

Poka-yoke System for Transfer Robot's Crossbar – H.D.A Locking assembly

Gnanasundar E S¹, Prasanna Gouda², Sagar Hn³

Asst. Professor, Department of Mechanical Engineering, PNS Institute of Technology, Bengaluru, Karnataka, India¹

Assistant Professor, Department of Mechanical Engineering, S.K.I.T Bangalore, Karnataka, India²³

ABSTRACT: In order to ensure the Transfer Robot's Crossbar-H.D.A (Handling device accessory) locking operation safe and reliable, centralized monitoring and control is very necessary. The main objective of this proposal is to monitor and detect the fault in the crossbar-H.D.A locking system using PLC logic function. Faults such as H.D.A are not properly locking to the crossbar and H.D.A loose or fall inside the die during production are not identified properly and thus leading to serious die damage. In order to avoid this type of serious conditions, we are applying various sensors in their operations using PLC (programmable logic controller) to provide protection for die in servo press shop. Manual control is more disadvantageous and is being the major reason for frequent accidents. In order to reduce these accidents and for increasing further enhancements, automation is required. .

KEYWORDS: Transfer Robot, Crossbar, H.D.A, PLC, Automation, Centralized Monitoring etc.

I. INTRODUCTION

The use of advance sensor in manufacturing enterprise greatly improved safety, productivity and reliability of the enterprise. The application of sensor in manufacturing enabled us to react to rapidly changing production conditions and help the personnel to react to qualitative decisions. This flexibility is achieved through an established information system that has the capability to get reshaped whenever necessary.

Integration of sensors with suitable control technology throughout the manufacturing operations within computer integrated manufacturing (CIM) enabled individual manufacturing process to flow-communicate and respond together as a unified cell.

The Proposed work is carried out on Transfer Robot which is used to Transfer Pressed Sheet metal from one Press machine to another. The basic architecture and terminologies of Transfer robot is explained below fig. 1.1

Transfer robot is a robust machine component mainly used to transfer the material from location to another. Complete automation is achieved in any manufacturing industry only if the transfer robot is used for material transfer. A typical transfer robot will have following components:

1. Robot arms i.e. one left robot arm and one right robot arm
2. Crossbar:

It is a rectangular bar like structure to which the robot arms are attached on it's either to form a transfer robot.

3. Handling Device accessories(H D A) ports:

A typical Transfer Robot will have 14-16 H.D.A Ports. To transfer the material from one location to another, a transfer robot requires fixtures to hold the material to be transferred. These external fixtures are called Handling Device Accessories. To accommodate these fixtures in the transfer robot ports are required. H D A units are physically inserted into the ports so that material transfer from one location to another is effective.

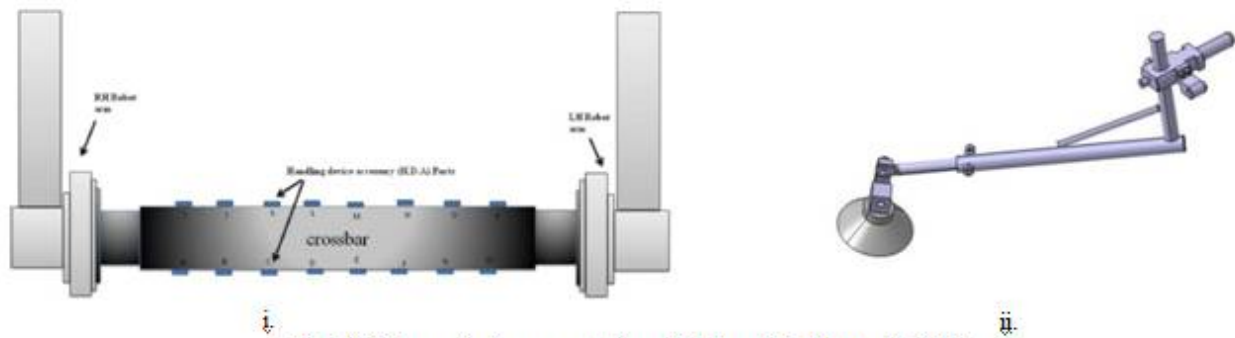


Fig 1.1. Schematic Representation of i) Transfer Robot ii) H.D.A

II. PROBLEM IDENTIFICATION

Background: draw die major damage due to handling device accessory (H.D.A) fallen inside the die during production.

Reason: Handling device accessory (H.D.A) operator not inserted the H.D.A fully in the H.D.A holder and there is no confirmation for the same in the equipment.

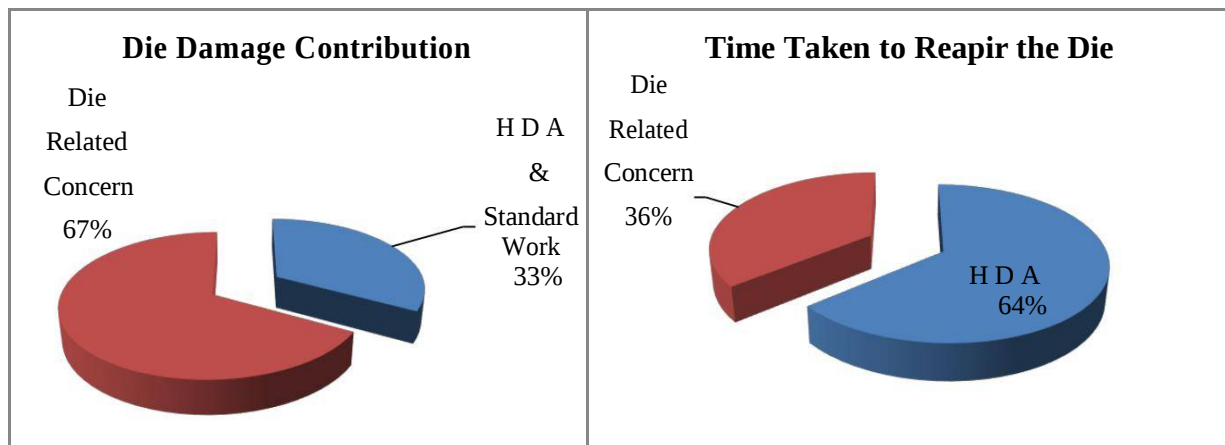


Fig. 2.1: Graphical representation of Die damage contribution & time required to repair the die

III. RELATED WORK

The following sequential steps are followed to solve the above said problem.

Step-1: first of all the processes in the press machine are studied in detail.

Step-2: The problem of H.D.A locking is thoroughly understood by close observation and by consulting concerned persons

Step-3: Then the data of the occurrence of the problem for 6 months is collected

Step-4: An analysis on the data collected is done based on various criteria.

Step-5: Major reason for the occurrence of the problem are identified and discussed with the concerned members of the their opinion

Step-6: The counter measure is planned and executed

Step-7: The data of occurence of the problem after the execution of the counter measuer was collected.

Step-8: From the post execution data the reduction/elimination of the problem is confirmed.

Step-9: Root cause analysis is made for the problem identified.

Step -10: Suggestions are put forward for eliminating the root cause of the problem.

Study of Existing Crossbar – H.D.A Locking System

H.D.A insertion to the Crossbar is manually oriented job and due human negligence and unavoidable human miss H.D.A's are not locked properly. during production H.D.A loosen and fallen inside the die causing severe die damage leading to major line stop and costing Lakhs of rupees for die repair.

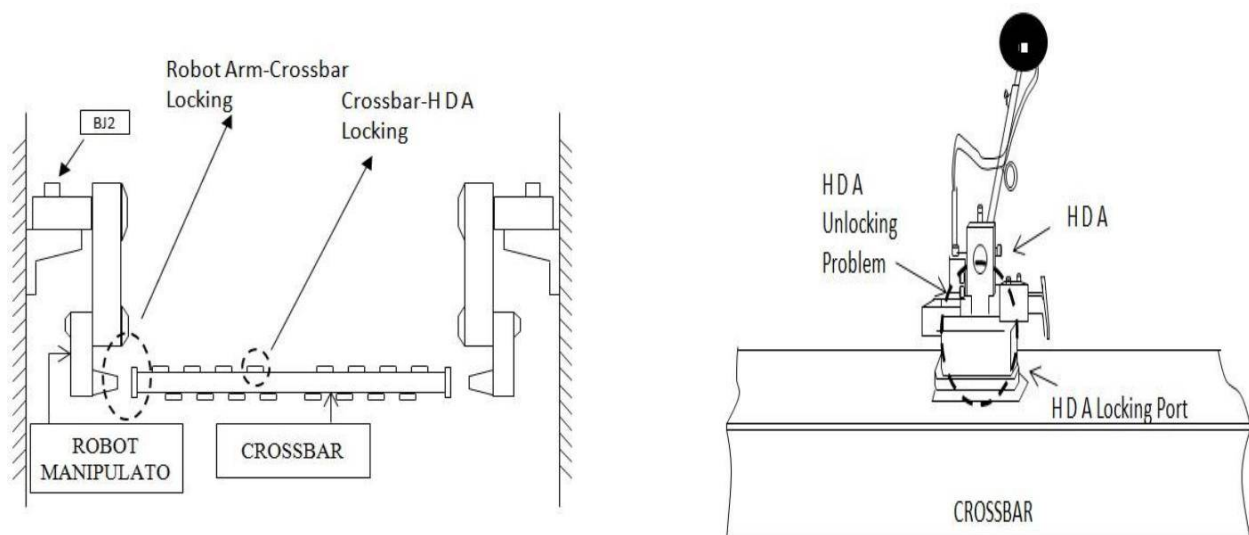


Fig.3.1: Schematic representation of i) Schematic Representation of Transfer Robot ii) Crossbar-H.D.A arrangement

Root cause analysis (RCA)

To solve any problem traditional quality tools are used. But in some cases these traditional tools are incapable to find the root cause of problem. Then there is a need for tools which can solve the problem which are occurring due to practical issues. Root cause analysis (RCA) is a problem solving technique whose main intense is to find the root cause of problem. Root cause analysis is systematic approach to find the factors those results in nature, magnitude, location and the timing of harmful outcomes of past events.

Problem Phenomenon:

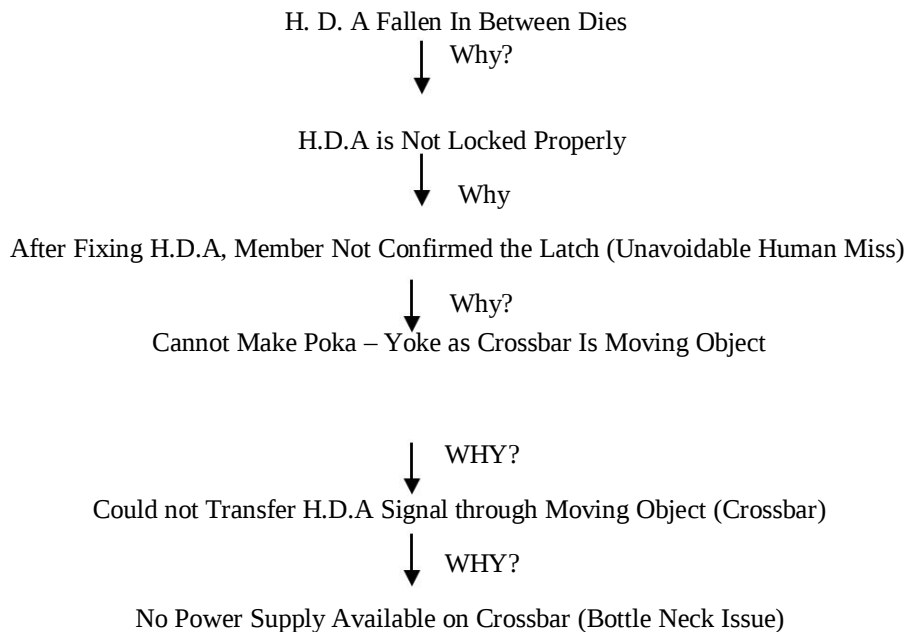


Fig.3.2: Flowchart of Adoption of 5-Why Analysis Technique

The above RCA Technic allows identifying the root cause of the Problem. Based on the analysis one can plan activities to develop a system which can identify the Root Cause and intimate the concerned authority before actually the die damage

Several trial and error methods followed in choosing the right method for detecting the wrong condition of H.D.A Fixing. Based on theoretical knowledge and experience A Proximity sensor is employed to detect the proper fixing condition (refer fig.3.3). A small mechanical screw or spool is introduced into the H.D.A Locking port such that the introduced the spool movement distance will give the indication of the locking condition of H.D.A

A Proper locking system will maintain a standard spool movement. A proximity switch (sensor) is mounted just below the mechanical spool over the crossbar. The mounted proximity switch acts as detecting agent for the proper fixing of the H.D.A. Sensor signal is designed such that for a normal condition i.e. standard spool movement the proximity switch will sense the spool distance and sends the green signal to the controller. In improper H.D.A Fixing the Mechanical spool fail the reach the normal distance. This uncertainty is sensed by the proximity sensor and gives the faulty signal.

Transfer of Proximity switch signal from H.D.A Port location to Controller is not easy task since both robot arm and Crossbar are moving objects. It is very difficult to send and receive a signal when the objects are in motion and another important aspect is we don't find power supply over crossbar.

A severe research is carried out in choosing a best alternative which can transmit signal in motion condition and it should have a power supply system over the crossbar for signal transfer. A remote sensor (BALLUF COMPANY) is selected which has the capability to send and receive signal during motion condition. Non-contact type of signal transfer is employed to transfer signal. Since robot arm and crossbar are not rigid fixed structures. Contact type signal transfer is not recommended in this case. The remote sensor is mounted such that the remote sensor of the crossbar and robot arm is aligned to each other maintaining a small gap. The signal transfer between these sensors is through

Principle of Inductance. The power supply from the power enclosure is fed to the H.D.A sensor via non-contact remote sensor. Once the H.D.A sensor receives power its get actuated and it senses the position of the spool and sends that signal to the main operation panel via remote sensor.

Remote sensor is an intermediate mode of signal transfer between main operation panel and H.D.A sensor. The alignment of transmitter and output sensor of the remote sensor play a critical role in signal transfer. If they are perfectly aligned then signal transfer is more effective. Fig.5.7 gives the details how the signal is transferred without contact.

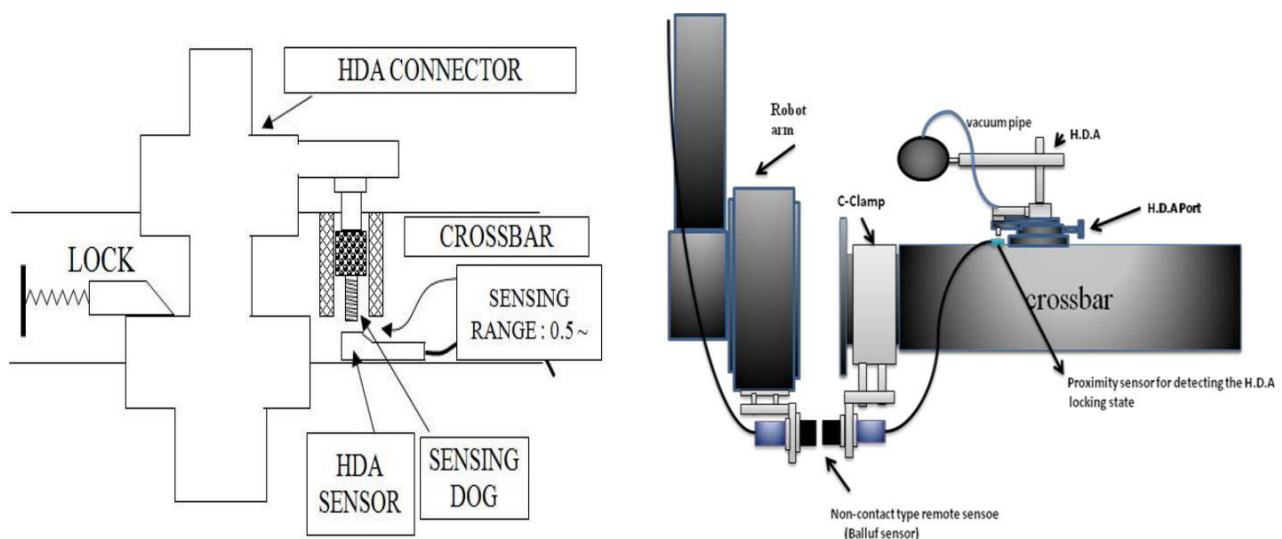


Fig.3.3: Schematic Representing the sensing mechanism of proper H.D.A Locking & Sensor mounting over the Transfer Robot

Programmable Logic Controller (PLC)

Now a day's all electromechanical processes require automation to better efficiency. For achieving automation a PLC, Programmable logic controller is used. PLC is normally used for factory assembly lines. The PLC's are designed in such a way that it can handle multiple input and multiple outputs. PLC's are available in wide temperature ranges, resistance to vibration, resistance to electrical noise etc.

Now a day's a logic system in the machine on the assembly line is replaced with PLC. It is similar to the relay logic. This is because the PLC's works on the "ladder Program" which is time reducing for the existing techniques. PLC's are also programmed with BASIC and C.

Since PLC Logic is company specific. The detail of PLC Logic is not disclosed in this Paper.

IV. EXPERIMENTAL RESULTS

Performance of press machine prior to Root cause analysis

The performance of 24A servo line prior to the implementation of root cause analysis is analysed using the parameter Availability, Mean time between failure (MTBF) and mean time to repair (MTTR).

The details of monthly downtime report before Root Cause Analysis are tabulated in the table 6.2

Table no. 4.1: Monthly down Time Report before Root Cause Analysis

Month	Total Available Hours	Total Breakdown Hours	Total Utilized Hours	Total No. Of Breakdowns
Feb.	168	20	148	15

$$\text{Availability} = \frac{168-20}{168} * 100 = 88.09\%$$

$$\text{Mean time between failure (MTBF)} = \frac{168}{17} = 9.87 \text{ Hours}$$

$$\text{Mean time to repair (MTTR)} = \frac{20}{15} = 1.34 \text{ Hours}$$

Performance of press machine after Root cause analysis

The performance of 24A servo line is estimated after the implementation of root cause analysis. Comparison is made between before and after implementation of root cause analysis to study the improvement in the parameters. The details of monthly downtime report after Root Cause Analysis are tabulated in the table 6.3

Table no. 4.2: Monthly down time chart after root cause analysis

Month	Total no. of hours	Total breakdown hours	Total utilized hours	Total no. breakdowns
June	176	42 min (0.67 Hours)	175.33	14

$$\text{Availability} = \frac{176-0.67}{176} * 100 = 99.62\%$$

$$\text{Mean time between failure (MTBF)} = \frac{176}{14} = 12.52 \text{ Hours}$$

$$\text{Mean time to repair (MTTR)} = \frac{0.67}{14} = 0.048 \text{ Hour} = 2.87 \text{ min.}$$

Establishment of centralized monitoring system for crossbar-H D A locking system is executed practically and percentage of MTTR and MTBF improvement is calculated using the below mentioned formula.

$$\text{Percentage Increase in MTBF} = \frac{\text{Final MTBF} - \text{Initial MTBF}}{\text{Initial MTBF}} * 100 = \frac{12.52 - 9.87}{9.87} * 100 = 21.17\%$$

$$\text{Percentage decrease in MTTR} = \frac{\text{Initial MTTR} - \text{Final MTTR}}{\text{Initial MTTR}} * 100 = \frac{1.34 - 0.048}{1.34} * 100 = 64.18\%$$

V. RESULTS AND DISCUSSION

The condition of machine prior to Root cause analysis and after Root Cause analysis is studied and the results are tabulated in the table 5.1.

Table 5.1: Comparison of Condition Before and After Application of Root Cause Analysis

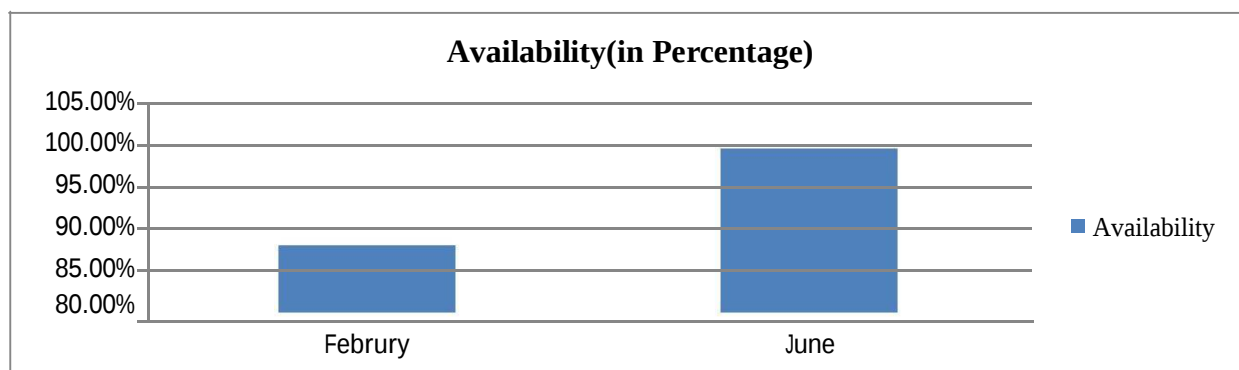
Sl. No.	Before	After
1.	No system to indicate or confirm handling device is locked properly into the crossbar of the transfer robot.	Sensor fixed and feedback linked press PLC to ensure Auto run should not start if Handling Device accessory is not locked properly.
2.	No Proper system to monitor proper fixing of H.D.A	In case handling device not inserted fully/miss, Auto run will not start.
3.	No system to detect H.D.A Loosening and protect Dies from Damage	If handling device loose during Auto running line will stop immediately and will not restart until manual recovery is done
4.	No indication for Operator about the H.D.A Fixing	Clear indication for operator about which wrong fixing of HDA can be avoided

The performance of the machine prior to and after root cause analysis can be analysed using the mentioned plots. The details of machine performance before and after Root cause analysis is tabulated in the table 5.2

Table 5.2: Comparison of Performance parameters before and after Root Cause Analysis

Sl.no.	Performance Parameter	Before Root Cause Analysis	After Root Cause Analysis
1.	Availability	88.09%	99.62%
2.	Mean time between failures(MTBF)	9.87 Hours	12.52 Hours
3.	Mean time to repair (MTTR)	1.34 Hours	0.048 Hours

The fig.5.1 represents the graph plot of Performance parameter Availability before and after implementation of root



cause analysis. It is evident from the graph that the availability of machine improved from 88.09% to 99% on application of centralized monitoring for H.D.A Disconnection.

The fig.5.2 represents a graph plot of Mean Time between Failures (MTBF) and Mean time to repair (MTTR) before and after implementation of root cause analysis. It is evident from the graph that the mean time between failures is improved from 9.87 Hours to 12.52 Hours which is a good sign of improvement.

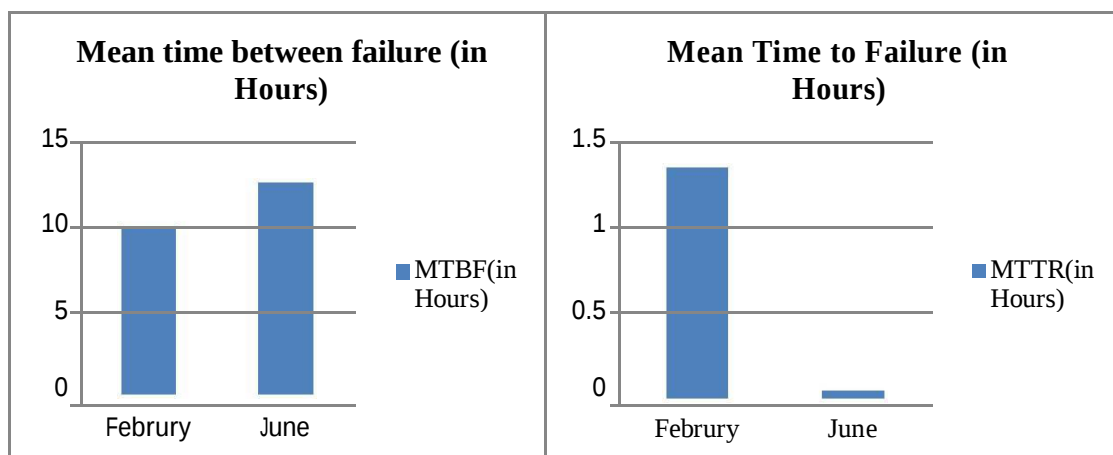


Fig.5.2: Graph Plot of Mean Time between Failures (MTBF) and Mean time to repair (MTTR) before and after Root Cause Analysis

It is evident from the graph that MTTR has improved from 1.34 Hours to 0.048 Hours (2.87 Min.) which is good sign of improvement.

VI. CONCLUSION

The following conclusions are drawn from the present work which involves establishment of Centralized Monitoring system for Transfer Robot's Crossbar-H.D.A locking system.

- The person-oriented job is converted into system oriented job.
- The system is so designed that if H.D.A is getting loose or fall inside the die it will be sensed by proximity switch. This proximity switch directs the control panel to stop the working of machine and provision is such that the machine will not start until problem is attended manually.
- On implementation of centralized monitoring system the availability of machine increased from 88.09% to 99.62%
- On implementation of centralized monitoring system, MTBF of machine increased from 9.87 Hours to 12.52 Hours.
- On implementation of centralized monitoring system, MTTR of machine Reduced from 1.34 Hours to 0.048 Hours.
- The result concludes that the present work is more suitable for establishing a centralized monitoring system for Remaining Crossbars

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