Development and Calibration of Pressure Probe: A Review

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***Abstract* -** Multi-hole probes are fluid flow instruments that measure pressure along pressure ports arranged on their tips. With proper calibration, this information can return three components of the fluid velocity as well as static and dynamic pressure. With the development of modern methods like laserDopplervelocimetry, particle-image velocimetry and others, the use of these probes has declined. But the emergence of miniature pressure sensors and modern electronics new multi-hole probes were designed and tested to match some of the features of other methods. Multi-hole probes are robust, and can sustain harsh environments, like very high temperatures, opaque fluids, flows carrying particulates and others. The use of probe is comparatively easy and inexpensive. The present paper includes review on recent developments in multi-hole probe technology. These technologies are instrumentation and calibration methods that increase the probe's frequency response, allow probes to take data in wide ranges of the Mach number. This review shows that probes can be effectively used for measuring the three dimensional flow fields.

***Index Terms* -** *Pressure probe, wind tunnel*

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I. INTRODUCTION

The multi hole probe is a pressure measurement technique, which was firstly presented in 1980 by Gallington and Sisson. It is capable of providing quantitative information about the three dimensional flow field of the flow velocity vector, as well as about the stagnation and static pressures. It's simple shape, relatively easy construction and low cost established it in one of the most used techniques for velocity and pressure fields surveys on wind tunnel tests. In the literature, a large number of papers where the experimental results were obtained using this measurement technique can be found. In the field of aerodynamic research, Pitot - static tube was used to measure the velocity of the stream. Pressure manometers have also been used to measure the difference between total and static pressure, and thus allow the calculation of the velocity, if the density of the fluid was known. Accurate measurements can be obtained with pitotstatic tube if the flow is uniform and if the probe is nearly aligned with the direction of the flow velocity. Both conditions represent significant limitations for the measurement of the velocity at a point within a flow field. Still pitot-static probes are extensively used where the direction is known a priori, or if the direction of the flow does not change significantly. The design of modern Multi-Hole Probes (MHP) for the measurement of flow velocity is based on the principle of operation of a Pitot-static tube.

II. LITERATURE REVIEW

The papers manage outline, examination and execution of test with various openings. Some papers and reports are given underneath as a piece of writing overview.

S.J. Lien et.al [1], In this paper creator had concentrated on the issues of misalignment to stream course and the need to penetrate a tapping gap on an estimation surface to get aggregate and static weights make the utilization of Preston test in skin erosion estimation in a turbulent stream a lumbering errand. The appropriateness of a multi-gap weight test in a non-nulling mode to beat these issues was, along these lines, explored. The close divider impact on multi-gap weight test readings was inspected both tentatively and hypothetically. The outcomes show that the nearness of the divider had insignificant general impact. Tests were completed in a funnel, on a level plate and on a cleared forward confronting venture to mimic one, two, and three-dimensional turbulent streams. The skin grating coefficient decided utilizing the multi-gap weight test was found to have great concurrence with distributed information. Since the system depends on comparability rule with test distance across as a trademark parameter.

M. Yasar et.al [2], Author researched a multi-tube weight test adjustment strategy for estimations of mean stream parameters in twirling streams. A basic and touchy estimation technique for multi-tube weight tests relevant in whirling stream fields is exhibited in this paper. Determination of stream heading connected with neighborhood pitch, , and yaw, , points, extents of nearby static and element weights can be accomplished through an alignment strategy utilized with 3- and 5-tube renditions of a multi-tube weight test. The 5-tube test was tried in an ordinary air violent wind where a solid rotational stream won while the 3-tube test was utilized as a part of a low twirl stream field in a channel inside fitted with a helical curled wire embed. The technique depends on the rotational affectability of the weight test took care of through non-dimensional adjustment parameters.

L.J. Fingersh et.al [3], This examination demonstrates that the Wind Tunnel Calibration of 5-Hole Pressure Probes for Application to Wind Turbines. A technique to measure the neighborhood inflow vector on a pivoting turbine cutting edge utilizing a 5-gap static weight test was produced at the National Wind Technology Center. The system licenses measurement of element weight, approach and cross-stream edge to extents of 400 in any inflow course parallel to the test centerline. A depiction of the static and element adjustment system, cycle arrangement for information diminishment, and field results are incorporated.

A. R. Paul et.al [4], Author performed a novel adjustment calculation for five-opening weight test. Five-gap pneumatic weight tests are utilized to complete the steadystate estimations of three segments of speed, inflow edges, static and aggregate weights at the same time for a point in a stream field. Different alignment calculations for five-gap tests are considered in this paper as reported in the writing. Creators have characterized non-dimensional weight coefficients in various ways. In view of specific constraints, another arrangement of weight coefficients are proposed in this paper, which beat the impediments in the writing and gives less computational blunders in ascertaining the stream parameters. In this strategy, the impact of weight recorded by focal gap is considered in characterizing these coefficients.

H.K. Sung et.al [5], this paper demonstrates the Calibration of a Five-Hole Multi-Function Probe for Helicopter Air Data Sensors. In the flight of air vehicles, precise air information data is required to control them adequately. Particularly, helicopters are regularly placed in radical movement included with high edge of assaults keeping in mind the end goal to perform troublesome missions. Among different sensors, the multi-function probe (MFP) has been utilized as a part of the present concentrate for the most part attributable to its points of interest in auxiliary straightforwardness and ability of giving different data, for example, static and aggregate weight, speed, and pitch and yaw edges. In this study, a five-hole multi-function probe (FHMFP) is created and its adjustment is directed utilizing different relapses. In this work an adjustment study on the FHMFP, an air information sensor for helicopters, is accounted for. It is demonstrated that the pitch and yaw edges precision of alignment is 0.910 at a cone point of 00 to 300 and 200 at 300, 430, separately.

A.J. Pisasale, et al [6], His study delineate the A novel technique for amplifying the adjustment scope of five-opening test for very three-dimensional streams. Five-gap test utilized as a part of a non-nulling way to discover obscure stream properties is restricted to a low scope of acknowledgment edges because of peculiarity experienced in the alignment technique. A novel technique to augment this reach by evading peculiarity is created permitting alignment of a five-gap test up to much bigger edges of pitch and yaw. The technique has been tried utilizing exploratory adjustment information of a five-gap test that were acquired utilizing the 18in.subsonic shut circuit wind passage of the University of New South Wales at the wind burrow pace of 15 m/s. The new technique demonstrates that the alignment extent can be effectively reached out to points of up to 750.

K.M. Argüelles Díaz [7] contemplated the impact of the head geometry on the execution of various kind of tests. Three distinctive geometry had been tried as appeared in fig.1 He presume that the cobra sort tests give the biggest agent precise reach, while tube shaped outlines minimize the blunders in the determination of both weight and speed stream variables when the Reynolds number or the pitch edge vary from the pattern alignment.

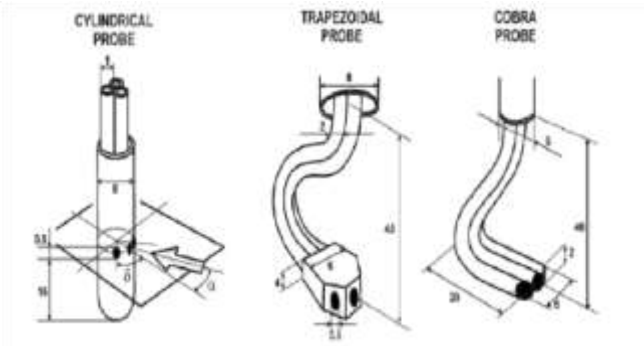

Fig.1 Sketch of the probe geometries: cylindrical, trapezoidal and cobra type.

III. CALIBRATION PROCEDURE

Multi-opening tests are solid and beneficial alternative to gauge stream edges, stagnation and static weights in complex stream situations. Estimation by such Multi-opening tests is sorted into two techniques; the adjusting one (null method) and the altered one (non-null method). In the invalid strategy, the test is turned so that the weights from the openings are adjusted with a specific end goal to quantify the stream course, static and aggregate weight. This technique, notwithstanding, requires a mind boggling test crossing component for the revolution of the test, which frequently makes trouble introduce the estimation unit into the given stream field. Alignment and information decrease require less exertion with the adjusting one (null method), yet it requires an unpredictable test crossing instrument and a base time to conform the test setting edge to the stream edge. In the non-nulling strategy, the test does not require any turn. In which the Multi-gap test is altered amid the test and the point is acquired from the differential weight over the inverse weight taps by a cautious alignment. The test alignment is typically done in a shut wind burrow or a free fly [5] at different stream headings. The test is turned to change the stream rate; while the test is kept stationary the weight level of every opening is recorded [5]. The stream heading is by and large communicated by a weight distinction between the test gaps. At that point, the non-dimensional weight contrasts are introduced in alignment maps [5]. The test will be aligned in the current wind burrow. Keeping in mind the end goal to investigate for an enhanced technique for adjustment that dodges peculiarity and extends the scope of alignment to higher pitch and yaw edges, an adjustment trial was performed. Alignment of these tests are frequently completed in an open plane wind burrow on account of the expansive blockage mistakes that happen when the adjustment set up is put in a shut wind burrow test area. The air quality as far as low turbulence and consistency of stream inside a shut test segment is, in any case, better than that of an open plane. Therefore, a test holder and rakish development instrument was particularly intended for alignment so that the system could be worked remotely by appending it outside to the highest point of the wind burrow test area. Pneumatic tests are still a valuable apparatus when examining stream fields inside turbo machines, falls or whatever other streamlined office. Because of the way that stream speed and stream bearing can't be measured specifically by the tests and also because of a few errors when fabricating the test's head, an alignment procedure is vital. Weight tests are instruments to gauge the nearby speed and the weight esteem in a stream. Alignment of a five-opening test requires subjecting the test to a known stream field at various blends of yaw and pitch points. Weights at all five openings are measured for each rakish position of the test. The deliberate information are spoken to as dimensionless weight coefficients. They are generally favored over other modern optical gadgets because of their upkeep and moderately minimal effort, and their strength and effortlessness of operation in various examination and mechanical purposes. Indeed, weight tests are broadly utilized as a part of turbo apparatus applications.

IV. YAW AND PITCH ANGLE

Pitch angle: The angle between the axis of the stack or duct and the pitch component of flow, i.e., the component of the total velocity vector in a plane defined by the traverse line and the axis of the stack or duct. (Figure illustrates the "pitch plane.") From the standpoint of a tester facing a test port in a vertical stack, the pitch component of flow is the vector of flow moving from the center of the stack toward or away from that test port. The pitch angle is the angle described by this pitch component of flow and the vertical axis of the stack. Yaw angle: The angle between the axis of the stack or duct and the yaw component of flow, i.e., the component of the total velocity vector in a plane perpendicular to the traverse line at a particular traverse point. (Figure illustrates the "yaw plane.") From the standpoint of a tester facing a test port in a vertical stack, the yaw component of flow is the vector of flow moving to the left or right from the center of the stack as viewed by the tester. (This is sometimes referred to as "vortex flow," i.e., flow around the centerline of a stack or duct.) The yaw angle is the angle described by this yaw component of flow and the vertical axis of the stack.

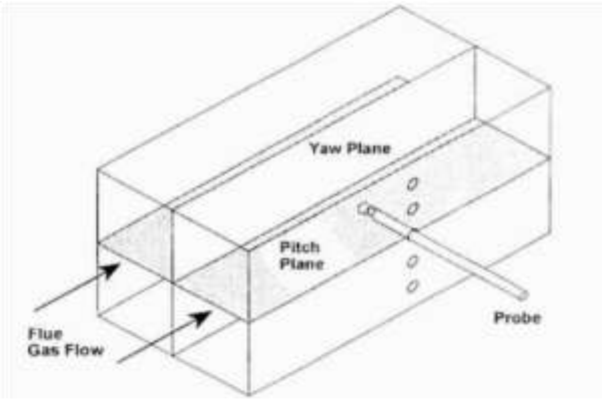

Fig.2 Pitch and Yaw planes in Duct (Test section)

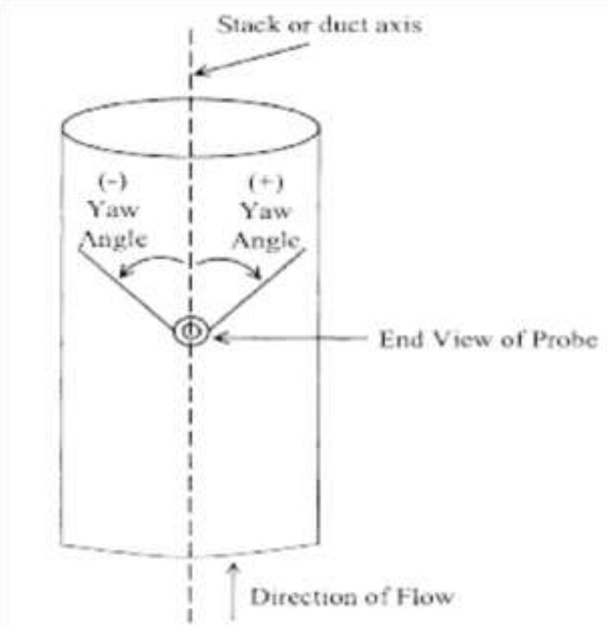

Fig.3 Probe rotation representing positive and negative yaw angle.

V. CONCLUSION

The design of modern Multi-Hole Probes (MHP) for the measurement of flow velocity in x ,y and z direction is based on the principle of operation of a Pitot-static tube. From this paper we conclude that,

[1] Multi-hole probes are robust, and can sustain harsh environments, like very high temperatures, opaque fluids, flows carrying particulates and others.

[2] Moreover, they are easier to use and less expensive.

[3] In the present paper I review recent developments in multi-hole probe technology, namely, instrumentation and calibration methods that increase the probe's frequency

response, allow them to take data in wide ranges of the Mach number, and correct for inertial effects.

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 153164, 2011.

[2] M. YasarGundogdu "A multi-tube pressure probe calibration method for measurements of mean flow parameters in swirling flows." Department of Mechanical Engineering, University of Gaziantep, 27310-GaziantepTurkey Received 25 July 1997; accepted 25 June 1998.

[3] L.J. Fingersh, M. C. Robinson. "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] AkshoyRanjan Paul "A novel calibration algorithm for five-hole pressure probe" International Journal of Engineering, Science and Technology Vol. 3, No. 2, 2011, pp. 89-95.

[5] 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.

[6] A.J. Pisasale, N.A. Ahmed. "A novel method for extending the calibration range of five-hole probe for highly three-dimensional flows" School of
Mechanical and Manufacturing Engineering, The University of New South Wales, 2052 Sydney NSW, Australia Received 30 July 2001; received in
revised form 7 February 2002; accepted 12 March 2002

[7] K.M. Argüelles Díaz, J.M. Fernández Oro. " Head geometry effects on pneumatic three-hole pressure probes for wide angular range".University of Oviedo, Fluid Mechanics Group, Campus de Viesques, 33271, Gijón
(Asturias), Spain.