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Reducing Down time for Engine Block Washing Machine

Selvam M, Palani S, Logesh M, Ramesh G, Jayabalan

Abstract: ***The machine down time and decrement in the production rate are due to the frequent setup changes done in the industrial machines. This is about detection and elimination of setup change-over in H-Series engine cylinder block washing machine in industry. Unlike the cylinder block of these engines, the design of both BS3 and BS4 type block is almost symmetrical which results in wrong loading of component in the machines. A detailed study of the design and the machining provides significant details on loading and unloading time. Considering the pros and cons of these ideas we finalized and implemented ideas such as Guide plate design change-over, Safety stoppers for doors and Design and material allocation for Roller, Shaft and Bush which was successful. This report covers the detailed study of the industrial washing machine, the ideas explored to overcome defects and the final ideas which were implemented..***

Keywords: engine block; washing machine; machine down time; production rate; design; material.

I. INTRODUCTION

The H-Series (Platform A and B) engine block & head casting are machined at manufacturing industries which consists of bays with 266 machines. In which H-series (Type A and B) block are machined in three bays with nearly 89 machines. Due to the almost symmetrical design of the Engine Block, there are many instances while loading the component in the machine. This was a serious problem as it affected the quality of the product, safety concerns as well as it affects the life of other arrangement settings such as Guide plate, Inlet and Outlet Guide stands. The calibration as an active approach for eliminating setup change related failure due to machine avoidable activities **[1**]. Smed is often oriented with quick changeover of die or component that consumes the production and cycle time. It mainly focus empirically on the reduction in setup time from 45 minutes to 15 minutes and underlines the maximum importance of the lean production **[2]**. Maintenance time and machine down time consume 15.7% of the overall production time. This literature explains the Repairs characterized by their effectiveness, which is often referred to as the degree of repair - the extent to which the condition of the system function is to restore repair **[3]**. The specific principle applied to reduce the setup time of machine. Implementing parallel operation by eliminating adjustment to further setup time reduction presented using SMED technique [4, 5]. The 5s concepts are the problems during the implementation of kaizen, Kanban and Poka Yoka technique. It is holding the information for quality function development and functional requirement [6, 7]. The lack of quality is improvement and maintenance management inside the organizations to neglect maintenance for competitive improvement. This will results in fast deteriorations towards production thereby this leads to unreliable failure in delivery of performance [8, 9]. The Maintenance performance and its measurement in the manufacturing industry has innovative approach and they utilized to manage maintenance performance and its operational settings.[10]. Literature on survey explains the systematic approach to identify, break and eliminating waste by continuous improvements as well as Lean manufacturing is flexible manufacturing techniques and reduce the 50% of human efforts [11]. The relation between Setup time elimination using smed and increasing production efficiency through product capability analysis and it also showed that the smed is adoptable method for manufacturing and solving maintenance problems [12, 13].

II SETUP CHANGE ELIMINATION IN INDUSTRIAL WASHING MACHINE

The clear objective of the setup change elimination is to prevent the machine down time and eliminate the production losses. Eliminating setup time will increase company's production capacity and manufacturing flexibility that helps increasing overall output. During the period where an operators or technicians are about to change tooling from one to the next machine or assembly operation that is idle, the time that is wasted cannot be recovered.

2.1 Glance at Washing machine

There are different types of washing machines used in the industrial area. These washing machines are employed for different purposes. Figure 1 show the types of washing machine used.

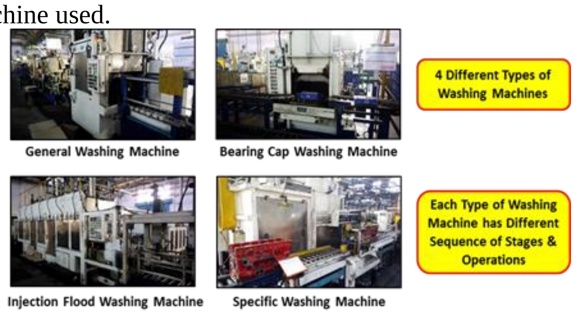

Figure 1: Types of washing machine used

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2.2 Machine purpose

To remove dirt, oil, paint, carbon, rust, scales from Internal as well as external surfaces. Post Machining cleaning to remove coolant, cutting oil, metal chips & other residues. Unblocking Mounting holes, Cooling Circuits, Oil & Water gallery's in component. To provide clean component to Next manufacturing process stage, Performance testing, Visual & Stage Inspections and CMM measurement & component assembly.

2.3 Rotary cage

The rotary cage is responsible for holding the cylinder block and splashes the pressurized water upon it to remove the chips, dust and oil particles. The rotary cage weights up to 300kg and is placed in the mid position of the washing machine. The rotary motion of the cage is controlled by the chain driven motor. The figure 2 shows the existing design of rotary cage.

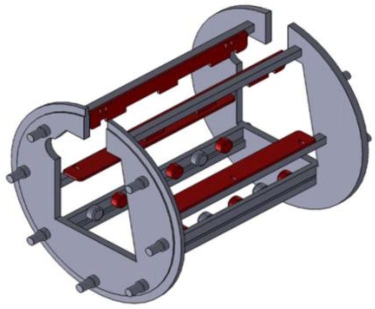

Figure 2: Rotary cage existing design

III DEFECT DETECTION

3.1 Defect in Guide arrangement

The deflection and ultimate strength of damaged steel plate with simple support are investigated by using FEM analysis. These results and discussions lead to the conclusions that are listed below. The cyclic load makes the increment of deflection and reduction of strength. In condition under the same cyclic load, the higher value of the width - thickness parameter R is the larger the deflection. If the damage deflection is lesser than the limit deflection, the ultimate strength equals with the strength of the undamaged steel plate. When the damage deflection exceeds limit deflection, the decreasing residual strength depends on the only damage. The estimation for damaged steel plate is proposed. This method needs only the width thickness parameter and also damage deflection.

3.2 Failure modes of guide plate

The arrangement and fixture of the guide plate is affected by both internal and external factors such as the temperature, impact loading and corrosion. Internal and external factors are sequentially broke downed to identify the exact cause and effect of the problem. The guide plate is seriously affected by the external factors such as the changing atmospheric condition and internal factor like the frequent heavy impact of the block component. These issues can be overcome by eliminating the movable guide plate mounting and replacing it with impact resistive, increased life time period and easy handling during the period of maintenance. Figure 3 shows the indicating guide plate failure mode.

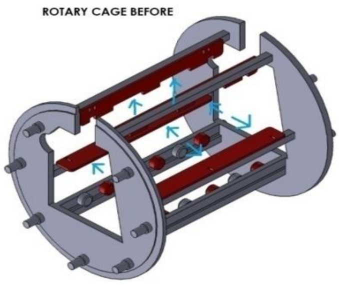

Figure 3: Indicating Guide plate failure modes

3.3 Safety issue in Industrial washing machines

3.3.1 Importance of Safety stopper

In manufacturing sector everyone is affected one or the other way. The maintenance worker who carries out maintenance related work is at fatal risk around dangerous equipment or within a dangerous environment. Industrial workman is particularly at risk in unfamiliar working atmosphere. The doors of the washing machine are being controlled by the pressurized air. During maintenance hours the entire power of the washing machine are shut down where the pressure becomes zero. Due to this the door losses control and slams with heavy weight and causes damage to the machine components and also to the worker who is repairing during the maintenance period.

3.3.2 Issues and risk factors

Working with manufacturing machines endures several risks issues to employees as well as to the maintenance workers. Machines that have sprockets, gears rotating shafts and pulleys pose risks internal and external risk factors. When a machines two hard surfaces move together, workers are at risk of fatal injuries and machines that have sharp edges or those performing scissoring actions put workers at risk of cuts severed limbs. Workers are also at risk of trip-and-fall accidents if a machine has cable damages. Employers should initiate machine safety guards to eliminate the risk of these accidents like turning machines off while they do maintenance services. Maintenance service can be dangerous, it is estimated that between 25 and 35% of all manufacturing industry in Britain result deaths from maintenance and other service activity.

These are the main issues that are being faced in the manufacturing industry. These are the main issues that are being faced in the manufacturing industry such as accessing equipments in harsh machining area. Force impact on human body might cause musculoskeletal disorders. Handling electrical hazards are exposure to the critically restricted area in the manufacturing sector. Contact with the most dangerous chemicals.

IV METHOD USED FOR APPROACHING THE PROBLEM

4.1 Implementation of kaizen

The Figure 4 shows the proposed kaizen system.

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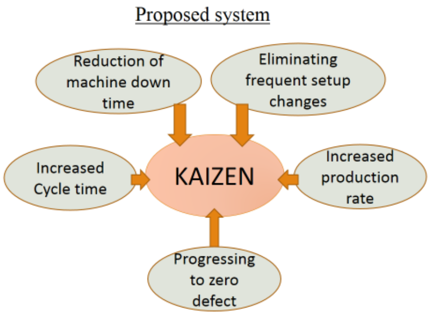

Figure 4: Proposed kaizen

Kaizen eliminates waste, delay time period that includes worker movement and production loss and also communication Space utilization and employee retention. Therefore, improving the production method job a part of a function or process of kaizen. The use of kaizen for continuous improvement demands both flow and process that kaizen are used, process of kaizen are used most often to focus workers continuous small improvements. Kaizen activities covers the improvements in a series of areas including Quality Bettering products, service, environment and processes, Cost, reducing expenses and use of material and manpower, energy utilization and resource facilitating, Delivery , Cutting delivery time.

4.2 Design to eliminate failure

The risk factors are concerned while designing the guide plate and tested in first machine LA4581 and then it is further processed in the following machines. The Figure 5 shows the new design of rotary cage.

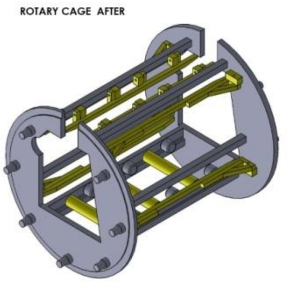

Figure 5: New design of rotary cage

4.3 Materials used

The material used for roller fabrication is 52100 chrome steel undergoing heat treatment processes as shown in the figure below. The Figure 6 shows the fabricated rollers.

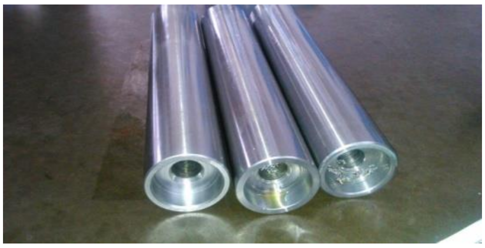

Figure 6: Fabricated rollers

V CALCULATIONS OF FORCES

5.1 Roller calculation

The engine body is on the rollers so the load is equally distributed all the rollers.

The total weight of the body =165kg
The total force acting on the body =165*9.81 =1618.65N
For safety factor consider the load as 1700N
At the load distributed all the rollers equally and the rollers are in the cantilever structure
Total number of rollers=12
Total number of rollers =12
The force acting on the each roller =1700/12 =141.67N
To calculate UDL load at a distance 50mm
=141.67/50
=11.81N/mm
To find the values of the R_x and R_y take the free body diagram
For the equilibrium conditions are take $\sum X=0, \sum Y=0$
For the horizontal forces are R_x =0
The vertical forces are
R_y-11.81*50 =0
R_y =141.67N
Shear force at A =-141.67N
Shear force at B =-141.67+141.67*50
=0N
At the cantilever beam the shear force diagram follows the linear law load at each points follows the -wx.

5.2 Bending moment calculation

Bending moment at A $=-wl^2/2$
$=-11.81*50^2/2$
=-14762.5Nmm
Bending moment at B $=50*141.67+11.81*50^2/2$
=0Nmm
At the bending moment diagram follows the parabolic law at equation $-wx^2/2$. Figure 7 shows SF and BM diagram of cantilever roller.

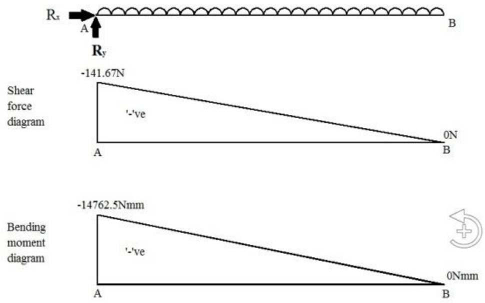

Figure 7: SF and BM diagram of cantilever roller

5.3 Rotating gage at an angle 0^0

The **Figure 8 shows Engine position at 0^0**.

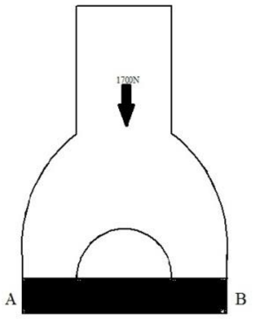

Figure 8: Engine position at 0^0

the rollers are converted into the simply supported beam so at the load acting at the UDL =1 N/mm

the apply the equilibrium conditions

$\sum V$ =0
R_a+R_b =1*285
=285N
$\sum M$ =0
R_b*285-285*285/2 =0
R_b =142.5N
R_a =142.5N

5.4 Shear force calculation

Shear force at A =-142.5N
Shear force at B =-142.5+1*285(before)
=142.5N
B =142.5-142.5
=0N

5.5 Bending moment calculation

At bending moment at A =0Nmm
Bending moment at B $=142.5*285-1*285^2/2$
=0Nmm

A the centre the bending moment diagram the value is -10153.125Nmm. Figure 9 shows SF and BM diagram.

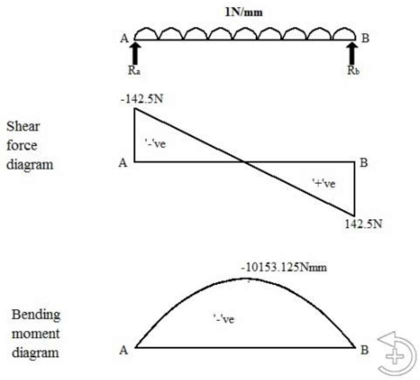

Figure 9: SF and BM diagram of simply supported beam

5.6 Rotating gage at an angle 90^0

The figure 10 shows Engine position at 90^0.

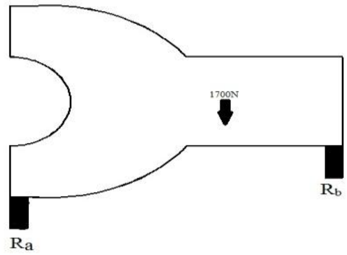

Figure 10: Engine position at 90^0

At this stage the two supports are provided the load is distributed at this two fixtures

At the equilibrium conditions

$\sum V=0, \sum M=0$

R_a+R_b =1700
R_b*170-30*1700 =0
R_b =300
R_a =1400

5.7 Horizontal Fixture 1

At this load R_a is distributed all over the length so UDL load is 2Nmm

5.7.1 Shear force calculation

Shear force at A =-695N

Shear force at C to D due to the UDL load the values are decreasing

Shear force at B =695N

5.7.2 Bending moment calculation

Bending moment at A =0Nmm
Bending moment at C =45*695
=-31275Nmm
Bending moment at D $=-740*695+2*695^2/2$
=31275Nmm
Bending moment at B =0Nmm

Figure 1 1shows the SF and BM of horizontal fixture 1

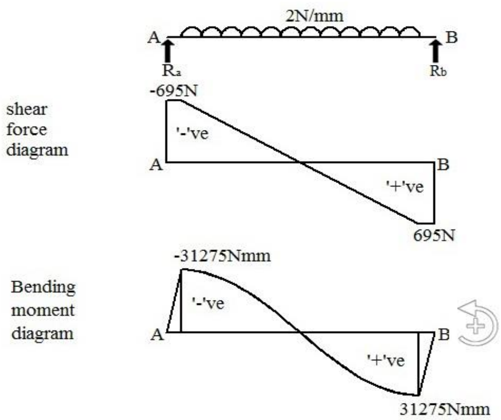

Figure 11: SF and BM of horizontal fixture 1

5.7.3 Horizontal Fixture 2

At this load R_b is distributed all over the length so UDL load is 0.43Nmm

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5.7.3.1 Shear force calculation

Shear force at A =149.425N
Shear force at C to D due to the UDL load the values are decreasing
Shear force at B =-149.425N

5.7.3.2 Bending moment calculation

Bending moment at A =0Nmm
Bending moment at C =45*149.425
=-13448.25Nmm
Bending moment at D $=-740*149.425+2*149.425^2/2$
=13448.25Nmm
Bending moment at B =0Nmm

Figure 12 shows the SF and BM of horizontal fixture 2

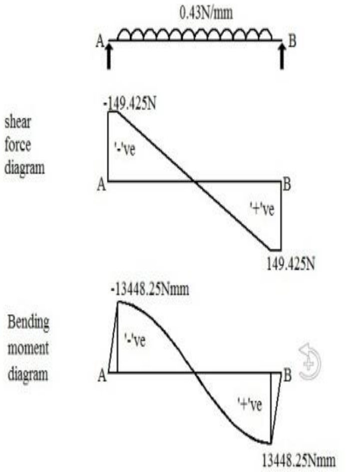

Figure 12: SF and BM of horizontal fixture 2

5.8 Rotating gage at an angle 180^0

Figure 13 shows the Engine position at 180^0

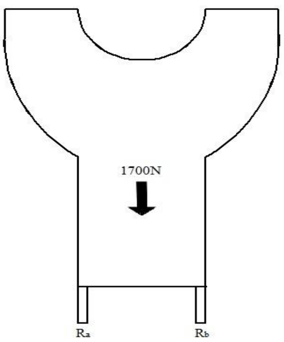

Figure 13: Engine position at 180^0

For the vertical equilibrium $\sum Y$ =0
$R_a+R_b=$ 1700
Take momentum about B
$140*R_a-70*1700$ =0
R_a =850N
R_b =850N

The load is equally distributed all over the guide plate so the UDL force is
850/695 =1.22N/mm

The fixture is spitted into three elements for the calculation of the reaction forces
850/695 =1.22N/mm

5.8.1 Fixture element 1

Apply the equilibrium condition
$\sum V$ =0
$R_a+R_{b1}-1.22*297.5$ =0
$\sum M$ =0
$R_{b1}*297.5297.5^2*1.22/2$ =0
R_{b1} =181.475N
R_a =181.475N

5.8.2 Fixture element 2

Apply the equilibrium condition
$\sum V$ =0
$R_{b2}+R_{c1}-1.22*100$ =0
$\sum M$ =0
$R_{c1}*100-100^2*1.22/2$ =0
R_{c1} =61N
R_{b2} =61N

5.8.3 Fixture element 3

Apply the equilibrium condition
$\sum V$ =0
$R_{c2}+R_d-1.22*297.5$ =0
$\sum M$ =0
$R_d*297.5-97.5^2*1.22/2$ =0
R_d =181.475
R_{c2} =181.475

5.8.4 Shear force calculation

Shear force at A =-181.475N
Shear force at B =-181.475+297.5*1.22N
=181.57N
B =181.57-242.475(after)
=-61N
Shear force at C =-61+1.22*100(before)
=+61N
C =+61-242.475(after)
=-181.475N
Shear force at D =-181.475+297.5*1.22 (before)
=+181.475N
D =+181.475-181.475(after)
=0N

5.8.5 Bending moment calculation

Bending moment about A =0Nmm
Bending moment about B $=297.5^2*1.22/2-297.5*181.475$
=0Nmm
Bending moment about C $=1.22*397.5^2/2-181.475*397.5-242.475*100$
=0Nmm
Bending moment about D $=1.22*695^2/2-695*181.475-242.475*397.5-242.475*297.5$
=0Nmm

At the E ,F and G values are -13497.20313Nmm, 1525Nmm and 13497.20313Nmm respectively

Figure 14 shows the SF and BM diagram of vertical fixture

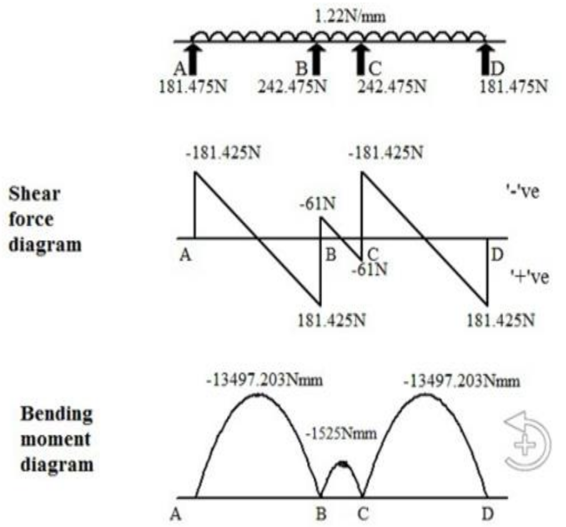

Figure 14: SF and BM diagram of vertical fixture

VI Analysis using ANSYS

The Figures 15 and 16 shows the analysis of the new designed rotary cage

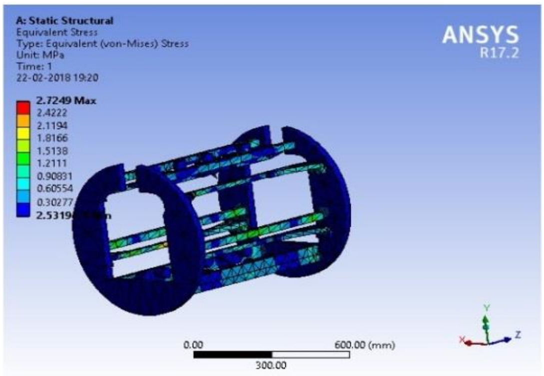

Figure 15: Stress analysis

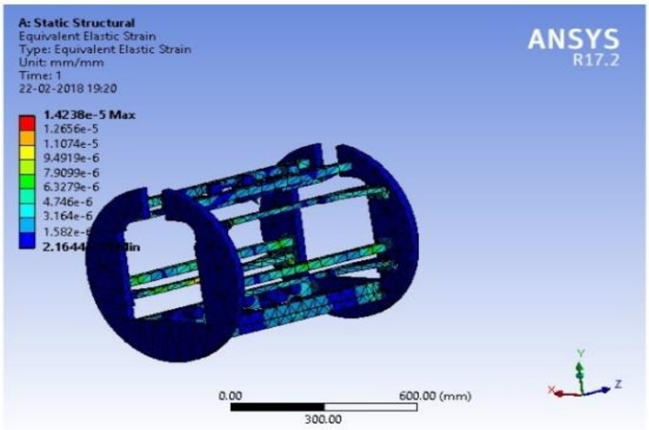

Figure 16: Strain analysis

VII RESULT AND DISCUSSION

7.1 Benefits of the project

After the implementation of the fixtures setup in the washing machine tested for the both the A type and B type engines, the fixture arrangement is suitable for the both the engines. So the setup change time is reduced and also not need to change and adjustments of the guide plates, almost the 45 minutes are save at the total six machines. Also safety factor is increased because of the no need to adjust the guide plate components. And also the damages of the components are also reduced because of the closed fixtures.

7.2 Production rate comparison

At the saving of the time due to the elimination of the setup we can get 45 minutes. There we can produce more components so the production rate is improved the production rate chart is shown in the figure17.

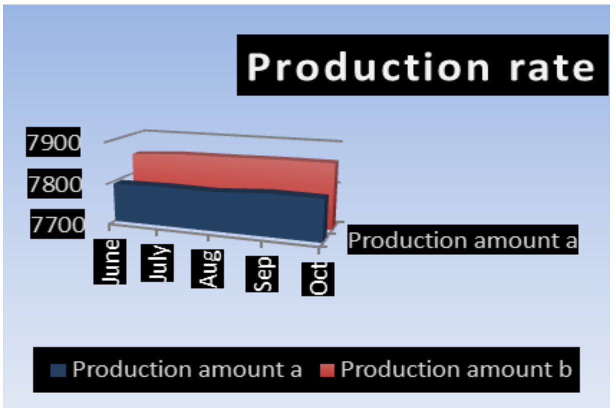

Figure 17: Production rate chart

7.3 Reduction of losses

Due to the impact of the engine block and the rotating cage more number of the engine blocks are damaged these losses are prevented at the after the implantation of the fixtures the losses of the five months data's.

VIII CONCLUSION

The major internal problems faced by the manufacturing Industries such as production delay, reduction in cycle time, repetitive machine failures, quantity of production and quality issues. These are unavoidable issues that frequently occur to varying conditions and are provided with temporary solutions.

This project completely eliminates frequent setup change-over in the Industrial washing machine that enables increment in the quantity of production upto 1.4%, reduces machine down-time upto 40mins. Due to the prevention of the machine down time, the cycle time of the production is increased which in turn produces additionally 50+ components. The breakdown occurring due to the positioning failure of the engine block component is prevented by the permanent setup design where the time period consumed for this particular purpose can be used in any other productive manner. The percentage of gain with an amount is 0.91% decrease in the loss and increase the production which amounts for about 0.89% of production cost.

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Palani S was born in Madurai, Tamilnadu, India, in 1967. He received the B.E., degree in Mechanical Engineering from M.K. University, Madurai, Tamilnadu, India in 2003, and the M.E., and Ph.D. degrees in Manufacturing Engineering from the Anna University, Chennai, Tamilnadu, India in 2005 and 2013, respectively. He has 13 years of experience in teaching and research and working as an Associate Professor in the Department of Mechanical Engineering, Vel Tech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, Avadi, Chennai-600 062. His research area include Advanced Manufacturing Technology, Artificial Intelligent Techniques, Machine Vision, On-line Monitoring, Material Science, Bio-Fuel, Heat Exchanger etc., He published more than 100 research papers through National and International Journals and Conferences. He is an authorized Research Supervisor for Anna University and Guiding more than 7 Ph.D., research scholars. He was awarded as a “Distinguished Scientist” by Venus International Foundation -Research Awards-VIRA 2016. He is a Life member of MISTE [LM91981} in professional bodies.

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