DIFFERENTIAL TYPE HIGH PRESSURE AIR GAUGE INTERFACED TO COMPUTER: A KEY INSTRUMENT IN MASS PRODUCTION"

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Abstract: Air gauging is one of the important instruments used in metal working industry in mass production. Differential type-high pressure air gauge has wide range of applications in automobile industry. An effort was made to interface the differential type-high pressure air gauge to computer to facilitate the gauging. In our experimental setup LVDT is used to sense the displacement of the bellow and the amplified output of LVDT is given to the AD-DA card of the computer. This instrument can be used on critical machines to have data for continuous monitoring and statistical analysis of the process.
Key words: Air gauging, mass production, LVDT, Computer interface.

1. INTRODUCTION

Use of compressed air, as a basic means of sensing secured precise measurements is commonly accepted and widespread in industry. Air gauges have fairly good applications in outside and inside diameter measurement in industry compared to other mechanical comparators. There are several reasons why air gauging equipments are popular, useful and profitable to use as it is precise and accurate, it is a non contact type gauging hence reducing the wear and tear of gauging heads, it can perform multiple tasks such as checking of ovality, tapers and run outs in the jobs, trained manpower is not necessary to operate, it can be readily used in multiple gauging setups and can be attached to electronic devices for automatic recording of data and can be further statistically analyzed using other software.

Air gauging, of course, is limited to a particular field of comparative measurements where the range of dimensional variations is relatively small. Considering that the largest number of dimensional measurements is required in mass production, air-gauging applications can be easily visualized (Kennedy & Andrews ,1977).

In this paper an experimental setup was developed to interface a differential type-high pressure air gauge to computer. A LVDT is used as a transducer to sense the displacement of air bellows in the air gauge equipment and the electrical signal from LVDT is further amplified and supplied to an AD-DA interfacing card of computer to directly display the dimension of the component on computer monitor.

2. EXPERIMENTATION

The total experimental set-up incorporates-
i) Differential type air gauge equipment, ii) Sensing element LVDT, iii) the amplifier and iv) the AD-DA card along with computer.
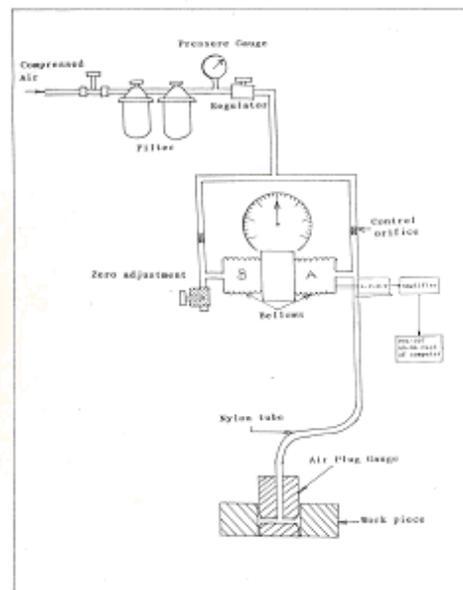

Fig.1. Experimental setup

2.1 Differential type Air gauge equipment.

Fig. 1 shows the complete air gauge assembly. It contains the following parts –
i)   Compressed air from compressor comes to the assembly through. Hose pipe
ii)   Pressure cock
iii)   Twin filter
iv)   Pressure gauge
v)   Hose Pipe
vi)   The indicating unit
vii)   Nylon tube
viii)   Air plug gauge
ix)   Two master setting rings.

The compressed air from the compressor is cleaned in the air fitter and maintained at a constant working pressure by the regulator. The air pressure is maintained at 4 kg/cm^2. The air stream is then split and passed through the two inner restricting orifices. The air escapes through the air plug gauge and the zero setting screw when the instrument pointer is positioned at zero the amount of air escape is equal at both air plug gauge & the zero setting screw. And, therefore the bellows A & B are each receiving the same backpressure.

When measuring bores either larger or smaller than nominal size, more or less air will flow from that air plug then from the zero setting screw, which will in turn increased or decrease the pressure in bellow. The bellows subsequently transfers these changes in pressure to the pointer mechanism, given a corresponding deflection.

Using two setting masters sets the air gauge. Two setting masters are preferred as they also serve to check the amplification setting of the instrument.

A 25±0.020 mm air plug gauge is selected for our experimentation based on the availability of jobs. Two setting rings of 25+0.015 mm and 25-0.015mm are selected.

2.2 The sensing member (L.V.D.T.)

Fig. 1 shows how the displacement of the bellows is sensed by the L.V.D.T. plunger, fixed to the control member of the bellows, which get displaced when the bellows are displaced in both positive & negative direction. The strip other end is fixed to the plunger of the L.V.D.T. hence the displacement of bellows is directly transferred to the LVDT leading to some output electrical signal i.e. voltage.

2.3 The amplifier

The output signal of LVDT i.e. voltage output is very weak in the range of 32 mv to +32 mv and the input voltage needed for the PCL – 207 interfacing card +5 volts. Hence this signal is to supplied to the PCL – 207 card.

A 741 OP AMP is used for this amplification. The pin configuration for 741 OP AMP is as follows.

Pin no 1 & 5 are for offset null to make the output zero when the input is zero.
Pin No. 7-> to Connect +VCC of 10 volts to initiate the OP-AMP
Pin No. 4-> to Connect -VCC of 10 volts to initiate the OP-AMP
Pin No. 2 -> Inverting terminal.
Pin No. 3 -> Non-inverting input.
Pin No. 8 -> No connection.
Pin No. 6 -> Output.

2.4 The PCL 207 A/D-D/A card

The PCL – 207 low cost AD/DA card is an easy to use, cost effective multifunction data acquisition card for IBM PC/XT/AT and compatible computer. It is a high performance analog interface card for compatible computers. It uses the hardware based successive approximation method, providing 25 thousand samples per second acquisition rate. The maximum A/D conversion time is 25 microseconds.

It requires an analog input range -5 V to 5 V. The A/D trigger and data transfer are controlled by programming.

The PCL – 207 also has powerful and easy to use software driver routines which can be accessed by the BASIC CALL statement.

2.5 Base Address selection

The PCL – 207 interface card is controlled through input/output port. These ports are addressed using the I/O port address space.

An 8 way DIP switch is present on board out of which SWI to SW6 is used for base address selection and SW7 & SW8 are used for software trigger selection.

The PCL – 207 requires 16 consecutive address locations in the I/O space. Valid addresses are from Hex 000 to Hex 3FF. Before installing the card in the computer, the switch setting to any of the addresses given below is to be done.

Table 1. Switch setting for PCL 207 Card.

I/O address range (Hex)	Switch position					
	1	2	3	4	5	6
000-00F	0	0	0	0	0	0
100-10F	0	1	0	0	0	0
200-20F	1	0	0	0	0	0
210-21F	1	0	0	0	0	1
220-22F	1	0	0	0	1	0
300-30F	1	1	0	0	0	0
3F0-3FF	1	1	1	1	1	1
Note ON = 0, OFF =1.						

2.6 Execute an A/D conversion

The step by step implementation procedure for different A/D operation is given below.

To perform a software trigger and programme control data transfer following steps are considered.

Step 1 : Set the input channel by specifying the MUX Scan range.

Step 2 : Trigger by writing some value to the I/P Port (Base +2)

Step 3 : Wait for the DRDY by reading the A/D high byte register (BASE +5) DRDY bit.

Step 4 : Read data from A/C converter by reading the A/D data register (BASE +5 & +4). Always read high byte first.

Step 5 : Data conversion of binary A/D data to an integer.

2.7 A/D calibration

There are 3 variable (VR) on the PCL – 207 to assist in making accurate adjustment on the A/D and D/A channels. The function of each VR is listed below :-

VR1 : D/A gain adjustment, VR2 : A/D offset adjustment

VR3 : A/D gain adjustment

Procedure to calibrate A/D function of PCL-207.

1) Apply a short to the input channel & adjust VR2 (offset) to obtain zero data.
2) Apply +4-9963 V to the input channel and adjust VR3 (gain) so that the data lies between 2046 and 2047.

Other voltage can be applied to the input to check the linearity.

2.8 Computer programme for A/D conversion using pcl-207 card

```
10 Port% = & H220
20 OUTOPORT% +10.0
30 OUTPORT% +12,0
40 DH% = INP (PORT% +5)
50 IF DH% > 15 TOTO 40
60 DL% = INP (PORT% +4)
70 DTA% = (DH% * 256 +DL% - 2048) / (5)
80 DTA% 25000 – DTA%
90 LOCATE 12,40
100 FOR I = 1 TO 5000
110 REM DEALY
120 NEXT I
130 CLS
140 DTA = DTA/(1000)
150 PRINT DTA
160 GOTO 20
170 END
```

3. TESTING

For testing, 50 no of inner race of ball bearings are used. An air plug gauge of 25±0.02 mm and setting rings of 25+0.15 mm and 25 -0.15 mm are used.

The air gauge is set by the master setting rings. Then the inner races of ball bearing are tested by using the air plug gauge. First the LVDT output signal is noted for all the samples. The output voltage is measured by multimeter and tabulated as follows in Table 2.

It is seen from the reading that for +15 um the LVDT O/P voltage is +39 mV and for -15 um the LDVT O/P voltage is -39 mV. Fig.1 shows the linear relationship between deviation in size and LVDT output.

For the PCL-207 A/D-D/A card the input requirement is +5 Volts. Hence the LVDT output is amplified and the amplified output of LVDT is fed to the AD-DA card.

Table 2 LVDT output for the deviations in basic size of job.

| Sr. No.	Deviation from basic size in um.	LVDT O/P voltage mv	Sr. No.	Deviation from basic size in um.	LVDT O/P voltage mv
1	-1.5	-12	26	+2.0	+13
2	+5.0	+19	27	+4.0	+17
3	+4.0	+17	28	-4.0	-17
4	+5.0	+19	29	+2.5	+14
5	+2.5	+14	30	+1.5	+12
6	+1.5	+12	31	+2.5	+14
7	+1.5	+12	32	+2.0	+13
8	+3.5	+16	33	+5.5	+20
9	+7.5	+24	34	+2.5	+14
10	-1.0	-11	35	+4.0	+17
11	+0.5	+10	36	+3.5	+16
12	+4.5	+18	37	+3.5	+16
13	+7.5	+24	38	-2.5	-14
14	-1.5	-12	39	-1.5	-12
15	-1.0	-11	40	+6.5	+22
16	+1.5	+12	41	+0.5	+10
17	+10.5	+30	42	+2.5	+14
18	+3.5	+16	43	+12.0	+33
19	+4.5	+18	44	+2.0	+13
20	+0.5	+10	45	+8.5	+26
21	+4.0	+17	46	+1.0	+11
22	-1.0	-11	47	+2.0	+13
23	+1.5	+12	48	+1.5	+12
24	+1.0	+11	49	+4.5	+18
25	+6.5	+22	50	-0.5	-10
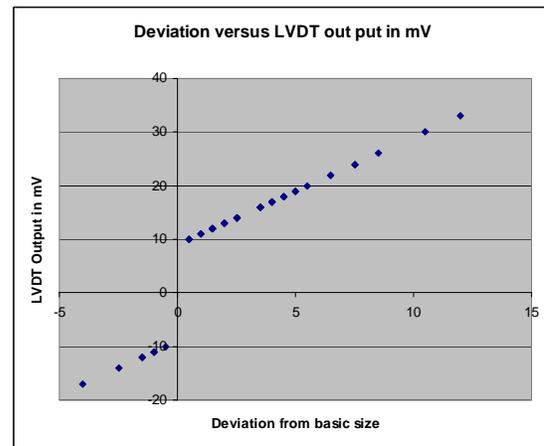
Fig.1 Size Deviation and the LVDT output

The computer program is made in such a way that the direct size of the job is obtained i.e. the inner race of bearing on the screen of the computer. The 50 samples of inner races are tested & the readings are noted. Table 3 shows the dimensions of 50 samples.

Fig. 2 shows the photograph of testing with air gauge with LVDT setup.
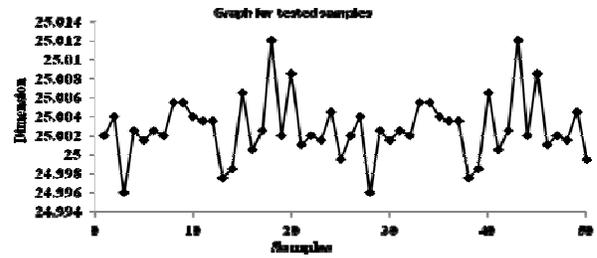
Fig.2 Photograph of testing

Table 3. Dimensions of 50 samples.

S. No.	Inside diameter of bearing inner race (mm)	S. No.	Inside diameter of bearing inner race (mm)
1	24.9985	26	25.002
2	25.005	27	25.004
3	25.004	28	24.996
4	25.005	29	25.0025
5	25.0025	30	25.0015
6	25.0015	31	25.0025
7	25.0015	32	25.0020
8	25.0035	33	25.0055
9	24.0075	34	25.0055
10	24.9990	35	25.0040
11	25.0005	36	25.0035
12	25.0045	37	25.0035
13	25.0075	38	24.9975
14	24.9985	39	24.9985
15	24.9990	40	25.0065
16	24.0015	41	25.0005
17	25.0105	42	25.0025
18	25.0035	43	25.012
19	25.0045	44	25.002
20	25.0005	45	25.0085
21	25.0040	46	25.001
22	24.9990	47	25.002
23	25.0015	48	25.0015
24	25.001	49	25.0045
25	25.0065	50	24.9995

Based on the reading a simple graph 2 is plotted with basic size and the job dimensions on Y – axis and sample nos. on X-axis.

Fig 2 Dimension versus sample numbers

4. CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

4.1 CONCLUSION

The general pneumatic gauges are comparator type but based on the total experimental setup and the computer programme developed, this pneumatic gauge gives the actual dimension of the component under gauging on the screen of the computer. Also the accuracy and consistency in measurement is high compared to the general pneumatic gauge. The out of the LVDT is also linear to the dimensional variations of the jobs under test hence the results obtained are accurate.

4.2 SUGGESTIONS FOR FUTURE WORK

The data produced by the system developed can be stored in the memory of the computer. The same data can be statistically analyzed by developing another computer programme for finding out process capability.

Process Control

In process air gauging can be adopted to continuously monitor the process and the data stored can be further analyzed by for process control. Hence the same PCL-207 AD-DA card can be used effectively for process control.

5. REFERENCES

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