fig.8 shows the Mach 2.5 condition analysis, where the shock wave angle is decreased along with deflection angle.

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(a)Turbulent Viscosity (b) Static Temperature

(c)Velocity Magnitude (d) Static Pressure

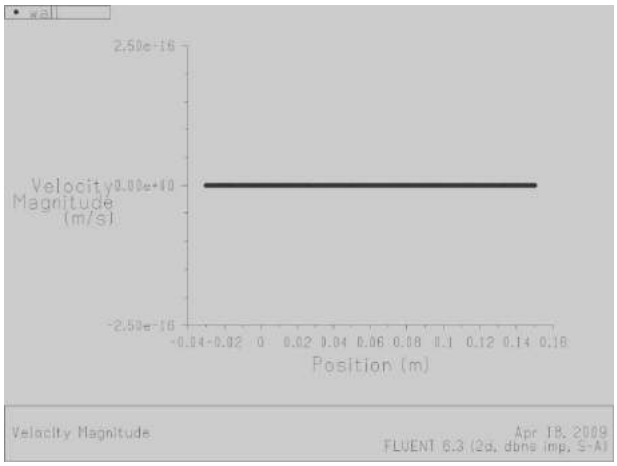
Fig.8. MACH 2.5 output responses of the conical four-hole probe

In MACH 2.5, the static pressure of the probe is again fitted with the probe tip as shown in Fig (d). The shock wave angle has already been reduced in the previous stage. The velocity of the air is also at a high level which is clear from the Fig (c).The turbulence viscosity shown in Fig(a) is of medium level and is represented by the green color

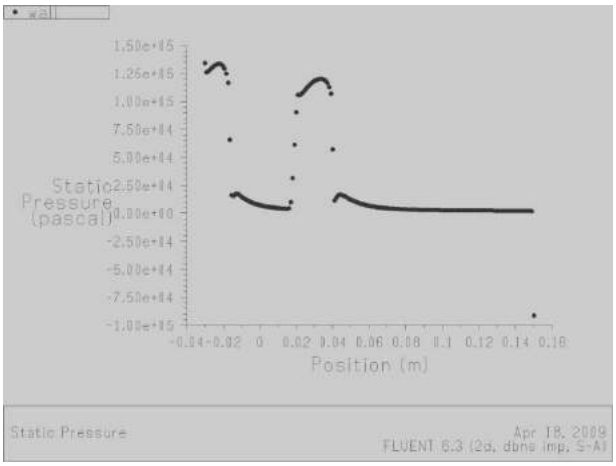
Shadow graph

Fig.9 shows the shadow graph of the probe. In Mach 2.5 condition, the static pressure of the probe is more or less identical to that in the earlier stage.

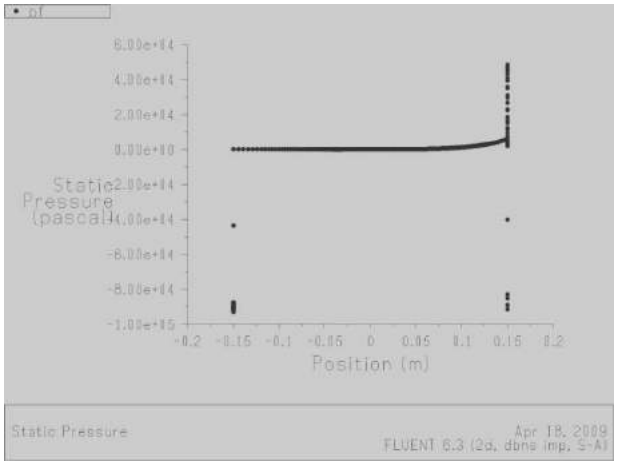
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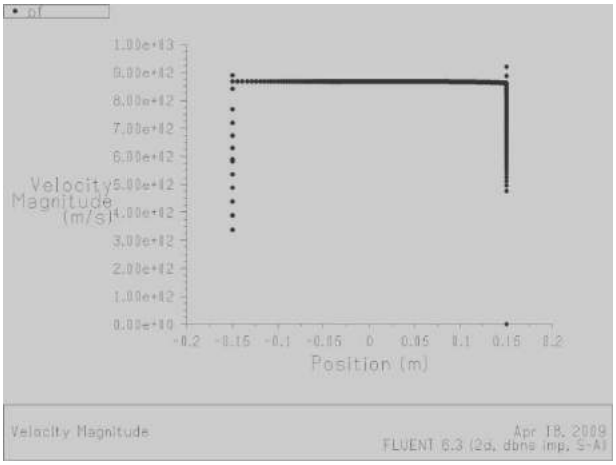
(a) Velocity Magnitude (wall)



(b) Static Pressure (wall)



(c)Static Pressure (pf)



(d) Velocity Magnitude (pf)

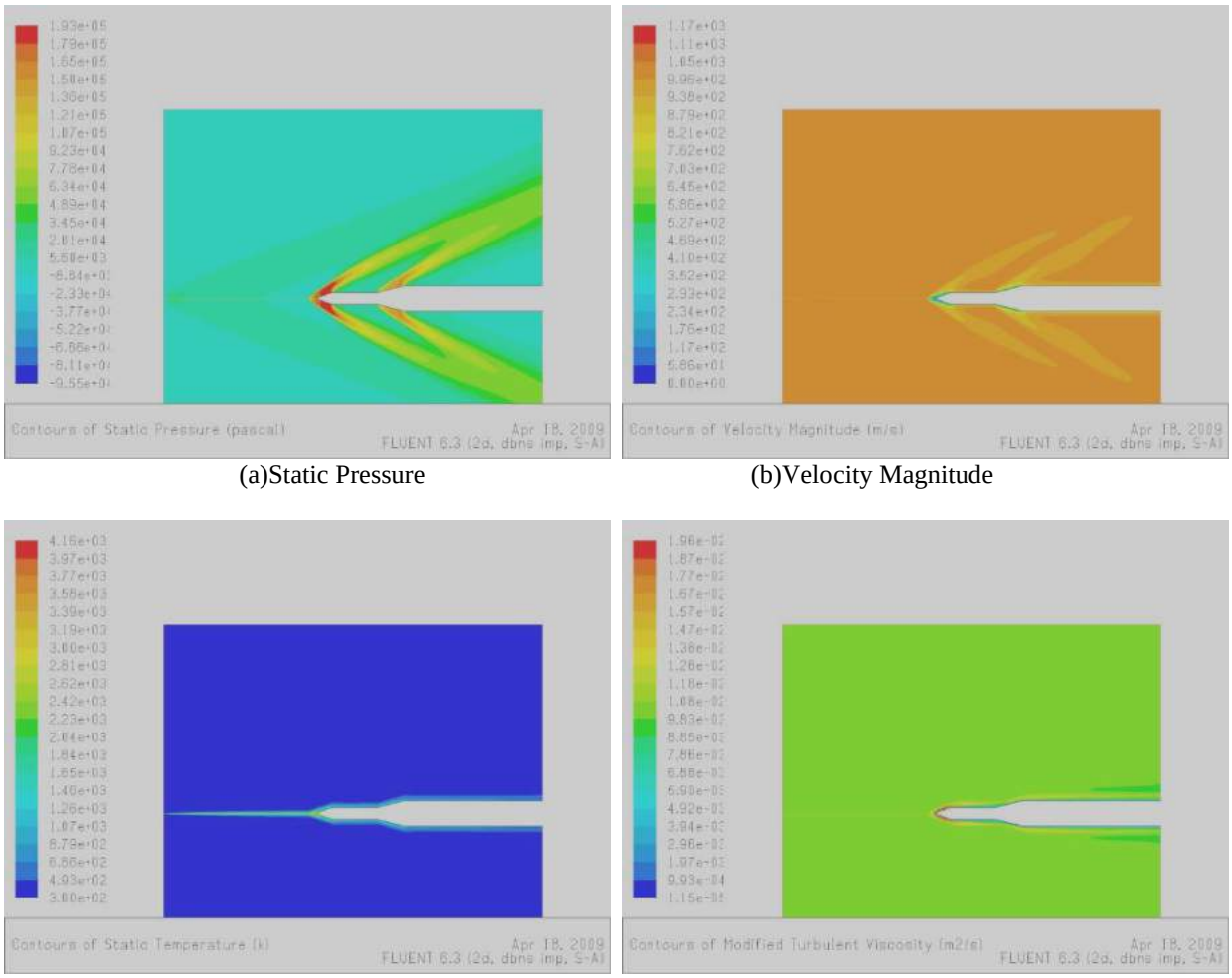
Fig.9 Shadow graph of the Probe in different positions in MACH 2.5

The velocity magnitude and the static pressure are shown in Figs (a) and (b) respectively. The velocity is found to be constant at all points of the probe. The static pressure flow in the probe is approximately the same and constant in cases where Mach number exceeds 2. The velocity is shown in Fig (d). Moreover, the static pressure and velocity magnitude of pressure flow is found to be reciprocal to each other as illustrated by Figs (c) and (d).

III.1.2.4 MACH 3

Fig.10 shows the Mach 3 condition, in which the static pressure of the wind is perfectly fitted with the shock waves and pressure is measured accurately. The velocity of the wind is very high as illustrated in Fig (b). The pressure fitted on the probe with minimum angle is clearly depicted in Fig (a).

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(a)Static Pressure (b)Velocity Magnitude

(c) Static Temperature (d) Turbulent Viscosity

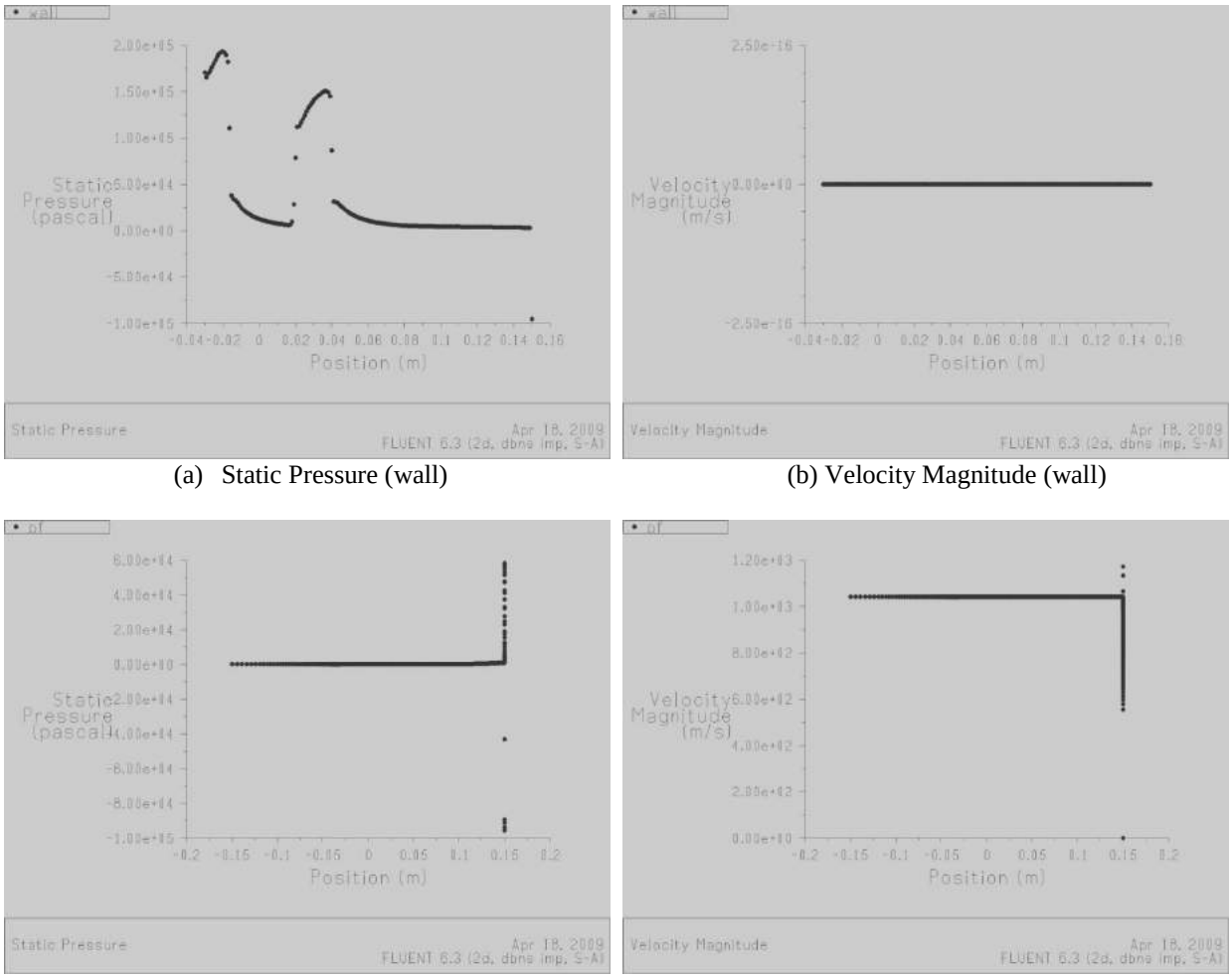
Fig.10. MACH 3 Output responses of the conical four-hole probe

The static temperature and turbulence viscosity are nearly same after mach 1 in all cases. The following Figs show the shadow graph of the probe. The static pressure of the probe is shown in the Fig (a), which gives the path of the air pressure in the probe wall side. The static pressure and velocity of the pressure flow are found to be identical above mach 2 and almost go on increasing constantly, as shown by Figs (c) and (d).

Shadow Graph

Fig 11 shows the Mach 3 condition shadow graph of the probe, along with the static pressure and velocity both which are identical to the earlier condition.

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(a) Static Pressure (wall) (b) Velocity Magnitude (wall)

(c)Static Pressure (pf) (d) Velocity magnitude (pf)

Fig.11. Output of the Probe in different positions in MACH 3

From all the 2D graphical analysis, it is evident that if the Mach number increases, the wind pressure is measured by the probe very accurately. When the air pressure increases the supersonic condition, the velocity of the wind goes to a very high value which is also measured by the probe. The graphs plot Static pressure vs. Position of the probe and velocity magnitude vs. position of the probe separately and they exhibit the probe quality at a higher value in these conditions.

III.1.2 3D analysis method

In 3D analysis method, the three conical probes are used to analyze the real time conditions. Here also, identical conditions are used to check the conical four-hole probe. Table 2 shows the different sonic speeds with constant ambient pressure and temperature conditions.

TALE III

3D ANALYSIS FOR VARIOUS MACH NUMBERS

S.NO	VELOCITY	AMBIENT PRESSURE	AMBIENT TEMPERATURE
1	Mach 1	1.01325 bar	288 K
2	Mach 2	1.01325 bar	288 K

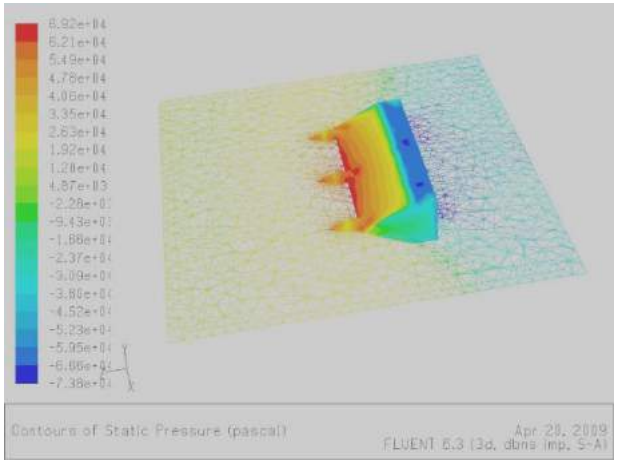
The 3D analysis graph shows the output of the static pressure and temperature, velocity magnitude and turbulent viscosity at various mach numbers. The three probes used for the analysis are fitted with a single wedge. This probe section is used for 3D graphical analysis. The following figures show the 3D analysis of the probe. Each probe separately shows the figures for their performance.

III.1.2.1 MACH 1

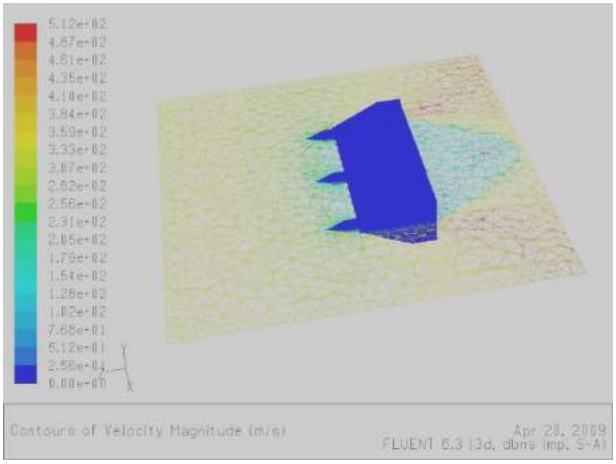
The following 3D graphical Fig.12 shows the three probes analyzed with the same condition. In the 3D analysis method, to get the accurate result of the air flow,

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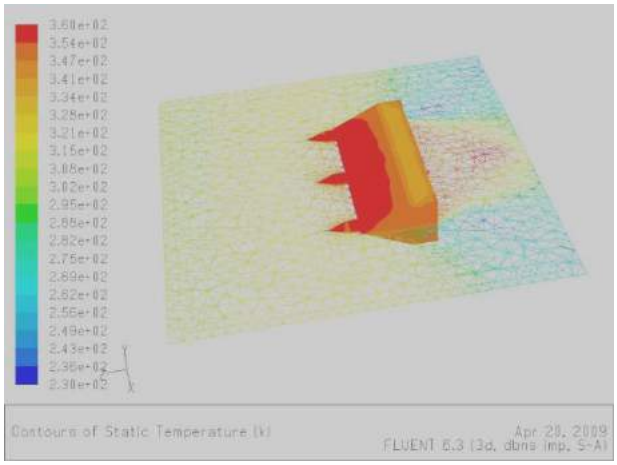
the wedge-type probe yaw meter is used and the various Mach number conditions are checked.



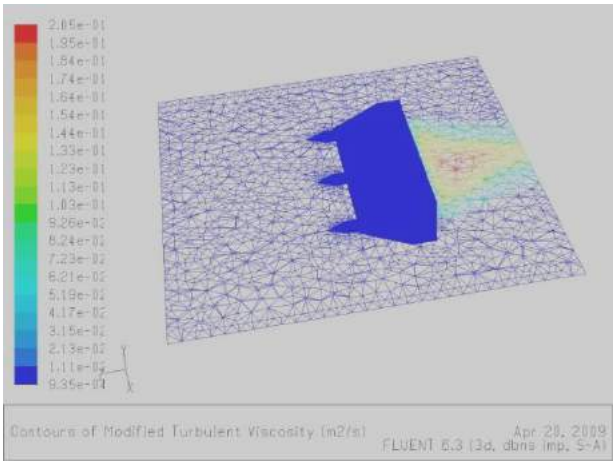
(a)Static Pressure



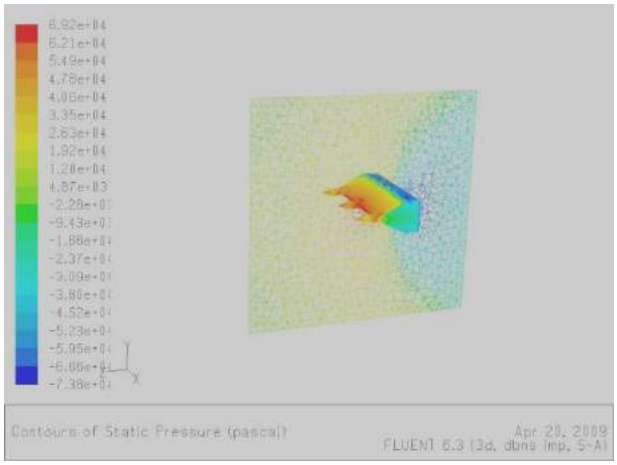
(b)Velocity Magnitude



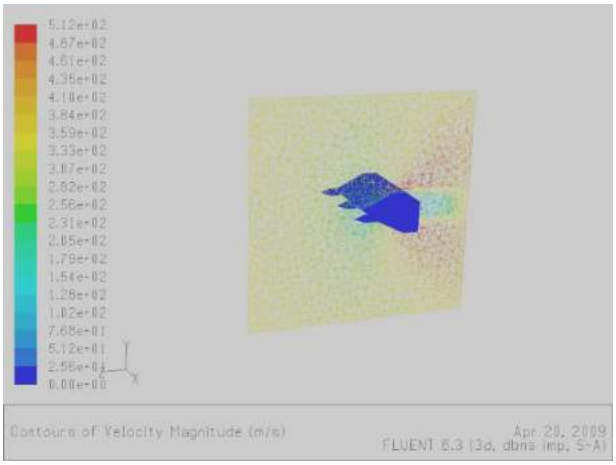
(c)Static Temperature



(d)Turbulent Viscosity

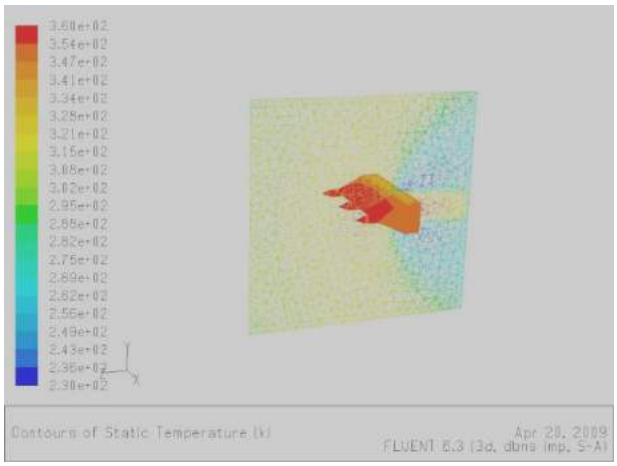


(e)Static Pressure

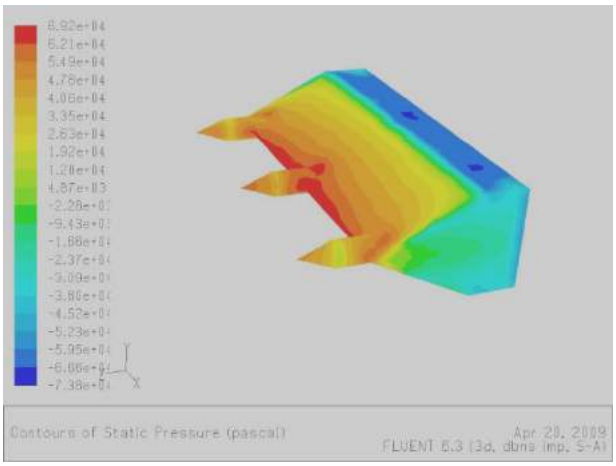


(f)Velocity Magnitude

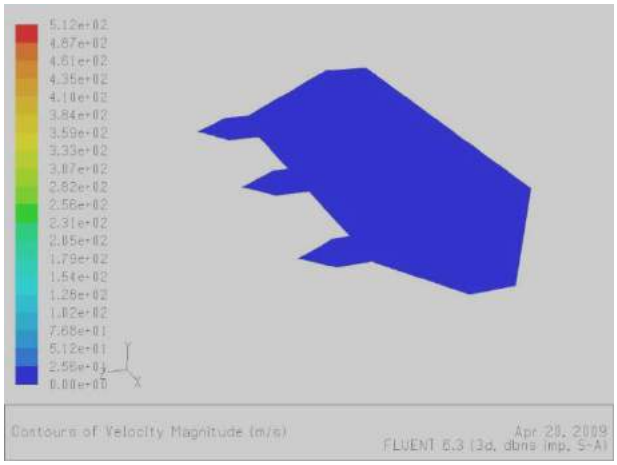
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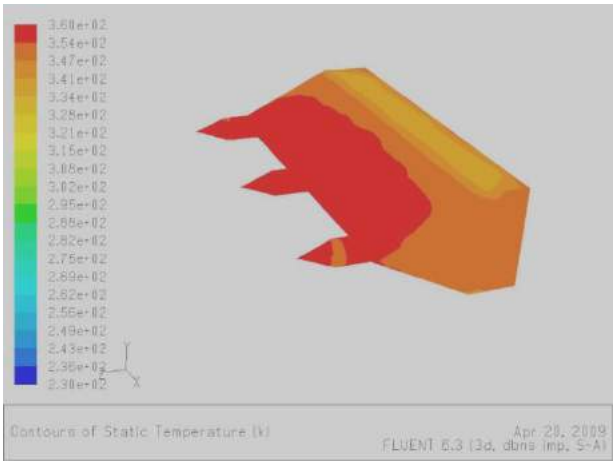
(g) Static Temperature



(h)Static Pressure



(i)Velocity Magnitude



(j)Static Temperature

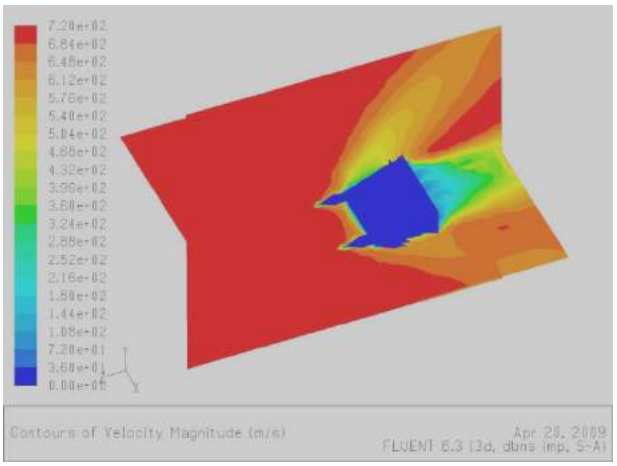
Fig.12. MACH 3 Output responses of the conical four-hole probe

In MACH 1 condition, the probe set is analyzed with the ambient pressure and temperature 1.01325 bars and 288K respectively. The wedge type conical four-hole probe is analyzed with the identical condition of the single probe. Fig (a), (b), (c), and (d) show the static pressure, velocity magnitude, static temperature and turbulence viscosity of the wedge type three probes respectively. The static pressure of the wedge probe is represented by yellow color in Fig (a). The velocity of the air flow is shown as yellow color in Fig (b) and the minimum speed in wedge surface of the probe is represented by blue color. The maximum static temperature is illustrated as red color on the wedge surface in Fig (c). The remaining figures show the different position or angles of the wedge probe. Fig (e) depicts the lower side of the wedge probe static pressure and also its rear side which with minimum pressure attains medium value. The Fig (h) shows the static pressure of the wedge type probe on its surface. The colors indicate how the probe gets affected by the pressure. Fig (f) shows the velocity of the probe in rear side. The light blue color shows that the velocity is getting reduced to the minimum level and is very high at their sides.

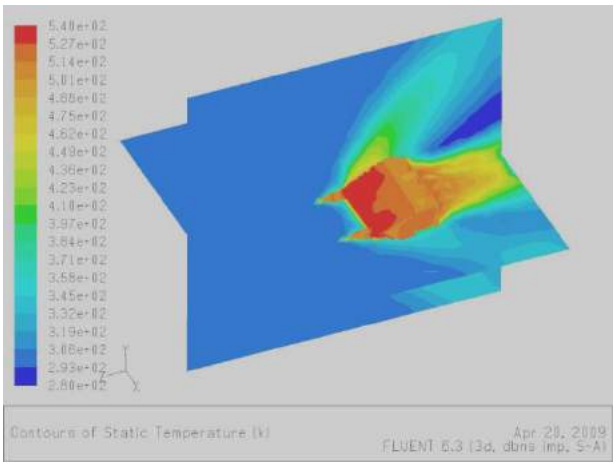
III.1.2.2 Mach 2

Fig.13 shows the wedge type probe in mach 2 condition. The static pressure of the wedge-type probe is shown in Fig (d) which is fully spread in the probe and wedge of the probe. The Figs (e)-(l) illustrate the different positions of the probe.

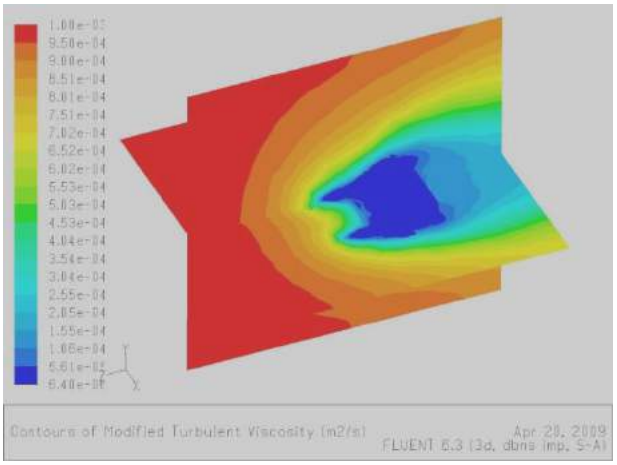
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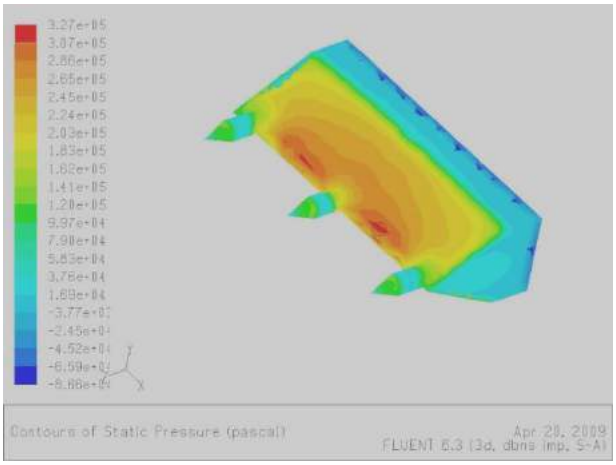
(a)Velocity Magnitude



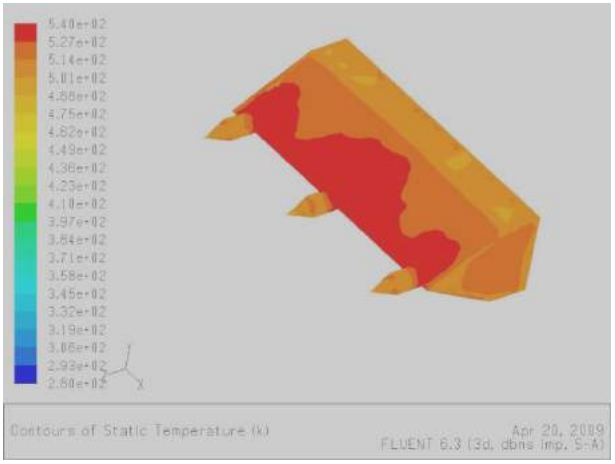
(b)Static Temperature



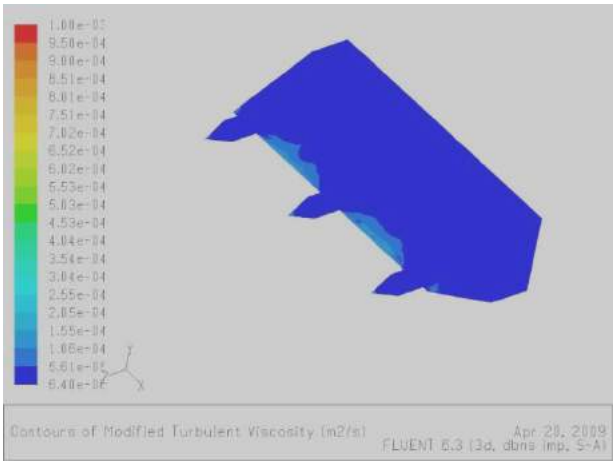
(c)Turbulent Viscosity



(d)Static Pressure

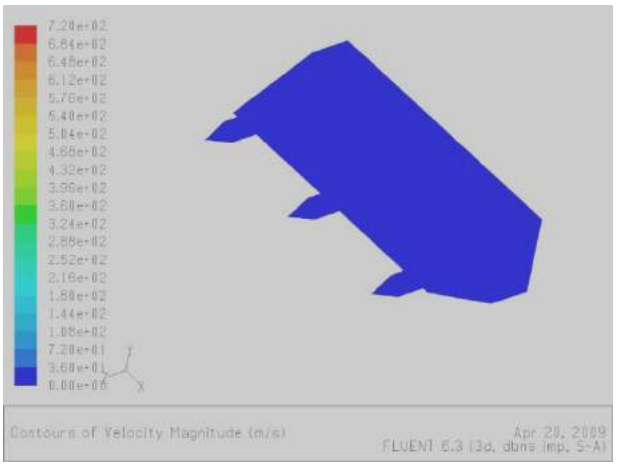


(e)Static Temperature

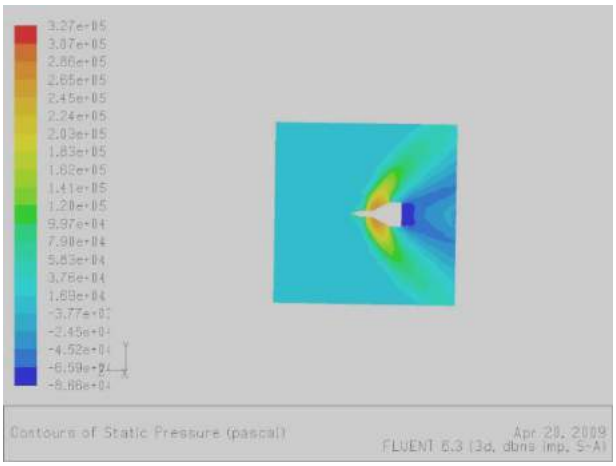


(f)Turbulent Viscosity

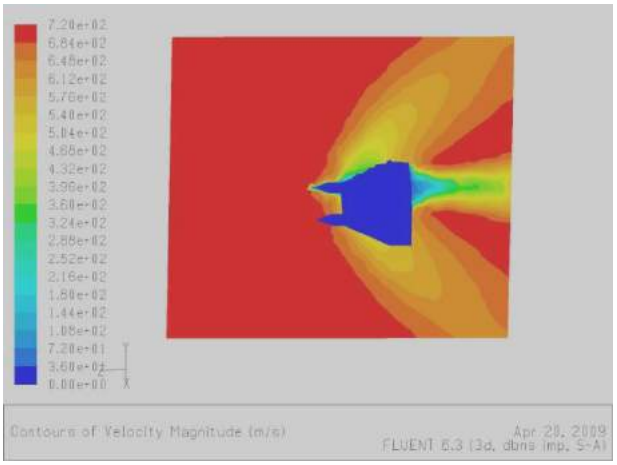
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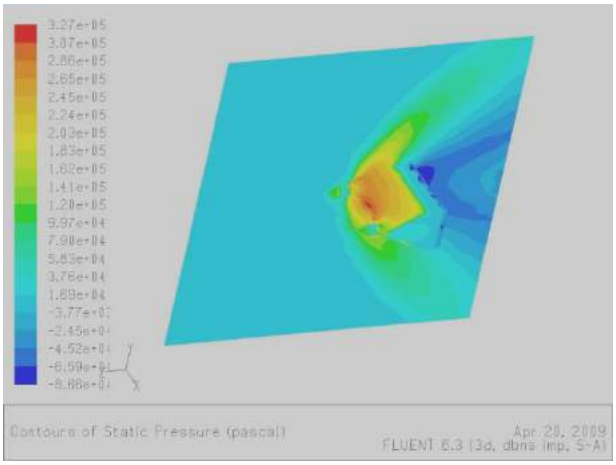
(g)Velocity Magnitude



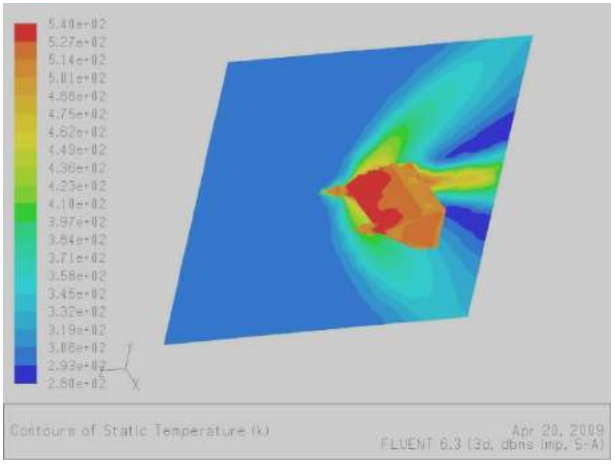
(h)Static Pressure



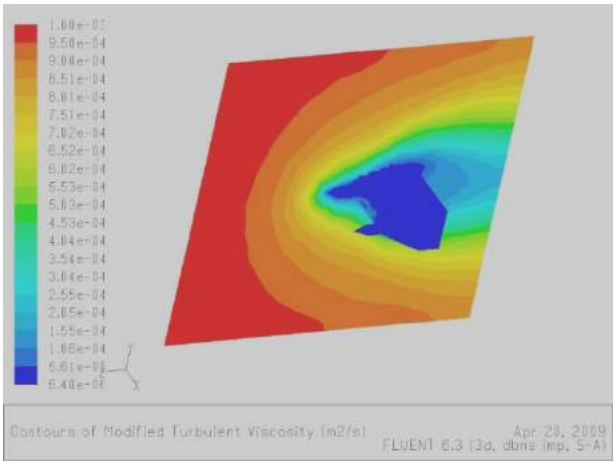
(i)Velocity Magnitude



(j)Static Pressure



(k)Static Temperature



(l)Turbulent Viscosity

Fig.13. MACH 3 Output responses of the conical four-hole probe

In Mach 2 condition, the static pressure of the probe at tip turns out medium values. But the pressure is maximum in wedge surface of the probe as shown by the yellow color in Fig (a) and the rear side of the probe attains minimum value represented by the light blue color in the figure. The static temperature is maximum in slope of the wedge and at probe side shown as red color in Fig (b). It is clearly shown in Fig (e). The velocity furnished in Fig (a) is the maximum in outer side of the probe as indicated by the red color but at the surface of

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the wedge it is low as shown by the blue color. The Figs (e) and (k) show the static temperature of the probe which indicates that temperature is high in front side and rear side with minimum variation as indicated by the brown and yellow colors respectively. Figs (g) and (i) indicate the velocities of the probe in both sides. The green color represents the medium value at the tip of the probe and maximum at side of the probes. The different positions of the wedge type probe are shown in the various Figures. From the 3D analysis method, it is clear that as the Mach number increases, the pressure flow also gets diverged. The shock wave is formed in the detached form of the waves.

IV. Conclusion

The wedge type three conical probes or yaw meter is planned by their shock wave angle and made-up according the pre-specified dimensions. The captioned wedge type probe (yaw meter) setup is made to effective scrutiny and fruitfully experimented by means of the CFD 2D and 3D investigation techniques. With the result, the mach value tends to enhance, with the shock wave angle getting reduced. At the supersonic level, the planned probe puts in check the pressure and temperature of the air flow at mach 2.8 and to the tune of mach 3 levels. The captioned wedge type probe is exploited in the horizontal motion and the yaw axis angle moments are estimated. It is formulated with the help of the stain less steel material for its stiffness. The days are not far off when these alloy materials are combined similar to the blending of titanium and ceramics for reinforcing the material in elevated temperature values and superior hardness metals and also to design the yaw meter setup either in vertical axis basis or in both axis moment basis for reaping rich harvests in performance of the yaw meter.

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