DESIGN OF FACILITY FOR MEASURING AND INSPECTION OF PLATE CYLINDER DIMENSIONS AND TOLERANCES

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ABSTRACT

Measuring and Inspection is the means by which poor quality is detected and good quality is assured in products that are produced in a production process. Inspection is usually carried-out manually via the use of various technologies that examine specific variables. Some inspection techniques use manually operated devices such as micrometers, callipers, protractors, and go/no-go gauges; whilst other techniques are based upon modern technologies such as co-ordinating measuring machines (CMM) and machine vision, which use computer-controlled systems that allow the inspection procedure to be automated.

I. INTRODUCTION

Measuring and Inspection plays an important role in modern manufacturing since complex specifications have to be met for more and more products. Measuring and Inspection generally involves a time-consuming operation that takes up a large portion of manufacturing lead time, and therefore, Sophisticated manufacturing systems require automated inspection and test methods to guarantee quality.

Plate cylinder is most important part of offset printing machine. Plate cylinder of offset printing machine required smooth and high reliable performance as they operate in a harsh environment of heat, Pressure, abrasion, and chemical attack that cause wear. The plate cylinder designed to meet high precision tolerance and dimensional accuracy. It also required high quality surface finish. To measure and inspect quality of such product special inspection setup is required. Human inspector measures the dimension and inspects quality with the help of conventional gauges. This process is time consuming and takes up large portion of manufacturing lead time. It increases labor cost, and chances of inconsistency and variability associated with human inspection stress.

Therefore, it is essential to provide a quick, automated inspection system for such complicated parts to eliminate manual inspection. This project work leads to Design and Development of facility for measuring and inspection of plate cylinder.

II. PLATE CYLINDER

Plate cylinder is most important part of offset printing machine. Plate cylinder of offset printing machine required smooth and high reliable performance as they operate in a harsh environment of heat, Pressure, abrasion, and chemical attack. The dimensions of plate cylinder have a significant influence on the accuracy of the offset printing machine results and the life-span of the plate cylinder. The plate cylinder used in this project work has outer diameter (Ø183 $^{+0.01}$) and length (1505$^{-0.3}$). Its Material is SS 410 and finish weight is 235.4 Kg. Schematic sketch bellow represents plate cylinder.

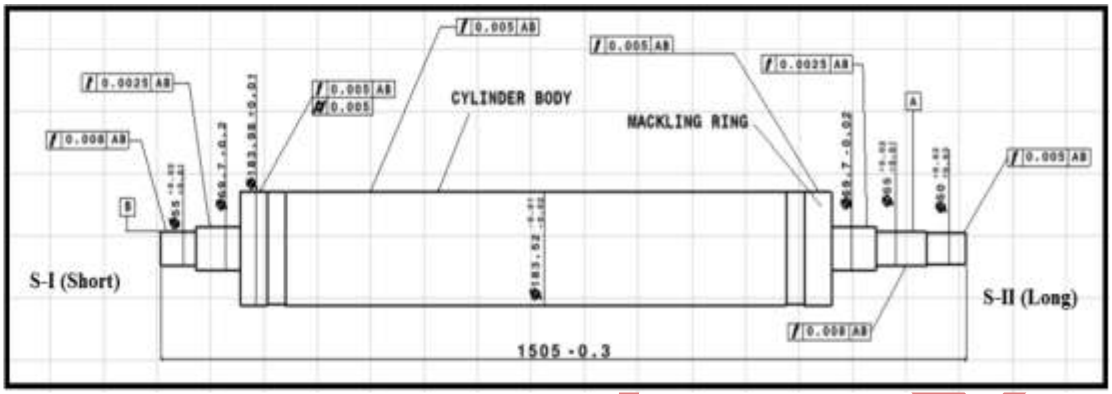

Figure 1 Plate Cylinder.

Cylinder is inspected by two methods,

1) Manual by using conventional gauges.
2) By using Co-ordinate Measuring Machine

For complete inspection and measurement of plate cylinders following measurement are being done

Table 1-Measurement of Pate cylinder

Sr. No	Descriptions	Dimensions	Measuring Instrument Presently Used
1.	Diameter of Mackling ring.	Ø183.98$^{+0.01}$	Dial Snap Gauge 0.001mm
2.	Diameter of Body.	Ø183.52$^{-0.01/0.02}$	Dial Snap Gauge 0.001mm
3.	Runout On Mackling Ring	0.005	Height Gauge Plunger Dial 0.001mm
4.	Runout On Body	0.005	Height Gauge Plunger Dial 0.001mm
5.	Step diameter.	Ø55$^{+0.011 \text{ to } 0.018}$	Dial Snap Gauge 0.001mm
6.	Parallality between side faces.	0.05	Lever Dial 0.01

2.1 Manual Inspection

Manual inspection of roller consists of following activities:

i) Setting of roller V Block on surface plate.

ii) The plate cylinder to be inspecting is kept on roller V Block.

iii) Inspecting of the five different diameters of plate cylinder by separate dial snap gauge

iv) Rotating plate cylinder manually to check runout with help of height gauge and plunger dial.

v) Measuring the center distance by Digital height meter (Trimos)

vi) Preparing Inspection report.

This method depends on skill of inspector. A setting of cylinder on surface plate is complicated process and requires Approximate 20 min. One batch of plate cylinder contains approximately 12 number of quantity. Complete inspection of plate cylinder Batch requires (12no.x20 min =240 min) i.e. 4 hr. It makes delay in assembly processes of final product.

2.2 By using Co-ordinate Measuring Machine

Co-ordinate Measuring Machine, is accurate and are also efficient for checking dimensions and tolerances, But using a coordinate measuring machine, these parts can be inspected only on a sampling basis. Each and every component cannot be checked by co-ordinate measuring machine because of handling problem and thus 100% inspection is not feasible. It requires highly skilled Operators / Inspectors.

III. SUMMARY OF THE MEASUREMENT METHODS

A considerable amount of research has been done and is being done to improve the performance of different types of displacement sensors which however are best suited for laboratory conditions or otherwise controlled environments. The accuracy and band width of the typical displacement sensors are adequate to the runout measurement. There are some other issues that may be more important when choosing the measurement method (Table 2).

Table 2. Symmetry of Measurement Method

S.N.	Method	Advantages	Disadvantages
1.	**Contact sensors** Dial gauge, LVDT (L.C. = 1µm)	-Easy to use -No calibration to the target needed	-Wear, warming-up -May damage the surface -Used only for slow speeds
2.	**Noncontact sensors** **Capacitive** (L.C. = 1µm)	-Suitable for a range of different materials -Insensitive to the material Properties	-Sensitive to the properties of the medium (dirt, dust)
	Eddy current (L.C. = 0.1µm)	-Insensitive to the environment	-Electrical runout -Only for conductive metals -Calibration to the target Needed
	Optical (L.C. = 1µm)	-Long measuring distance and range	-Speckle noise -Sensitive to dirt and dust Careful alignment needed

The two methods, based on the principle of the probe with a sliding contact to the surface and a method for detecting the movement of the probe, solve at least some of the problems. As hand-held devices they are quick and easy to take in use and to move to different locations. No supports or fixtures are needed either. Measurement can be made from a longer distance and the environmental conditions and the target properties do not have as much influence on the measurement as they would have with the conventional methods. Warming-up of the sliding probe does not have a direct effect on the measurement as does the warming-up of the probe in the LVDT sensor, for example. On the other hand, these methods require that the target is accessible by the measure. Any dirt or other surface irregularities will have an effect on the measurement. Accuracy and performance of the methods must also be studied.

IV. RUNOUT MEASUREMENT BY FFT ANALYZER

4.1 Device

A device and a method for the measurement of a plate cylinder runout based on the measurement of radial acceleration of the surface are described. A number of measurements have been done to demonstrate the applicability of the method.

The basic operation principle of the method is the one in a cam mechanism (Figure 2). Cams are used to convert rotary motion into reciprocating motion. As the cam turns, the cam follower traces the surface of the cam transmitting its motion to the required mechanism. Between the rotational input θ and linear output y there is a functional relationship

$$y = y(\theta).$$

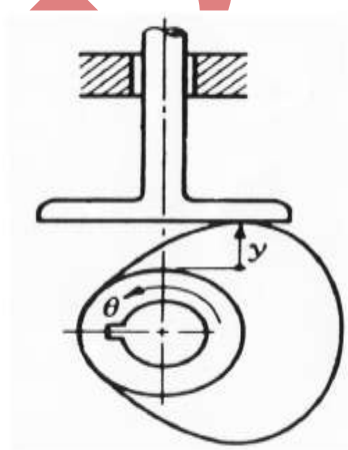

Figure 2 Cam Mechanisms with Flat-Faced Follower

The flat-faced follower can be replaced by a slide pad while the roll surface acts as a circular or eccentric cam with very small undulations. The measurement of the radial displacement of the slide pad yields the runout of the roll. An accelerometer is one of the most often used sensors in condition monitoring applications. Accelerometers are very sensitive instruments and can detect even the smallest vibrations on any surface. As vibrations are always related to the movement of the media, it is possible to obtain the displacement of the surface by measuring its acceleration. Attached to a slide pad which is in sliding contact with the roll surface, the movement of the surface can be measured with an accelerometer (Figure 3). The velocity and displacement can be obtained by integrating the acceleration.

Thus the device consists of a polymer based slide pad which is in contact with the moving surface, an accelerometer attached to the slide pad and an extension handle for the user to hold the device on the target surface (Figure 4).

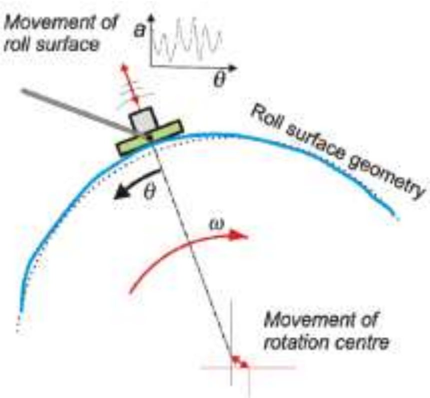

Figure 3 Basic Operation Principle of the Measurement

Figure 4 Device on Cylinder Surface

The benefit of this method compared with conventional methods is that there is no need for vibration sensitive holding fixtures or supports for the probe. The reference of the measurement will be the shell of the roll itself instead of a fixed datum. The body of the user will efficiently dampen possible vibration arising from the environment. It is possible to quickly carry out measurements in numerous positions and inconvenient locations such as working platforms or service elevators.

4.2 Body and slide pad

When the measurer places the slide pad on the target surface, the slide pad should orientate itself tangential to the surface and be stable, in contact with the surface even if the measurer moves a little. The device will be subjected to high surface velocities (up to 2000 m/min). The material used for the slide pad has been selected to have low coefficient of friction, good wear resistance and high heat distortion temperature. In the first versions of the device the body and the slide pad were separate parts made of different materials. The sliding surface was made of reinforced PTFE while the body was made of a common engineering plastic.

The connection of the slide pad to the extension handle has been implemented with two joints which make it possible for the slide pad to self-align itself on the target surface. A fork wrench allows the pitch movement with the hinge joint (1) while the pivot joint (2) with a journal bearing allows the slide pad to rotate along the axis of the handle, roll. The pin of the fork wrench is located as close to the slide surface as possible to make the device stable. The details of the structure are represented in Figure.

4.3 Accelerometer

An accelerometer measures directly the acceleration related to the motion of the surface to which it is attached. Typically an accelerometer consists of a mass that is free to move along a sensitive axis within a case. The acceleration is acquired by measuring the displacement of the mass. In a piezoelectric accelerometer, which is used in this case, the mass is in direct contact with a piezoelectric component. When a varying motion is applied to the accelerometer, the piezoelectric crystal experiences a varying force excitation which in turn will cause an electric charge to be developed. A charge conditioning amplifier is needed to obtain more useful voltage signal. Piezoelectric accelerometers have no dc response so they can only be used for dynamic measurements. For the same reason the position of the sensor does not have an influence on the output of the sensor.

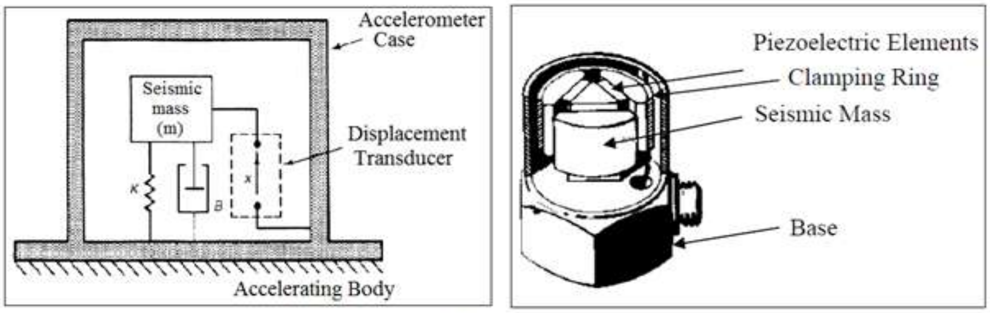

Figure 5 Accelerometer

4.4 Fast Fourier Transform (FFT)

The FFT spectrum analyzer is an invaluable tool for mechanical engineers in today's world of measurement and analysis of mechanical systems. FFT analyzers are an essential tool in such fields as vibration and shock data analysis, machinery monitoring and analysis of complex waveforms. Use of the FFT analyzer is required in many industries, including military, transportation, aerospace, manufacturing and consumer products.

4.5 Integration

Sinusoidal linear movement can be described as

$$x(t) = A \sin \omega t$$

Where *x* is displacement, *A* is the amplitude, ω is angular velocity (= $2\pi f$) and *t* is time. Derivation of movement in relation to time yields velocity and acceleration

$$v(t) = \dot{x}(t) = \omega A \cos \omega t = \omega A \sin\left(\omega t + \frac{\pi}{2}\right)$$
$$a(t) = \ddot{x}(t) = -\omega^2 A \sin \omega t = \omega^2 A \sin(\omega t + \pi)$$

This means that is possible to integrate acceleration to displacement simply by dividing the acceleration by the negative angular velocity squared

$$x(t) = \frac{a(t)}{-\omega^2}$$

The frequency of the movement remains unchanged, only the phase is shifted 180 degrees

V. MEASUREMENT AND INSPECTION FACILITY DESIGN

In this project work, facility is designed and developed on the conventional grinding machine base. The support stand with magnetic base and slide pad assemble is shown in figure 4.7. Five such assembly of support stands are fitted on slider mechanism and whole unit is placed on grinding machine base as shown in figure 7. An accelerometer is installed on each of five different slide pads. The accelerometer is connected to FFT Analyzer, and then to Computer with the help of connection cables. Computer used for this facility is equipped with RT Pro Photon Software which analyses the signals coming from accelerometer and converted into acceleration- frequency graph format as shown in figure 6.

Figure 6 Slide Pad and Support Stand Assembly

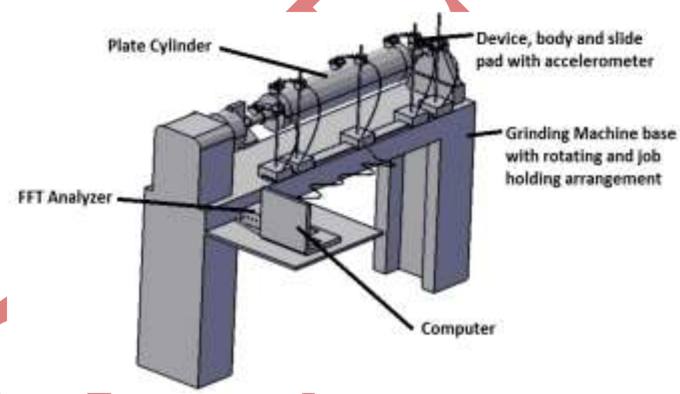

Figure 7 CAD Model of Facility

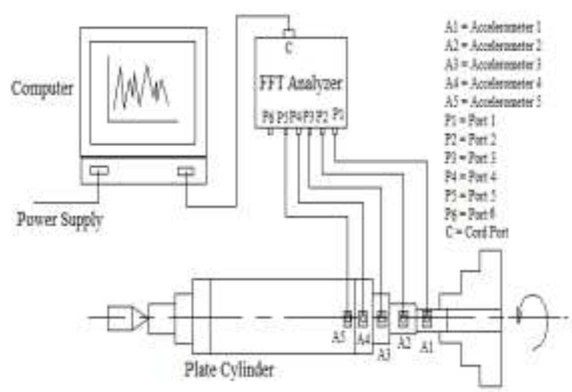

Figure 8 Schematic Diagram Of Inspection Facility Connection.

Figure 9. Actual Photograph of System

VI. MEASUREMENT PROCEDURE

The measurement procedure is:

1) Job (Plate cylinder) to be inspected is held on facility.
2) Five Slide pads are kept on the each of step diameter surfaces on S-I side of job.
3) Rotations are given to the plate cylinder.
4) In RT Pro Photon Software of FFT Analyzer, graph is seen when constant peak is achieved in graph, click on START button.

5) Enter this peak value of frequency and amplitude in Microsoft Excel software where formula of runout is all ready fed. It will give direct value of runout.
6) Slide pads are lifted.
7) Now they are kept on the each of step diameter surfaces on S-II side of job.
8) And repeat step no 3, 4 and 5.
9) Take print of inspection report.

VII. SAMPLE OBSERVATION

By slide pad method Observation is as follows

1) S-I side Ø55

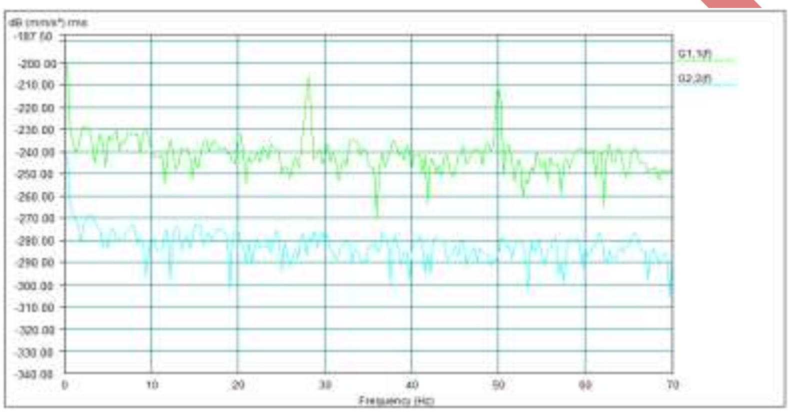

Figure 10. Signal Analysis of S-I side Ø55

By acceleration – frequency graph peak value is in table,

This frequency and acceleration value putting in to Microsoft Excel.

VIII. SAMPLE CALCULATION FOR RUNOUT

Calculation is done by using Excel software; here some sample calculation is included

1) S-I side Ø55

Displacement (i.e. Runout) is given by formula,

$$x(t) = \frac{a(t)}{-\omega^2} = \frac{a(t)}{-(2\pi f)^2} = \frac{-208}{-(2\pi \times 28)^2} = 0.00672 \text{ mm}$$

IX. RESULT

Acceleration	mm/s^2	-208
Frequency	Hz	28

Table 3 Result for Runout

i) Comparison between previous and improved practices.

The accuracy of an instrument is a measure of how close the output reading of the instrument is to the correct value.

Inspection Report (Quality Record)							
Drg. No:H578.22-27096.2/2-b					Part Name: Plate Cylinder Assly.		
Sr. No.	Specification	Basic Diameter Value	Acceleration(α)	Frequency(f)	Displacement (Runout)	Diameter	Remark
	Unit	Mm	mm/s2	Hz	mm	mm	
1	S-I side Ø55	55	208	28	0.00672	55.0124	OK
2	S-I side Ø69.7	69.7	170	42	0.00244	69.6888	OK
3	S-I side Mackling Ring	183.98	150	30	0.00422	183.9871	OK
4	Center On Body	183.52	85	24	0.00374	183.5119	OK
5	S-II side Mackling Ring	183.98	170	31	0.00448	183.9872	OK
6	S-II side Ø69.7	69.7	135	38	0.00237	69.6912	OK
7	S-II side Ø55	55	278	30	0.00782	55.0129	OK
8	S-II side Ø50	50	145	31	0.00382	50.0169	OK

To test the accuracy of the developed facility, same plate cylinder is measured by manually, CMM and by developed facility. In Figure 11 the slide pad results of diameter inspection also achieve a precision within 0.1 µm.

Table 4 Required Runout Value and Observed Runout Value y Plunger Dial, Slide Pad Method

Runout Comparison					
Sr. No.	Specification	Required Runout (mm)	Observed Runout (mm)		
		Method	Plunger Dial	C.M.M.	Slide Pad
1.	S-I side Ø55	0.008	0.007	0.00683	0.00672
2.	S-I side Ø69.7	0.0025	0.0025	0.00231	0.00244
3.	S-I side Mackling Ring Ø183.98	0.005	0.004	0.00418	0.00422
4.	Center On Body Ø183.52	0.005	0.004	0.00391	0.00374
5.	S-II side Mackling Ring Ø 183.98	0.005	0.004	0.00452	0.00448
6.	S-II side Ø69.7	0.0025	0.0025	0.00239	0.00237
7.	S-II side Ø55	0.008	0.007	0.00758	0.00782
8.	S-II side Ø50	0.005	0.004	0.00394	0.00382

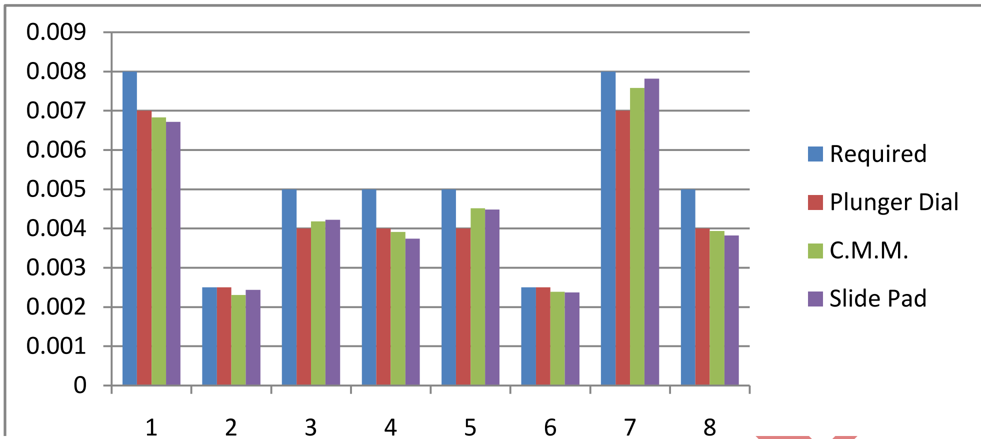

Figure 11 Runout Compressions Between Plunger Dial, CMM And Slide Pad Measurement.

X. CONCLUSIONS

The new facility developed for measuring and inspection of plate cylinder gives various advantages over the existing system of inspection. The results of the project work are concluded as follows:

1) Labor cost has been reduced by adopting the new facility. Organization can save Rs 1.5 lakh per annum in labor cost. It is major gain of the new developed inspection system.
2) The Runout and diameter of plate cylinder can be measured up to 1 µm accuracy, which gives more correct results which make the new developed facility promising.
3) In new developed facility of plate cylinder inspection, requires only 8 minutes instead of 20 minutes in conventional system. Thus 12 minutes inspection time is saved.

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