Impulse Line Blockage Detection of Differential Pressure Transmitter by Using Blockage Factor Technique

Vidya D. Aswar[1], Surajkumar V. Sawai[2], Meera A. Khandekar[3]

M. Tech Student, Dept. of Instrumentation and Control, College of Engineering, Pune, Maharashtra, India [1]

M. Tech Student, Dept. of Instrumentation and Control, College of Engineering, Pune, Maharashtra India [2]

Assistant Professor, Dept. of Instrumentation and Control, College of Engineering, Pune, Maharashtra, India [3]

ABSTRACT: This paper present result of study of methods for detecting the blockage in impulse line of differential pressure transmitter. Due to simplicity the combination of orifice plate and differential pressure transmitter is widely used for flow measurement in process industries. However one problem with this method is that the impulse line of the DP transmitter is easily blocked by congealed fluid, or by accumulations of impurities from the fluid. The vibration signals have random fluctuation signals due to turbulent flow in a pipeline and in case of impulse line blockage, the fluctuation signals vary from normal conditions. Mean square of differential pressure fluctuation has formerly been used to evaluate the blocking state. However, mean square of differential pressure fluctuation is strongly affected by flow rate. Then we have to calculate a specific parameter F called 'Blockage Factor' indicates the extent of each impulse line blockage. We confirmed that blockage can be detected by using Blockage Factor F. Impulse line blocking diagnosis of differential pressure transmitter contributes to predicting blockage impulse line and saving maintenance cost.

KEYWORDS: Differential Pressure, Fluctuation, Blockage, Impulse Line.

I.INTRODUCTION

Due to its simplicity, the combination of orifice plate and differential transmitter is widely used for flow measurement in process industries. Figure 1 shows a typical example of an installation for liquid measurement. For ease of maintenance, the transmitter is generally set up near the ground using long impulse lines.

But process connection using impulse line are easily blocked by accumulations of impurities from the fluid or by congelation of the measured fluid due to problems with heat tracing which is necessary when measuring high-melting-point fluid. If process connections become blocked, the DP transmitter won't measure actual process pressure accurately, so will output an inaccurate pressure values to the controller.

A study of the detection of blockages in process connection using fluctuating component of differential pressure computed by FFT has been reported. This time we studied the simple and practical method that can even detect which connection – high (upstream) side or low (downstream) side or both – is/are blocked, by maximum/minimum signal analysis using the fluctuating component but also high pressure.

II.LITRATURE REVIEW

Differential pressure transmitter with orifice plate has achieved great success in flow measurement. However, blockage in impulse line attached to transmitter is sometime caused by precipitating or solidifying liquids. In 1994 Amadi-Echendu, Zhu anf higham publish paper on "Signal Analysis to detect blockage in pressure and differential pressure measurement system" this paper deals with the analysis of noise signal in conventional output signals from pressure and differential measurement system to detect blockage in process connection . This paper initial emphasis on the integrity of the measurement system, this means that in addition to the measured signal, measurement system should provide an

indication of its operational status as the main task in this paper elaborate is to extract information from the measurement signal and present it in concise format for change detection.

In 1995 Taya and Kuwayama publish paper on " Detecting the blockage in process connections of Differential pressure transmitter" this paper talk about the study of detection of blockage in process connection using fluctuating component of differential pressure computed by FFT. This paper talked about the upstream and downstream or both –is/are blocked by maximum/minimum signal analysis using the fluctuating component of not only differential pressure but also static pressure.

II. BLOCKAGE TYPES

There are four types of blockage state. Diagnose for impulse line blockage is based on decrease in the fluctuation of high side or low side pressure. However fluctuation of is much affected by flow rate furthermore the change of differential pressure fluctuation is complicated. Fluctuation of differential pressure does not necessary decrease when one side blockage occurs because one side blockage makes its fluctuation in large most cases. It is difficult to tell whether the blockage occurs when flow rate changes then we developed a maximum/minimum analysis method for one side blockage in impulse line.

III.EXPERIMENTAL SETUP

The experimental set up shown in Fig.4 the major fluid was water. Process line size was 4 inches in diameter. Orifice type was concentric tap. Vibrations of impulse line are detected by using accelerometer sensor Bruel & Kjær which operates in the range of -54˚C to + 121˚C at resonant frequency 18 KHz with sensitivity of 100 mV/g. Vibration analyzer is having five channels so at a time five sensors can be configured to analyzer. Pulse Labshop software is used to monitor vibration. There are four windows configuration, measurement, function and Display.

Fig.1 Block diagram of set up

Configuration window contains details of the inputs and outputs on the Pulse Front-end and to specify what instruments are connected to this Front-end. Measurement window is used to setup signal grouping and to specify which analysers are to be used. Function window is used to setup the outputs from the analysers and how they are to be used. Display window show which measurements are currently displayed and allows modifications to be made to the way the measurements are displayed.
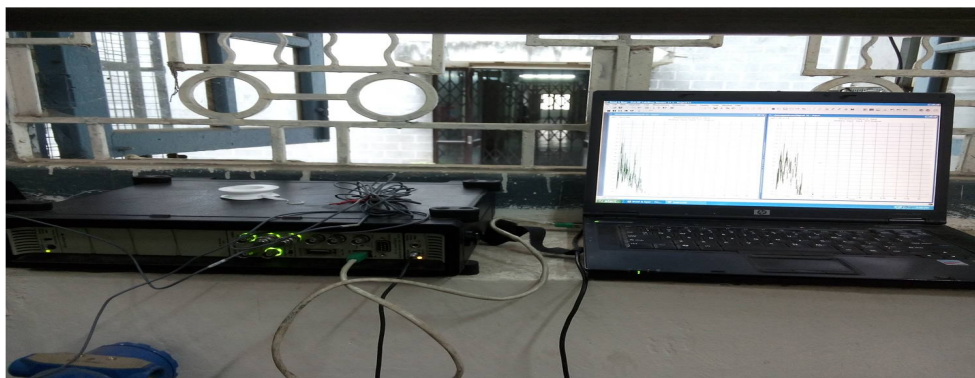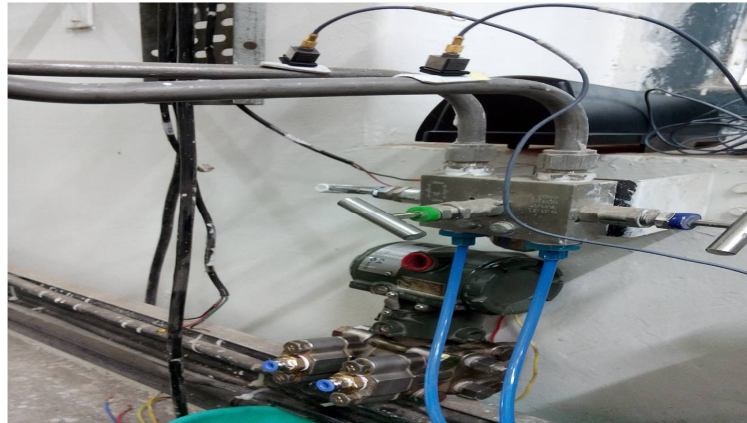

Fig.2 Experimental Set up

Fig.3 Sensor Installation

Figure 2 show the actual experimental set up for vibration analyzer with display PC. Ethernet is used for communication. Figure 3 actual installation of accelerometer sensor by using three needle valves we are creating blockage at upstream and downstream for diagnosis purpose. Accelerometer sensor is externally mounted on impulse line for detection of vibrations due to blockages.

IV. FLUCTUATING COMPONENT & ALGORITHM FOR ONE SIDE BLOCKAGE

The fluctuating component of vibration signal should decrease with build up of deposits (blockage), because flow resistance increases as effective diameter of process connection decreases, and as result the response to vibration change is smaller if the process connection is completely blocked, the fluctuating component vanishes altogether. By operating needle valves, we stimulated three types of blockages: 1.Complete blockage of connection (called "both-side-blockages") by closing both upstream and downstream needle valve, 2. Blockages of only upstream connection (called "H- side blockage") by closing the upstream needle valve, 3. Blockages of only downstream connection (called "L-side blockage") by closing the downstream needle valve. Blockage Factor is calculated depending upon fluctuating signals generated on impulse line. Four types of signals are needed to calculate blockage factor. Value of Blockage Factor 'F' indicates Blockage location and F varies from -1 to +1. Table 1.Shows Fluctuations are collected by manually creating impulse line blockage.

| Signal	Location of Sensor	Blockage Location
dwn_dwn	Downstream	Downstream
dwn_no	Downstream	No blockage
up_dwn	Upstream	Downstream
up_no	Upstream	No blockage
dwn_up	Downstream	Upstream
up_up	Upstream	Upstream

Table1. Sensor and Blockage location

The experimentally measured values of high side vibration and low side vibration signal are shown in Fig. 4. This shows that the fluctuations of HP, LP and DP (calculated by subtracting LP from HP) are different under each blockage status. Three kinds of fluctuation are needed in order to calculate Blockage Factor which can indicate low side and high side blockage. Three kinds of R.M.S of fluctuation DP, LP & HP are defined in equation (3), (4) & (5). These fluctuations are calculated by secondary differential fluctuation.
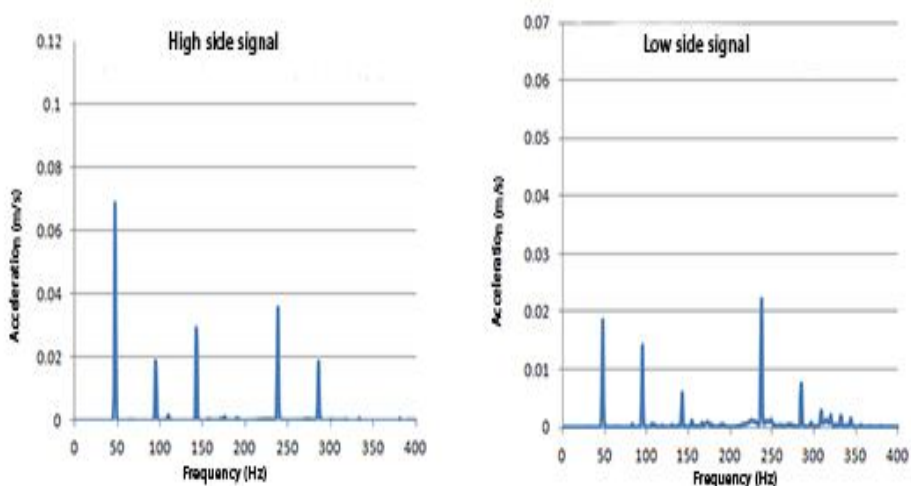
(a)   No blockage in connection (Normal status)
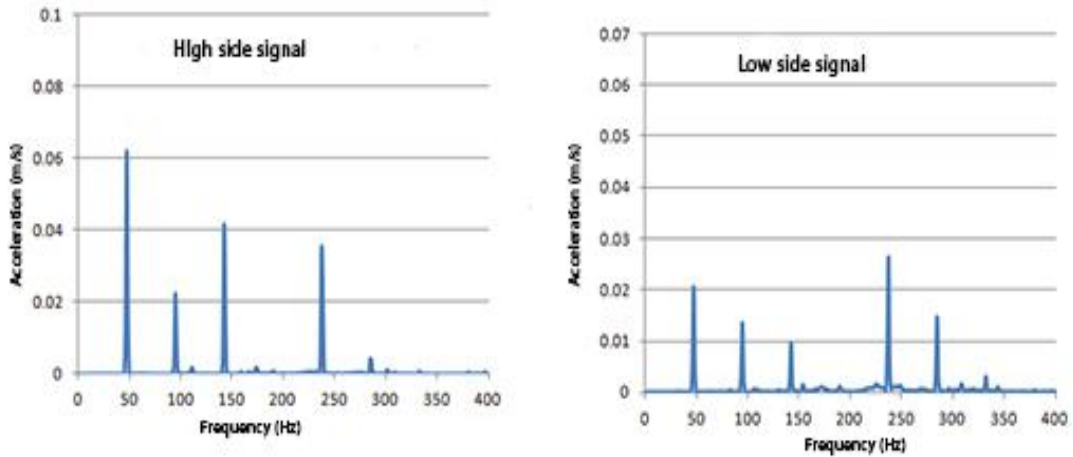
(b)   Blockage both Upstream and Downstream of connection (Both-side blockage)
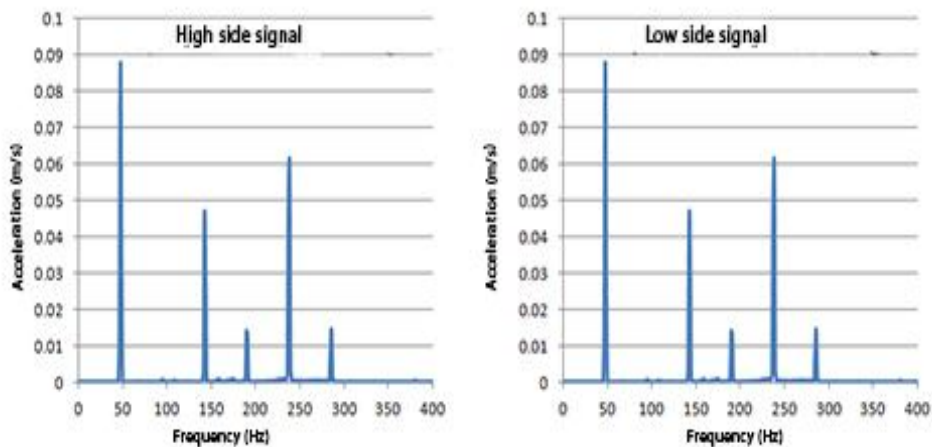
(c)   Blockage only Upstream of connection (H-side blockage)

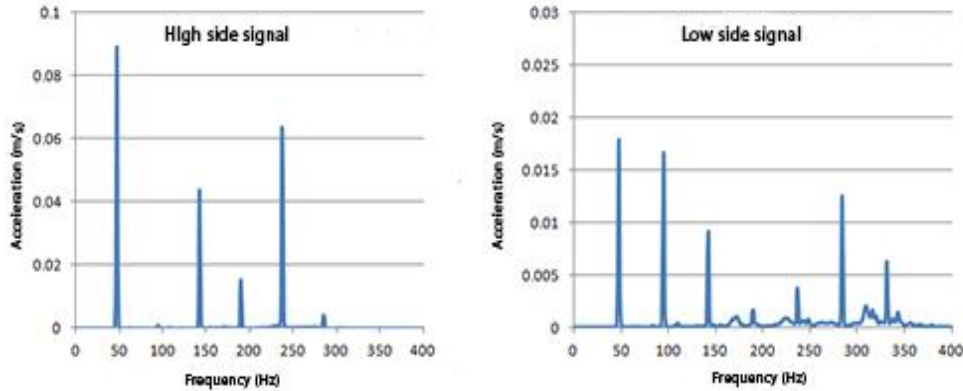(d)   Blockage only Downstream of connection (L-side blockage)

Fig. 4 fluctuating components of HP, LP under each blockage status

$$DP=HP-LP \tag{1}$$
$$F_{dp}(i)= F_{HP}(i)- F_{LP}(i) \tag{2}$$
$$R.M.S_{dp=} SQRT (\textstyle\sum F_{dp}(i)^2/N) \tag{3}$$
$$R.M.S_{LP=} SQRT (\textstyle\sum F_{LP}(i)^2/N) \tag{4}$$
$$R.M.S_{HP=} SQRT (\textstyle\sum F_{HP}(i)^2/N) \tag{5}$$

Where N = total sampling number

In case of low side blockage, It is expected that fluctuation of DP is similar to fluctuation Of High side vibration because $F_{LP}(i)$ is nearly zero. Therefore, Correlation between two vibrations is useful for evaluating one side blocking states. To calculate Blockage Factor two kind of correlation must be defined as in following equation.

$$CorL=\textstyle\sum F_{dp}(i)*F_{PL}(i)/N/(R.M.S_{dp}*R.M.S_{PL}) \tag{6}$$
$$Corh=\textstyle\sum F_{dp}(i)*F_{PH}(i)/N/(R.M.S_{dp}*R.M.S_{PH}) \tag{7}$$
$$Z=(1+CorL)/(1-CorH) \tag{8}$$
$$F=(1-Z)/(1+z) \tag{9}$$

Where
CorL: correlation coefficient between F_{dp} and F_{LP}
CorH: correlation coefficient between F_{dp} and F_{HP}

Making an intermediate valuable Z which combines two correlation coefficients and converting Z into Blockage Factor F, F can be normalized ranging from -1 to +1. Typical set of values of different terms is shown in following Table 2.

Calculated Term	Upstream Blockage	Downstream Blockage
CorL	--	Nearly -1
CorH	Nearly +1	--
Z	Nearly 0	Very large
F	Nearly +1	Nearly -1

Table 2. Values of Blockages

V. RESULTS OF EXPERIMENT OF ONE SIDE BLOCKAGE

There is a strong correlation between fluctuation of different pressure and low side vibration in case of high side blockage. This result implies that Blockage Factor F detects one side blockage. The value F varies from -1 to +1 as we expected in Table 3. In case of both side blockage, F take an uncertain value. Even if there is both side blockage, high side blockage and low side blockage are not completely the same.

Calculated Term	Upstream Blockage	Downstream Blockage
CorL	-0.4244	0.1626
CorH	0.9094	-0.9355
Z	0.3015	18.016
F	0.5367	-0.8948

Table 3. Result of one side blockage

VI.CONCLUSION

The diagnosis based on Blockage Factor is superior to convention method of diagnosis which compares RMS of fluctuation in normal condition with that in blockage. Blockage Factor F is little affected by flow rate. One side blocking state is simply classified because F value range is normalized form -1 to +1 according to blockage at low side vibration and high side vibration respectively.

ACKNOWLEDGMENT

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