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Investigation the Effect on Coefficient of Filled and Unfilled Port to Port Dimension with Plaster of Paris of 2-Holes Offset Probe

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Abstract: : The velocity of fluid flow like slurry flow , mud , dusty air is determined by the two holes probe or s type probe .The pitot static (L-type probe)is chocked due to flow of slurry , mud , dusty air , stack gas .The dirty or dusty particles blocked the L-type pitot tube at 90^0 bend so, s-type probe is used to avoid this type of stops or blockage .In present study the s-type probe is fabricated and having diff-2 Angle of Probe and filled Port to Port dimension with plaster of Paris and compared to unfilled Port to Port dimension with plaster of Paris to control the accurately coe-fficient. In wind tunnel, an experiment is conducted to see the impact of filled and unfilled Port to Port dimension on coefficient. When angles increases with filled Port to Port dimensions then Intensity of turbulent flow is also less. Here more large eddies are present and coefficient values in set of data are smaller than or equal to normalized value (0.833). Therefore fluctuation in pressure difference is less. In the present study it is noticed that the value of coefficient more fluctuate at lowest velocity ranging from 3- 14 m/s.
Keywords: 2-Hole Offset Probes, S-type Pitot tube coefficients; Wind tunnel test; Stack gas velocity

I. INTRODUCTION

The 2-hole soffset probe (S-type) and static probe (L type) both velocity measurement device [1, 2]. The 2-hole soffset probe (S-type) and static probe (L type) incompatible in shape and configurations but their working principle is same [2,3].The two holes offset probe (s-type) is avoid the blockage due to flow of stack gas and slurry, mud etc [4, 5, 6] and The Static tube (L type) is blockage due the bent at an angle of 90^0 in between the length (nominal, Leg) Whenever the particles flow at the 90 degree bend of static tube then the particles trapped and blocked the flow of air or fluid [7,8]. So,static used without caliberate,while two holes offset probe is used.

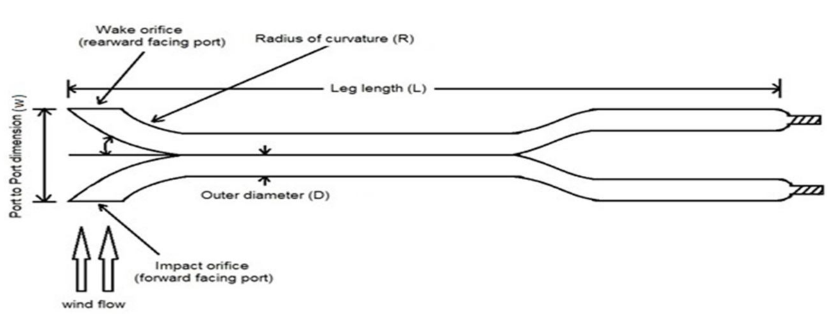

Fig 1: S-type probe and nomenclature

Trang et. al.(2012) [11] To see the impact on probe coefficient of various different parameters of probe.He was manufactured 5-different S-type tube. The findings showed that at range of velocity 0.2% - 0.7%, and hence there are large scattered in coefficient curve and coefficient curve more oscillates in low Reynolds number about(±1 %)

Further, and some values of coefficient in between 0.81 or 0.82 which is less than suggested value of 0.84 ± 0.01 [11].

However,Williams and Dejarnette(1977)[13] an experimental work is to be evaluated on the basis of fourteen different-2 parameters of probe to calculated out the consequences on coefficient.It experimental work was performed in subsonic wind tunnel of various different parameters of probe in range of velocity 4.52 - 30.45 m/s to carried out the impact of different-2 configurations on probe coefficient. It is also evaluated whenever velocity is increased then the values of coefficient is decreased, the values of coefficient which is less than value of coefficient 0.85 and the 5 percent of accepted value.

However, Kang at.al (2015)[2] worked to see the consequences on coefficient of process of manufacturing , configurations, geometry and improper installationsof tube [10].it is also calculated the rate of flow of industrial stack, dusty air, slurry flow in between 3000 to 22000 and the values of coefficient were smaller than 0.3% to 1.2%.it also determined that whenever change in the values of Reynolds number then there is not scattered values of coefficient if the pitot tube manufactured properly.

In the present experimental work, we observed that the first time variation in the pitot coefficient with changes in the velocity 0.90m/s to 33.34m/s is evaluated. Therefore an experiment is conducted to see the impact of filled and unfilled Port to Port dimension is found to see the impact on coefficient in the Reynolds number[11,13,14].We evaluated that the large fluctuation in coefficient in between the velocity 3 -14 m/s.it is also found that when angles increases with filled port to port dimensions then Intensity of turbulent flow is also less. Here more large eddies are presentand coefficient values in set of data are smaller than or equal to normalized value (0.833). Therefore fluctuation in pressure difference is less..it is found at low velocity the values of coefficient values has a slight dip. Hence, it is evaluated that if the dip is occurs is real and how it is varies in largest Reynolds number.

II. EXPERIMENTAL SETUP

A. Manometer

Pressure measurement by manometer is rather simple and inexpensive. A manometer consists of a U-tube by which pressure difference is measured by balancing the weight of a fluid column. Large pressure differences are measured with heavy fluids, such as mercury (e.g. 760 mm Hg = 1 atmosphere). Small pressure differences, such as those experienced at low speeds, are measured by lighter fluids such as water (in cm of H_2O or alcohol

B. Wind Tunnel

Three experiments which have different parameters were completed in wind tunnel .Firstly the higher rate of air flow in the settling chamber and the speed of air is maintain with the help of drive section,thereafter the air passes through the cone(contraction) due to shape of it the velocity is increased and hence caused difference in readings of pressure in manometer. The air goes from cone to test section where the model is tested. Then the velocity of air goes in the diffuser and the air goes into the atmosphere (as shown in Figure 2) [7,8,15].

1) At the test section (0.58m 0.34m 0.34m) centre in wind tunnel the both L and S type probe properly fixed in downstream location.
2) Both probes are connected properly within the flow so,the effect of pitch and yaw was not introduced.
3) Both probes are kept instant separatly so, there is no aerodynamic interference are occurs.
4) The manometer are connected with both pitot tubes with the help of plastic pipes.
5) The air leakage is checked around the test section centre of wind tunnel.

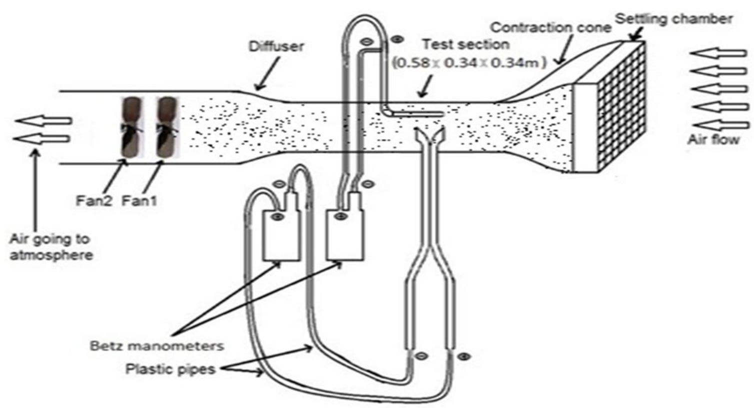

Fig 2: Systematic diagram of experimental setup.

C. Procedure of the Experiment

1) The frequency is raised with step 5 Hz when Fan-1 is switched on and and the frequency started from 0 -50 Hz.
2) The each data(readings) of pitot pressure is taken out from the manometer for both L and S type probe.
3) Now the frequency reached at 50HZ by the fan 1now the,switched on fan 2. 4. The increased in the frequency of fan 2 from 0-50 by a steps of 5HZ . so theoressure reading from the manometer is noticed for each step
4) The frequency is reached at 50hz through fan 2 so the frequency is noticed as 50+50 Hz.
5) Now slightly reduction in the frequency of fan 2 reached at 50-0HZ. And take data from the manometer,
6) In the Fan 1 frequency slightly reduce with a step of 5hz and reduced from 50-0HZ and note down reading of pressure of pitot from the manometer.

III. MATHEMATICAL FORMULA

S-type pitot coefficients are calibrated by comparing with corresponding coefficients of standard L-type pitot tube [13]. Manometer provides the values of $(\Delta p)_{std}$ and $(\Delta p)_{s-type}$. Thereafter, the coefficient of S-type pitot tube $(C_{p\,s-type})$ are calculated as

$$C_{p\,s-type} = \sqrt{\frac{(\Delta p)_{std}}{(\Delta p)_{s-type}}} \qquad (1)$$

Subsequently, the velocity is determined from the measured pressures on the fore and aft legs of the S-type probe tube from the following relations [14]

$$v_{air} = C_{p\,s-type}\sqrt{\frac{2(p_f - p_a)}{\rho_{air}}} \qquad (2)$$

where, $(p_f - p_a)$ is S-type probe pressure difference

p_f = pressure measure in the forward facing port (fore) of S-type probe (pa)

p_a = pressure measure in the rearward facing port (aft) of S-type probe (pa)

Reynolds number are calculated by following formula

$$Re = \frac{v_{air} \times D}{\vartheta_{air}} \qquad (3)$$

The value of ϑ_{air} (Coefficient of viscosity) was kept at $1.8958 \times 10^{(-5)}\ Pa - s$. D is the diameter of S-type pitot tube.

Lastly,

$$\text{Normalization of Cp} = \frac{\text{each value of Cp}}{\text{almost constant value occur of Cp}} \qquad (4)$$

IV. RESULT AND DISCUSSION

Result for 6.0 mm diameter of S-type probes at different angles with filled Port to Port dimension with plaster of Paris. All Experimental data as shown in Table 1.

1) *For 6.0 mm diameter of S-shaped probe at 25^0 angle and p-p dimensions filled with Plaster of paris.*

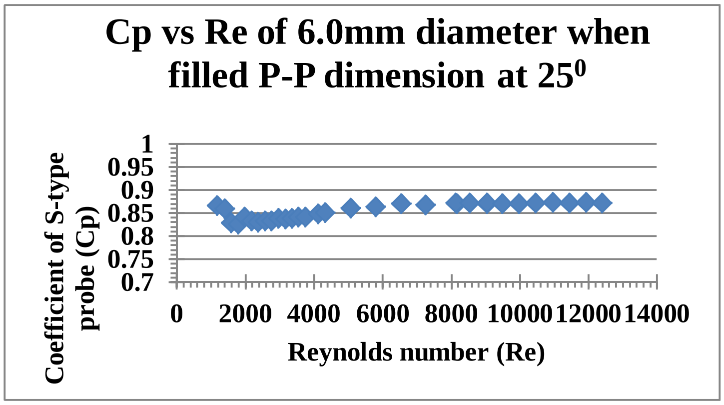

Fig 3: Reynolds number effects on the 6.0 mm diameter S-type probe at 25^0 with filled Port to Port dimension

From figure 3, it is observed that dip occurs for Reynolds number 1182 to 5073 and corresponding coefficient value ranges from 0.866 to 0.861. Experiment was conducted for filled port to port dimension with 0.0 mm inter tube spacing of 6.0 mm diameter of S-type probe at 25^0 angle in the range of 1182 < Re < 12404. Coefficient value shows more scatter for Reynolds number 1182 to 5812 and corresponding coefficient value range from 0.866 to 0.863. Thereafter coefficient value increases upto 0.870 where Reynolds number is 8169 and then shows nearly constant value. Therefore coefficient value (Cp) is normalized at 0.873 and 88.89% of coefficient values in set of data are smaller than or equal to normalized value (0.873). We have drawn the error bar for some coefficient point in the graph. The error in coefficient value decreases when Reynolds number increase, for Reynolds number range of 1500 to 4000 the error is in between ±5% and ±1%. Also for Reynolds number greater than 4000, error is less than **±1%**. After investigation we found that this type of error trend is shown in all experiments.

2) For 6.0 mm diameter of S-shaped probe at 60^0 angle with filled Port to Port dimension.

From figure 4, we can see that fluctuation in the pressure difference in filled port to port dimension of S-type probe at 60^0 angle is less than that of filled port to port dimension at 25^0. Intensity of turbulent flow is also less. Here more large eddies are present. Therefore fluctuation in pressure difference is less than that of at 25^0 angle. Experiment was conducted for unfilled port to port dimension with 0.0 mm inter tube spacing of 6.0 mm diameter of S-type probe at 60^0 angle in the range of 1182 < Re < 12423. From Figure 26, it can be seen that, coefficient value shows more fluctuation for Reynolds number 1577 to 7264 and corresponding coefficient value range from 0.794 to 0.842. Thereafter coefficient value decreases upto 0.835 where Reynolds number is 8169 and then shows nearly constant value. Therefore coefficient value (Cp) is normalized at 0.833 and 81.48% of coefficient values in set of data are smaller than or equal to normalized value (0.833). Experimental data is given in table 1.

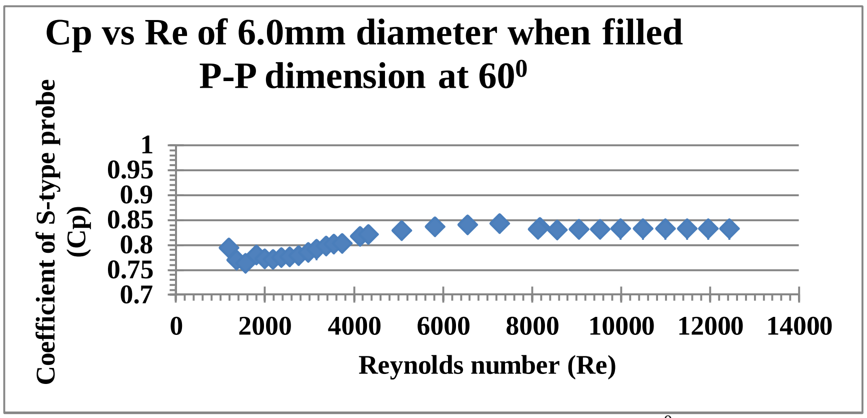

Fig 4: Reynolds number effects on the 6.0 mm diameter S-type probe at 60^0 with filled Port to Port dimension

3) For 6.0 mm diameter of S-shaped probe at 86^0 angle with filled Port to Port dimension

From figure 5, we can see that, fluctuation in the pressure difference in filled port to port dimension of S-type probe at 86^0 angle is less than that of filled port to port dimension at 60^0. Intensity of turbulent flow is also less. Here more intensity of large eddies is present. Therefore fluctuation in pressure difference is less than that of 60^0 angle. In this probe, fluctuation in pressure difference is mainly due to larger eddies.

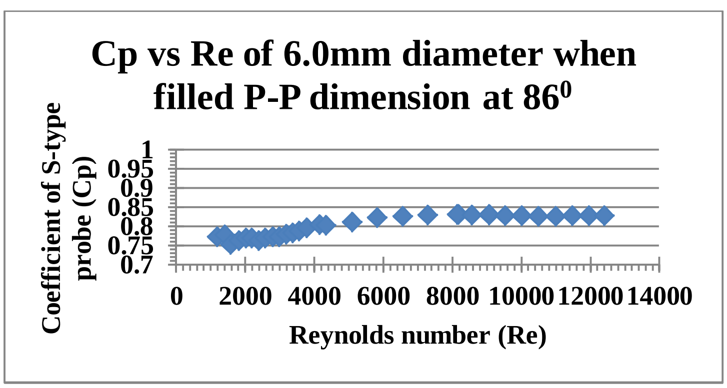

Fig 5: Reynolds number effects on the 6.0 mm diameter S-type probe at 86^0 with filled Port to Port dimension.

Experiment was conducted for unfilled port to port dimension with 0.0 mm inter tube spacing of 6.0 mm diameter of S-type probe at 86^0 angle in the range of 1182 < Re < 12404.

From Figure 5, it can be seen that, coefficient value shows more fluctuation for Reynolds number 1577 to 6556 and corresponding coefficient value range from 0.774 to 0.826. Thereafter coefficient value increases upto 0.830 where Reynolds number is 7288 and then shows nearly constant value. Therefore coefficient value (Cp) is normalized at 0.829 and 70.37% of coefficient values in set of data are smaller then equal to normalized value (0.829).

S.No.	Diameter (D) in mm	Port to Port dimension (w) in mm	Angle of bend (θ)	Dip occur	Experiment was conducted in the range of Reynolds number	Scatter in the range of Reynolds number and corresponding probe coefficient value	Flat curve show after Reynolds number	Normalizing value of probe coefficient	Coefficient value in the set of data are smaller and equal to normalized value
1	6.0	16.95	25^0	Not	1182 to 12404	1182 to 5812 (0.866 to 0.863)	8169	0.873	88.89%
2	6.0	16.95	60^0	Not	1182 to 12423	1577 to 7264 (0.794 to 0.842)	8169	0.833	81.48%
3	6.0	16.95	86^0	Not	1182 to 112404	1577 to 6556 (0.774 to 0.826)	7288	0.829	70.37%

Table 1:- Experimental Data for all Experiments

4) Combine results of Reynolds number vs coefficient of S-type probes at different angles with filled Port to Port dimension

It can be seen from figure 6 , coefficient value of filled Port to Port dimension of S-type probe at 25^0 angle is flat after Reynolds number 6000, but in 86^0 and 60^0 angles shows flat curve after Reynolds number 8000. Therefor we keep standard angle 25^0 in S-type probes. Fluctuation in pressure difference is decreased when the angle of S-type probe is increased. Fluctuation in pressure difference of 25^0 probe is higher than 60^0 probe. 86^0probe shows lowest pressure difference. Intensity of turbulent flow also decreases when the angle of S-type probe is increased for 6.0 mm diameter of S-type probes at different angle with filled port to port dimension.

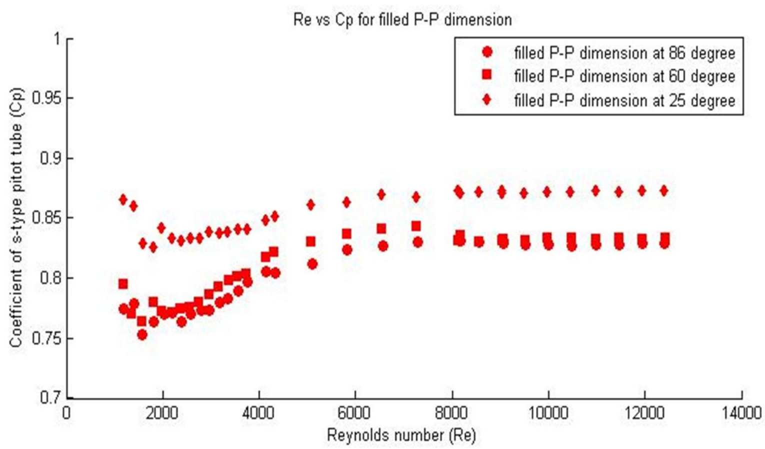

Fig 6: Combine graph of Reynolds number vs coefficient of S-type probes at different angles with filled Port to Port dimension

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5) Combine results of Reynolds number vs coefficient of S-type probes at different angles with unfilled Port to Port dimension

It can be seen from figure 7 that, graph of coefficient value of unfilled Port to Port dimension of S-type probe at 25^0 angle is flat after Reynolds number 3500, but in 86^0 angle shows flat curve after Reynolds number 8000. 60^0 angle does not show the flat curve of coefficient value. Therefor we keep standard angle 25^0 in S-type probes in unfilled Port to Port dimension. Fluctuation in pressure difference is decreased when the angle of S-type probe is increased. Fluctuation in pressure difference of 25^0 probe is higher than 60^0 probe. 86^0probe shows lowest pressure difference. Intensity of turbulent flow also decreases when the angle of S-type probe is increased for 6.0 mm diameter of S-type probes at different angle with unfilled port to port dimension.

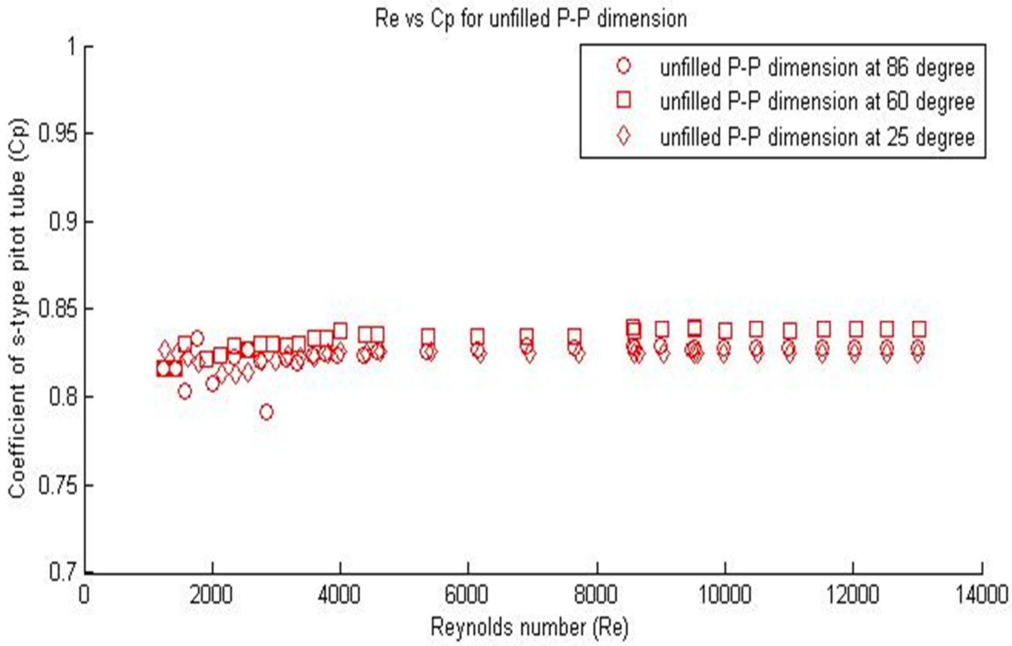

Fig 7: Combine graph of Reynolds number vs coefficient of S-type probes at different angles with unfilled Port to Port dimension

6) Compare results of unfilled and filled Port to Port dimension of S-type probes at 25^0 angle.

From figure 8, it can be seen that graph of coefficient value of filled Port to Port dimension of S-type probe at 25^0 angle shows flat curve after Reynolds number 6000, but coefficient value of unfilled Port to Port dimension shows flat curve after Reynolds number 3500. Therefore we keep standard angle 25^0 for S-type probes with unfilled Port to Port dimension for better accuracy. Intensity of turbulent flow of filled Port to Port dimension of S-type probe at 25^0 is less than that of unfilled Port to Port dimension. Fluctuation in pressure difference in unfilled Port to Port dimension of S-type probe at 25^0 is more than that of filled Port to Port dimension.

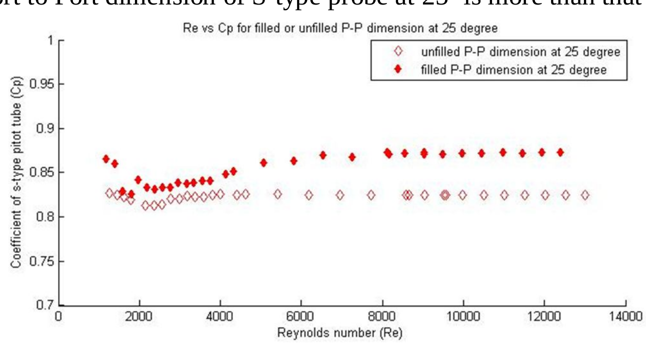

Fig 8: Compare the graph of unfilled and filled Port to Port dimension of S-type probes at 25^0 angle

7) From figure 9, it can be seen that graph of coefficient value of filled Port to Port dimension of S-type probe at 60^0 angle

Shows flat curve after Reynolds number 8000, but coefficient value of unfilled Port to Port dimension does not shows the flat value curve. Intensity of turbulent flow of filled Port to Port dimension of S-type probe at 60^0 is less than that of unfilled Port to Port dimension. Fluctuation in pressure difference in unfilled Port to Port dimension of S-type probe at 60^0 is more than that of filled Port to Port dimension.

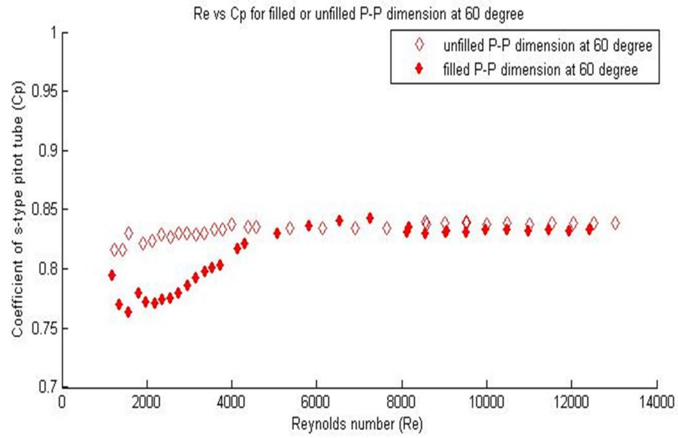

Fig 9: Compare the graph of unfilled and filled Port to Port dimension of S-type probes at 60^0 angle

8) Compare results of unfilled and filled Port to Port dimension of S-type probes at 86^0 angle.

From figure 10, it can be seen that graph of coefficient value of both S-type probes (filled and unfilled Port to Port dimension) at 86^0 angle show flat curve after Reynolds number 8000. Intensity of turbulent flow of filled Port to Port dimension of S-type probe at 86^0 is less than that of unfilled Port to Port dimension. Fluctuation in pressure difference in unfilled Port to Port dimension of S-type probe at 86^0 is more than that of filled Port to Port dimension.

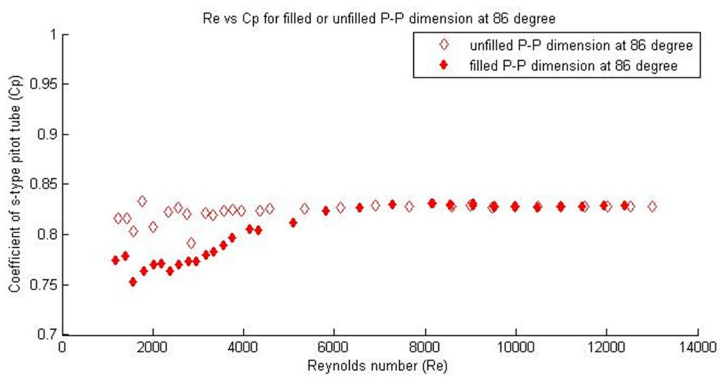

Fig 10: Compare the graph of unfilled and filled Port to Port dimension of S-type probes at 86^0 angle

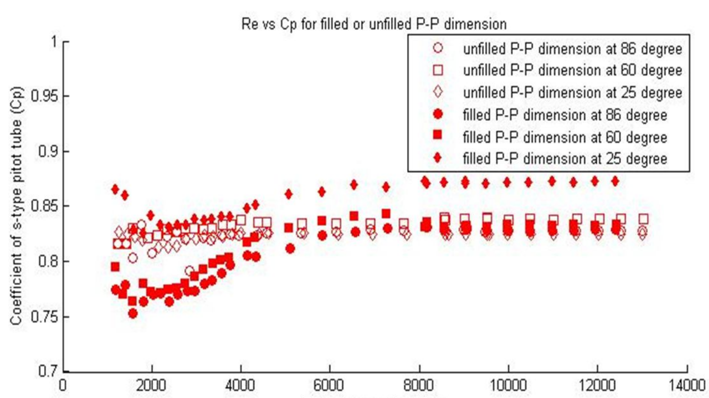

Fig 11: Combine graph of Reynolds number vs coefficient of S-type probes at different angles with filled and unfilled Port to Port dimension

The probe coefficient of S-type probes shows more fluctuation in the range of Reynolds number from 900 to 4000 and shows almost constant value after that, therefore coefficient of S-type probes is normalized, after normalization we compare the result of 6.0 mm diameter of S-type probes at different angles.

V. CONCLUSION AND FUTURE APPLICATIONS

The low Reynolds numbers behaviour of 2-hole offset probes are studied by testing the S-type probes in a standard air speed system. Factors that affect the probe coefficient were also studied. On the basis of discussion following conclusions are drawn:

1) The coefficient value shows more scattered value at low range of Reynolds number than larger one.
2) It is also observed that no consistent dip occurs.
3) S-type probes showed very scattered value of probe coefficients in the range of 650 to 4000 Reynolds number (corresponding velocity 3m/s to 14 m/s) and displayed almost constant values after that.
4) Additionally, for the Reynolds number greater than 4000, probe coefficient is almost constant and scatter lies between $\pm$ **1%** , which corroborates with result of Kang and colleagues [2].

Coefficient value scatters for wide range of velocity, it is also found that when angles increases with filled port to port dimensions then Intensity of turbulent flow is also less.

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