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The Experimental analysis on effect of low Reynolds number on probe coefficient having different-2 intertube spacing of S-type 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 ptobe .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 900 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 different intertube spacing with different port-port dimensions to control the accurately coe-fficient. In wind tunnel, an experiment is conducted to see the impact of different –different intertube spacing on coefficient. In the present study it is noticed that the value of coefficient more fluctuate at lowest velocity ranging from 3- 14 m/s. It is found that the when raising in intertube spacing then fluctuation in pressure is reduced.

Keywords: S-type pitot tube, Reynolds number, probe coefficient, velocity, Wind tunnel, Stack gas

1. 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] . 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. 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 numbarabout(±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.

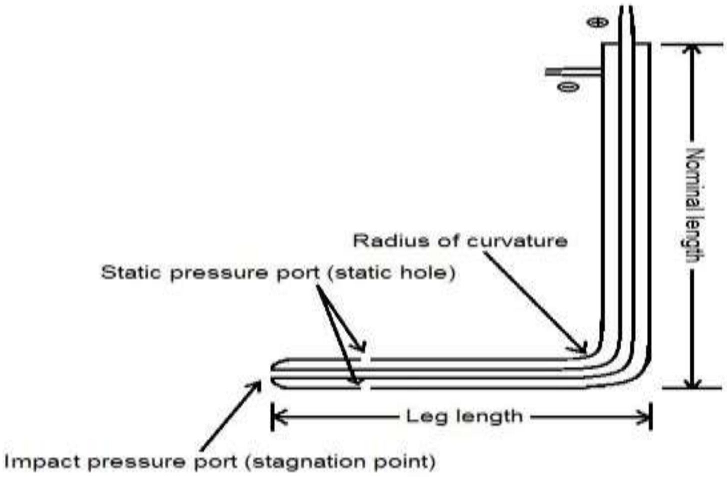

Fig 1: L-type probe and nomenclature

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.

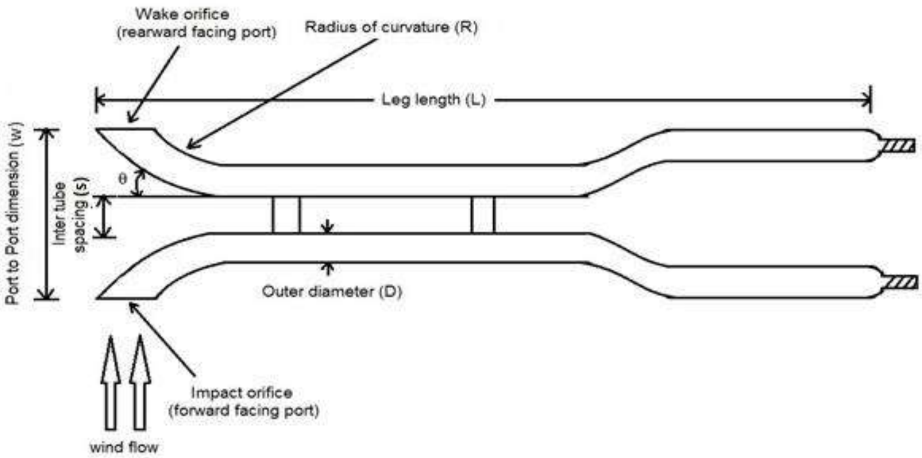

Fig 2: S-type probe with intertube spacing and nomenclature.

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 2-holes offset probe (S-type) of different intertube spacing (0 , 2.5 ,5.0 , 7.5 , 10.00) in mm 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 intertube spacing with port to port dimensions increases then the fluctuation in pressure is decreases.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.

2. RESEARCH METHODOLOGY

2.1 Experimental Setup

Five 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].

2.2 Physical description of apparatus

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.

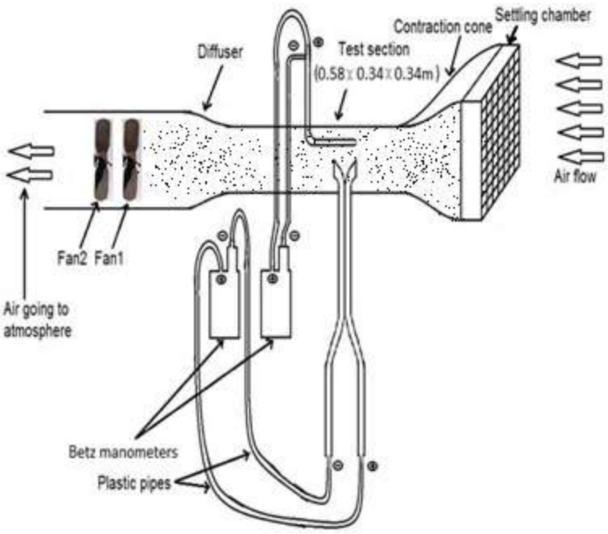

Fig 3: Systematic diagram of experimental setup.

2.3 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
5. The frequency is reached at 50hz through fan 2 so the frequency is noticed as 50+50 Hz.
6. Now slightly reduction in the frequency of fan 2 reached at 50-0HZ. And take data from the manometer,
7. 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.

3. 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 [14,20]

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

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,

$$\text{Normalization of Cp} = \frac{\text{each value of Cp}}{\text{almost constant value occur of Cp}}$$

.

4. RESULTS AND DISCUSSION

S.No.	Diameter of tube	Inter tube spacing	Dip	Range of Reynolds number	Scatter of coefficient in Reynolds number and their coefficient value	Flat curve after Reynolds number	Normalization of coefficie-nt value	Value of cp is smallest and equal to normalization value
1	6.0mm	0.0 mm	Not	937-13008	937-5349 (0.858-0.826)	6897	0.828	81.81%
2	6.0mm	2.5 mm	Not	1050-12812	1050-4499 (0.832-0.850)	10320	0.843	42.42%
3	6.0mm	5.0 mm	Not	1057-12940	1057-7601 (0.866-0.851)	9449	0.847	30.3%
4	6.0mm	7.5 mm	Not	1053-12884	1053-7575 (0.832-0.846)	9893	0.841	33.33%
5	6.0mm	10.0 mm	Not	1057-13930	1057-7593 (0.848-0.855)	9902	0.850	60.6%

Table 1. Experimental data of tube of 6.0 mm diameter at different-2 inter tube spacing.

3.1 Effect of S-type probes with different-2 intertube spacing at 86^0 fixed angle and fixed 6mm diameters of probe.

An example of coefficient S-type pitot tube of scatter value for intertube spacing at 0mm having Reynolds value 937 < Re < 13008 is illustrated in Figure 4. It is observed that fluctuation in pressure difference of pitot between Port A and B because of unstable turbulence patterns shedding from the forward facing port and flowing over the rearward facing port. Effect of pitot pressure of the forward facing port to the rearward facing port is large because inter tube spacing is zero mm dimension .Therefore, pressure fluctuation is wide than that of large inter tube spacing.

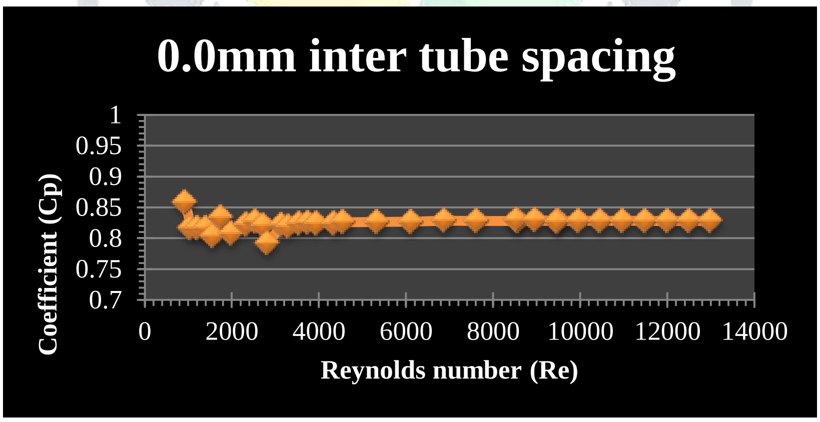

Fig 4: Reynolds number effects on the 0.0 mm intertube spacing of S-type probe.

The Coefficient shows large scatter in Reynolds number 937-5349 and corresponding coefficient value ranges from 0.858 to 0.826. Thereafter,Coefficient value raised upto 0.839 at which Reynolds number is 6897 and after that shows approximately constant coefficient. Therefore,The coefficient(Cp) is normalized to 0.828 and 81.81% of coefficient in fixed of data are smallest than or equate to normalized value (0.828)as shown in figure 4,it is observed that there is no dip in the coefficient value.Similarly, The coefficient S-type pitot tube of scatter value for intertube spacing at 2.5mm having Reynolds value 1050 < Re < 12812 is illustrated in Figure 5 ,here intertube spacing is large as comared to 0.0mm inter tube spacing and so, The consequence of pitot pressure between port A and B is less. Here large eddies are induced in between port A and B due to less flow sepration as compared to 0.0mm inter tube spacing. Therefore, fluctuation of pitot pressure difference is less.

As shown in figure 5,It is measured that there is no dip in the coefficient value. Experiment was performed for S-type probe with 2.5 mm inter tube spacing in the range of 1050 < Re < 12812. The mor fluctuation occurs in ranging of Reynolds 1050 to 4499 and its corresponding coefficient from 0.832 - 0.850. after that, coefficient value reduced to 0.843 at which the Reynolds number is 10320 and after that shows nearly constant value of coeffiient. Hence,value of coefficient (Cp) is normalized at 0.843 and 42.42% in the suggested value 0.843 of coefficient.

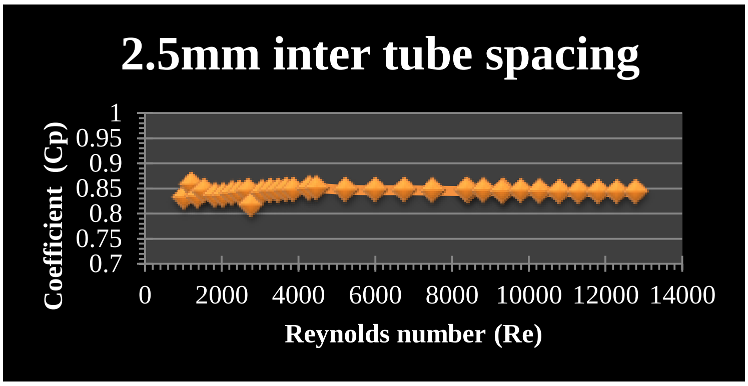

Fig 5: Reynolds number effects on the 2.5 mm intertube spacing of S-type probe.

Likewise, all the calculation values for other different intertube spacing are calculated and summarized in Table 1 and illustrated in Figure 6. Experiment was conducted for S-type probe with different intertube spacing ranging from 0.0mm to 10mm mm and their respective dip, Reynolds value, onset of flat curve, normalizing value of probe coefficient, coefficient of S-type pitot tube, scatter in the range of Reynolds number and corresponding probe coefficient values are summarized in Table 1.

Change in the dynamics of coefficient of S-type pitot tube with Reynolds number are plotted in Figure 6. From Figure 6, it is found that coefficient value of 6.0 mm diameter of S-type probe at 86^0 angle with 0.0 mm port to port dimension shows flat curve after Reynolds number 4000, but other inter tube spacing (like 2.5, 5.0, 7.5 and 10.0 mm) do not show flat curve over entire range of Reynolds number. Fluctuation in pressure difference decreases when the port to port dimension of S-type probe is increased. Fluctuation in pressure difference of 6.0 mm diameter of S-type probe with 0.0 mm inter tube spacing is large than that of 5.0 mm inter tube spacing which in turn is larger than that of 10.0 mm inter tube spacing.

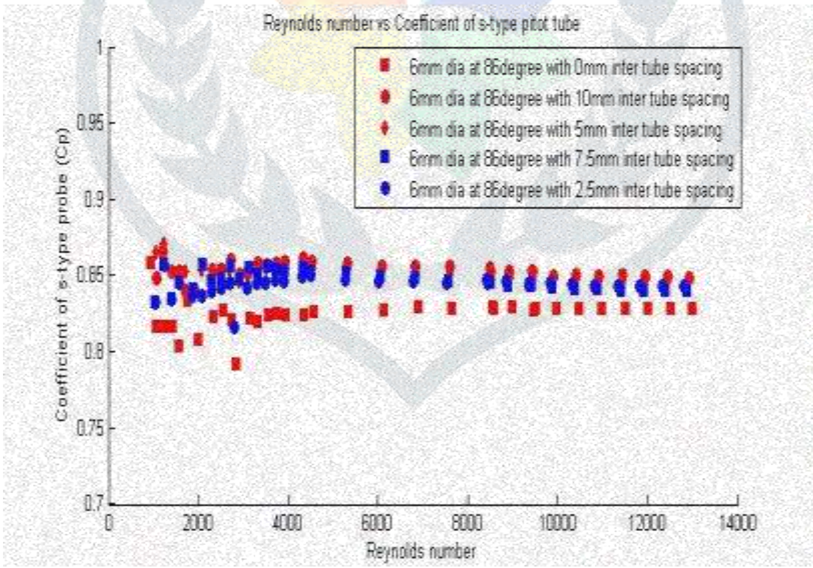

Fig 6: Combine graph of coefficient vs Reynolds number for different-different intertube spacing of probes.

When Port to Port dimension is small, pressure fluctuation is large because the stream is not stable and gap between ports is sufficient to generate the stream. If Port to Port dimension is larger, forward port pressure do not affect the rearward port.

Earlier researcher reported that with increase in the velocity there is slight reduction in the probe coefficient [9]. However, here show that probe coefficient of S-type probes shows large fluctuation in the pitot pressure in renging Reynolds number 1000-4000 and after that shows almost approximately constant value of coefficient,The coefficient of S-type probes is normalized, after normalization we compare the result of different intertube spacing of S-type probes [15,21].

	Diameter (D) in mm	Inter tube spacing (s) in mm	Turbulence intensity generation	Fluctuation in pressure difference
1	6.0	0.0	More than 2.5 mm inter tube spacing	0.11% more than 2.5 mm inter tube spacing
2	6.0	2.5	More than 5.0 mm	0.1% more than 5.0 mm
3	6.0	5.0	More than 7.5 mm	0.11% more than 7.5 mm
4	6.0	7.5	More than 10.0 mm	0.3% more than 10.0 mm
5	6.0	10.0	Less than 7.5 mm	0.3% less than 7.5mm

Table 2: Result of S-type probes of 6.0 mm diameter at 86^0 with different inter tube spacing

Klopfenstein reported low value of probe coefficient with lowering air velocity [16]. The high fluctuation in the coefficient at low Reynolds number has been also shown by Trang and colleagues [10].Afterwards, all normalisation values of coefficient value of S-type probes (Cp) with corresponding diameter of S-type probe are plotted in Figure 5. We found that dip only occur only 0.0mm intertube spacing and there is no dip with other intertube spacing. Dip occurs in S-type probes due to low value of Reynolds number.

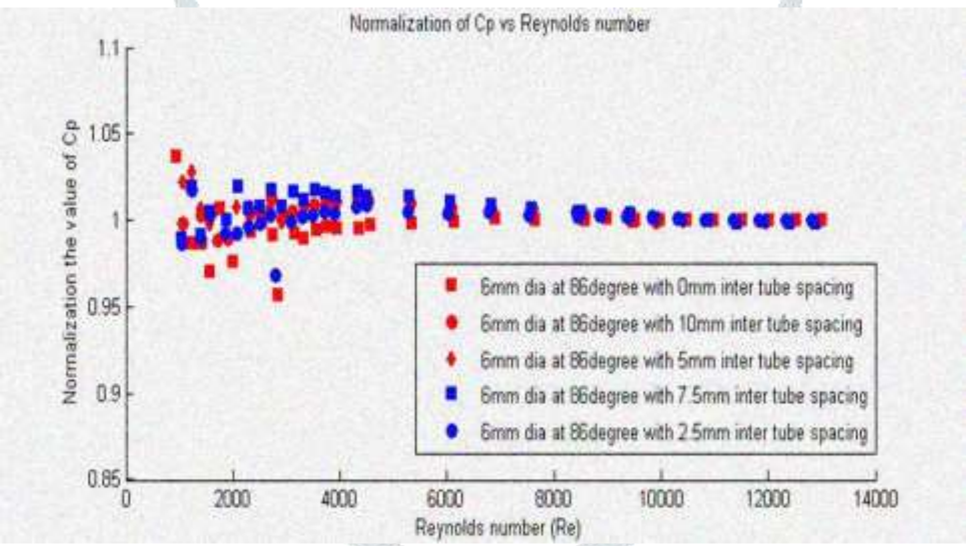

Fig 7: Normalization of coefficient vs Reynolds number for different-2 intertube spacing of probes.

4. Conclusion and future applications

The low Reynolds numbers behaviour of S-type probes are studied by testing the S-type probes in a standard air speed system. Factors that affect the probe coefficient were also studied. The following conclusions are drawn based on results and discussions:
1. Fluctuation of pitot pressure of 6.0 mm diameter with 86^0 angle of two holes probe at 86^0 angle and different intertube spacing is 0.0mm > 2.5mm >5.0mm>7.5>10.0mm .
2. Large eddies developed between port Aand B due to lesser flow sepration whenever increasing in intertube spacing.

3.Increasing in intertube spacing then fluctuating in pressure reduced so it is easy to gain data from manometer. But the area of approximately constant value of coefficient shifting at the higher ramnge of velocity .The tube shows scattered coefficients upto the velocity 19 m/s and after then that show approximately constant coefficient

4. It is also observed that no consistent dip occurs.
Our results showed that the Two hole offset probe (S-type probe) works efficiently even in slurry environment regardless of its diameters (0.0 mm to 10.0 mm) in measurement of air velocity. Though the current findings are based on wind tunnel the S-type probe is expected to show similar behaviour in chimneys to measure the velocity of stack gas and S-type tube tube is used in, Industries ,agriculture, chimneys ,aircraft to explore the utility of it.

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