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Multiply ofProcess Speed, Quality and Safety through Low-Cost Automation –A Case Study

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Abstract. Technological upgrading proposals often come across in industries. Nowadays manufacturers take shifts from manual operations to automation with consideration of productivity in man-hour, accuracy; timely delivery, safety, better finish, etc. The procurement of new machines or equipment or systems demands more investment. The case study was conducted in a leading valve manufacturing company. This research focuses on the valve end grinding operation. The following difficulties were exercised in loading and unloading of valves in the machine due to limited operator. That is the maximum stress for the workers in the loading and unloading process, further the time taken for the process is more, which affects the production rate. Accuracy of setting often error which causes rejection based on variation in critical parameters. In addition the safety for the workers involved in this process is very less. So in order to overcome the above difficulties, there is a need to design a more flexible system which will take care of the process and reduce the stress of the workers. The safety factor must also be concerned with the design. It was ensured that the proposed system increases the productivity, quality, accuracy, safety and comfort.

INTRODUCTION

Product demand is varies day by day. Based on the demand the manufacturing firm meets the same. Usually huge variation in demand prefers to establish the additional facility. But [1] applied Six Sigma method of ECRS methodology improved production rate and cast off the expansion plan and met the demand of 6000 units per month from the usual production of 4800 units per month. [2] enhanced processing rate from 208 gear boxes per month to 302 gear boxes per month by mechanization of loading and unloading tasks. [3] improved the production by line balancing methodology as well as priority based processing on the bottle neck machines and there by increases the turnover tremendously [4] improved TIG welding plant production by introducing material handling equipment for processing there by the production rated increased from 1140 to 1560 units per month. [5] increased the profit fromIndian rupee 51,37,455 to Indian rupee 56,16,265 by low cost automation. In this paper also discusses the interesting story of improving production rate more than double times by low cost automation in a leading manufacturing firm in Chennai, Tamil Nadu, India.

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PROBLEM

In the existing system, men are employed in loading and unloading operation [6-22]. There are various stages a valve will have to go through before it is being used in the engine. One of the operations is end grinding [23-39]. After the seat grinding operation the valves are taken to end grinding [40-52]. During the operation, grinding is done at one ends so as to produce the flat surface and proper tapping [53-61]. While loading and unloading the workers find difficult to take valve. Also the safety concern among the workers is inadequate [61-70]. The time consumed for loading and unloading the valves is more and it affects the production rate. The pneumatically operated system is cheaper in cost than that of hydraulic system, also quicker in operation. Air which is abundant in nature is used as the working source. So it was decided to use pneumatic operated cylinders and motors for the operation. By the system the loading and unloading becomes easier, also time saved, which will reduce the handling cost and increase the productivity. In addition, there will be more safety shown to the workers as the operator would now be a controller of switches for the automation system only. End touch grinding operation is a surface grinding operation in which fine burr materials are removed at the end of the stem of the engine valve with the help of a rotating grinding wheel. Such wheels are made of fine grains of abrasive materials held together by a bonding material called a bond. These abrasive materials have high hardness and a high heat resistance. Grinding provides a very good surface finish with high accuracy. Therefore, this operation is used for finishing operation. This process removes comparatively 0.010mm to 0.015mm. The End Touch Grinding machine is used to produce flat and plane surfaces .Here the valve is supported in the v-block and it is fed into the grinding wheel rotating at a speed of 1450rpm. The general flow process chart is drawn in Figure-1.

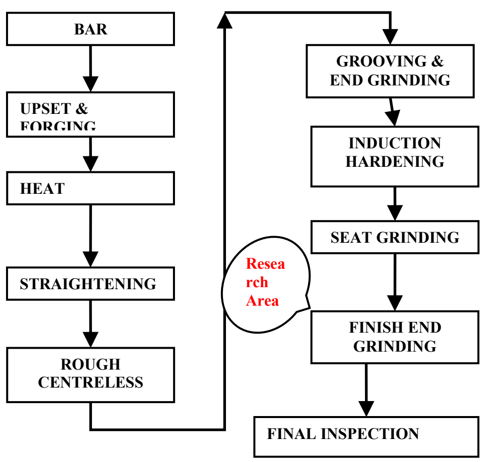

FIGURE 1. Flow Process Chart of Valve manufacturing

MATERIALS AND METHODS

Machine Features

The frame is a strong cast iron frame with heavy duty ribbing to give extreme rigidity and resistance to vibrations arising from the heavy duty cuts. The frame is machined on top and bottom .The top Machined surface houses all the main sub assemblies' i.e Wheel assembly, Slide assembly. The wheel slide assembly is rigidly clamped on the frame top, which can be loosened & adjusted for wheel wear compensation by graduating hand wheel at the rear of the machine. Auto loading chute is mounted next to the spindle housing. The chute is modified to facilitate front loading. A Pendulum pivoted at the center on taper roller bearings, carries on the top work holder assembly. A pneumo-hydraulic cylinder clevis mounted on the right side of the machine swing the pendulum over the wheel face and in the left side Pneumatic valves and accessories are fixed.

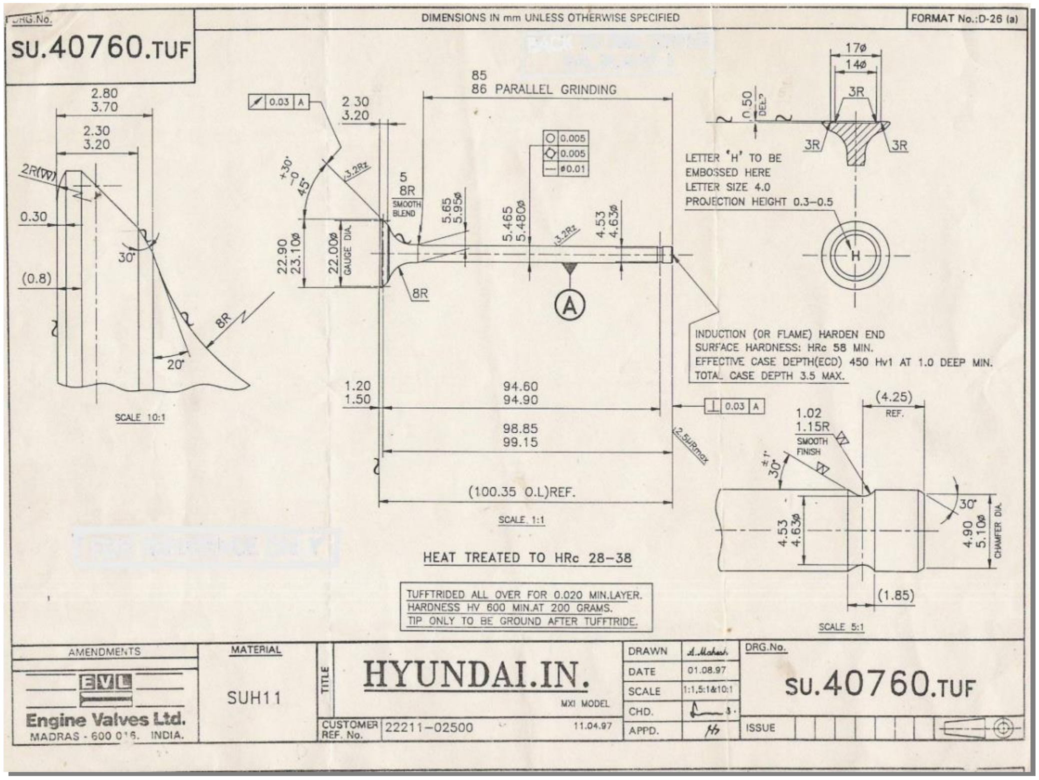

FIGURE 2. Production Drawing of Valve

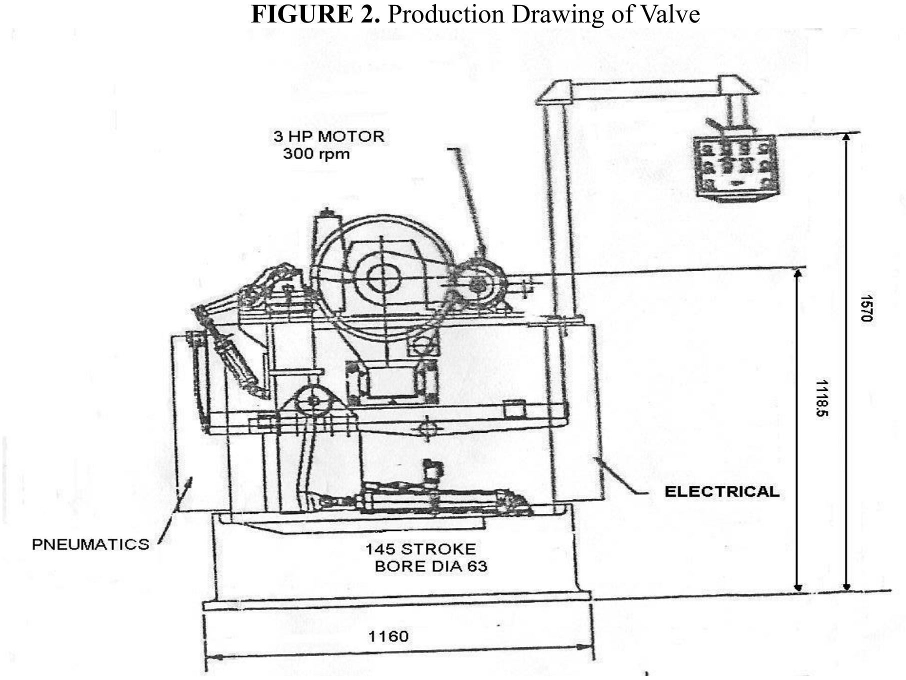

FIGURE 3. Special Features of EndGrinding Machine

Clamping Assembly

The clamping assembly is mounted close to the v-block in order to clamp the job on the v-block. It consists of two separate taper roller bearings mounted back to back with sufficient clearance to permit free swing to clamp the job. This is done with the help of a griper and stopper

Pendulum Assembly

The pendulum is fabricated and ribbed heavily to take the grinding load .It is assembled on a fabricated bracket which is bolted and doweled on the cast iron bed. The assembly consists of two taper roller bearings in two separate bearing housings mounted back to back with just sufficient clearance to permit free swinging.

Slide Assembly

The manual slide assembly is mounted at the top left side of the machine frame, which carries chute assembly. This slide is provided for chute adjustment to accommodate different length of jobs. The Ejecting cylinder assembly is mounted next to it. The ejector has its own provision for setting up/down or sideways

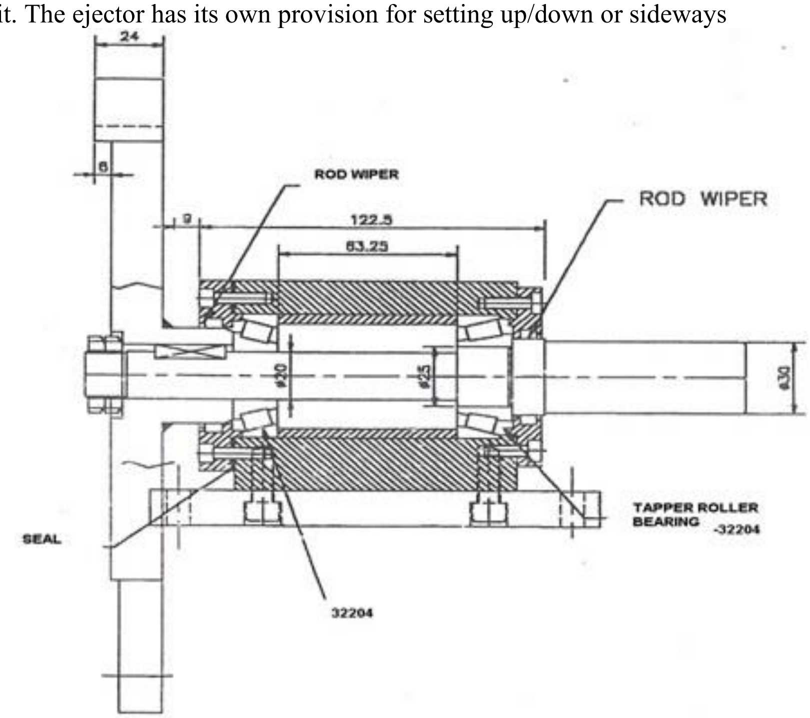

FIGURE 4. Clamping assembly

Loading & Unloading

Valves are manually loaded on to the chute; A singling unit actuated by pneumatic cylinder singles out the valves & drops a valve on the V-block. To eliminate valve jumping, a set of round pins with guides are provided on V-block at front. Some clearance gap between valve head and the pins should be there so that valve gets clamped against the V-block and not on pins. After receipt of a valve clamping will take place, the clamping OK or NOT OK will be decided with the help of two reed switches. If clamping OK then ejector comes &butts the valve against stopper, then cycle will proceed if loading is OK. And at the end of pendulum returned to home, the ejector will eject the valve.

Chute Setting

Setting chute for different types of valves, chute opening gap to be adjusted according to the valve diameter and neck profile. Chute gap should be such that valve slides on the chute freely and at the same time valve stem should not overlap each other. Ref.fig 07.Loose the M6 bolts(1), now one can adjust the chute gap by adjusting M12 bolts(2).After adjusting chute tighten all the bolts and nuts. Two studs are fixed on slotted singling units, opposite to each other and offset by slightly more than the diameter of the valve. This gap should be such that only one valve at a time enter between the studs. One more guide in the form of a bent sheet metal piece, is provided for valve head at the front top of the chute. This is the one makes the valve fall on the 'v' block horizontally. Enough gap to be provided between the chute and front guide for the valve head to fall freely.

Wheel Dressing

A separate hole is provided to the hold dresser. This hole is at side of the v-block. Switch of the wheel and bring the pendulum forward with reduced feed. (care to be taken that the dresser should not hit the wheel while pendulum coming forward).Stop the pendulum when the dresser comes in front of the wheel. Adjust the dresser with the wheel to get little clearance and tighten all the grub screws. Take the pendulum to home and give depth of cut for dressing by taking dresser forward. Now switch on the wheel, dress the wheel with slow pendulum movement.

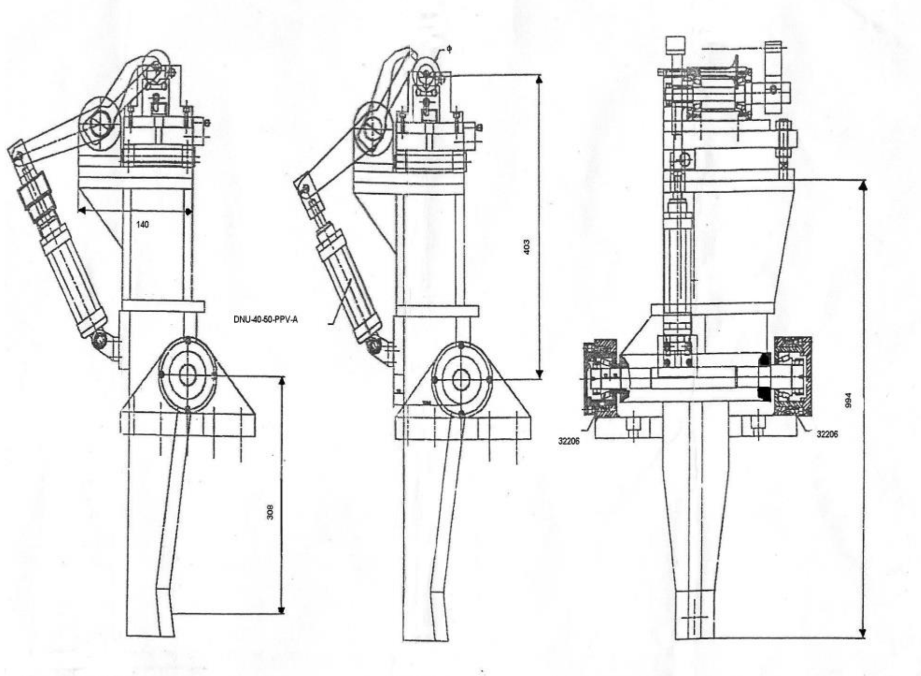

FIGURE 5. Pendulum Assembly

Pneumatic

The machine is operated pneumatically. Pneumatic valves and accessories are fixed on the left side of the machine. To achieve controlled uniform pendulum feed , pneumo-hydraulic cylinder is used (Ref.fig 04)
Pneumo-Hydraulic Cylinder

Mounting - Trunnion Mounting

Stroke Length - 143mm

Bore Diameter - 63mm

Piston Rod Dia -20mm

Piston Diameter –60mm

For clamping and decamping, two 3/2 pneumatic valve is used to attain the following points.

1. Both the solenoids are on for decamping.

2. S5 is on for clamping with reduced force.

3. Both off for clamping with full force.

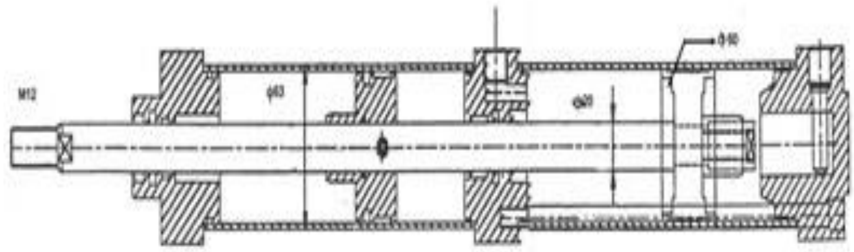

FIGURE 6. Cross sectional view of Pneumatic Cylinder

Pneumatic Cylinders

Clamping - DNU-40-50-PPV-A – 1 NO

Loading - AVL-20-10-A - 2 N0

Unloading – DNU-32-40-PPV-A – 1 NO

Operating Pressure - 6 BAR

Ambient Temperature - -20-80

Theoritical Force - 753 N

Mounting - ROD CLEVIS

Product Weight (AT Omm stroke) -727GRAMS

Additional Weight/ mm STROKE- 36 GRAMS

RESULTS AND DISCUSSION

Time Consumption in Manual Operation

Setting time for the operation = 15 min

Time taken to machine one valve = 3 sec

Time taken for machining 1000 valves=3*1000= 3000sec = 50 min

Dressing time (once for 250 valves) = 4* 10 = 40 min

Checking time (once for 5 valves) = 3 sec for 200 times (for 1000 pieces) = 600 sec = 10 min

Total time taken = setting time + machining time + Dressing time + checking time

= 15 + 50 + 40 + 10 = 115 min = 1 hr 55 min

Hence Time taken for 4200 valves = Time taken for 4000 valves + Time taken for 200 valves

Time taken for 4000 valves =4(50+40+10) + 15 = 400 + 15 = 415 min

Time taken for 200 for 200 valves = 20 min

Total time taken for 4200 valves in one shift = = 435 min = 7 hrs 15 min

Total shift time = 8hrs

No. of valves machined in one shift = 4200 valves

Time taken to machine one valve = 8 / 4200 = 0.0019 hrs = 6.85 sec

Time Consumption after the Low Cost Automated

Clamping Time

Force required,F = 589.04N ;

Pressure, P = 6 bar (constant)

Area of the piston ,Ap= F/P = 589.04/(6*105) = 9.817* 10-4m2

Diameter of the piston =[(9.817* 10-4*4)/π]1/2 = 35.35mm = 40mm (std)

Velocity, v = 450 mm/s

Hence Discharge (Q) = V*Ap = (450*π/4*402)/109 =5.654*10-4 m3/s

Time taken = stroke length/velocity = 50/450 =0.11 sec

Loading Time

Force required ,F = 188.49N

Pressure, P = 6 bar (constant)

Area of the piston ,Ap= F/P = 188.49/(6*105) = 3.141*10-4m2

Diameter of the piston = [(3.141* 10-4*4)/π]1/2 = 19.9mm = 20mm(std)

Velocity, v = 450 mm/s

Discharge , Q = V*Ap = (450*π/4*202)/109 = 1.413*10-4 m3/s

Time taken = stroke length/velocity = 10/450 = 0.022 sec

Unloading Time

Force required ,F = 482.1N ;

Pressure, P = 6 bar (constant)

Area of the piston ,Ap = F/P = 482.1/(6*105) = 8.035*10-4m2

Diameter of the piston =[(8.035* 10-4*4)/π]1/2 = 31.9mm = 32mm(std)

Velocity, v = 450 mm/s

Discharge, Q = V*Ap =(450*π/4*322)/109 =3.619*10-4 m3/s

Time taken = stroke length/velocity = 40/450 =0.08 sec

Swinging Time

Volume of pendulum Assembly = 14110.85 cm3; Density of mild steel = 8 grams/cc

Weight of the pendulum assembly = 14110.85*8 = 112886.85 gms = 1107.42N

Force required, F = 1107.42+589.04 = 1696.46N

Pressure, P = 6 bar (constant)

Area of the piston, Ap= F/P = 1696.46/(6*105) = 2.827*10-3m2

Diameter of the piston=[(2.827* 10-3*4)/π]1/2 = 59.9mm = 60mm(std)

Velocity, v = 450 mm/s

Discharge, Q = V*Ap =(450*π/4*602)/109 =1.272*10-3 m3/s

Time taken = stroke length/velocity = 150/815 =0.184sec

Machine setup time

(Once for 5000 valves) = 15 min

Set up time (for one valve) = 15 / 5000 = 0.003 min = 0.18 sec

Dressing time

(Once for 250 valves) = 10 min

Dressing time (for one valve) =10 / 250 = 0.04 min = 2.4 sec

Total time taken for one valve = 0.11 + 0.022 + 0.08 + 0.184 + 0.18+ 2.4= 2.976 sec

That is total time taken for one valve is 0.000826 hrs,

If the shift time is 8 hours means

No. of valves machined in 8 hrs = 8 / 0.000826 = 9685 valves

Maximum 9685 valves can be machined per shift so the percentage of increase in production is more than double (Refer Figure

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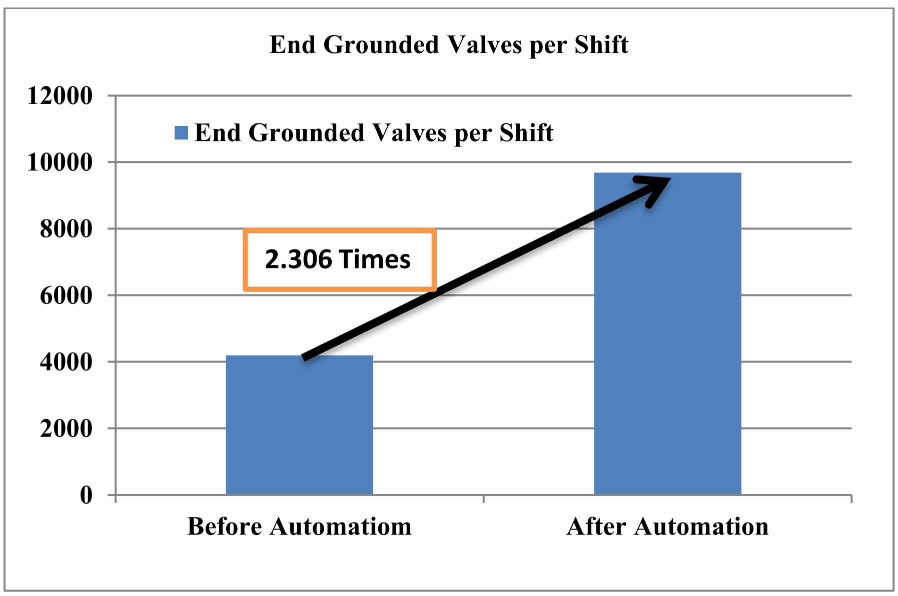

FIGURE 7. Benefit of Automation

CONCLUSION

This research papers stress the importance of automation in primary manufacturing equipments to increase the production rate and ensure safe and trouble-free working environment. This was systematically illustrated with case study. Purchasing new equipment is more costly than making simple automation. That is mechanization of necessary activity is cheap and more profitable. The re-engineering of production is must. So the certification bodies of TQM, TPM, and QS9000 etc considered process improvement is important factor and also giving proper approach of such improvements make possible in their industries. In this case, the automation reduces the time taken for machining one valve by 56%. This makes possibility for increasing production rate from 4200 valves to 9685 valves per shift. That is more than double the production per shift with safety andcomfort operation.

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