Productivity Improvement by Low Cost Automation in Manufacturing of Steam Turbine Blades

Mr. Abhijeet B. Nigade[1] Prof. S. J. Madki[2]
[1]Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]BMIT, Solapur

Abstract— The Pick and Place robot is one of the technologies in industries and designed to transfer materials from one location to another. The system is very important to minimize human errors and to get more precise work done. It can also save the cost in long run and help to solve problems and tasks. The advancement of automation in the field of manufacturing has led to the innovation of varieties of Robots. Automation is a technology that deals with the application of mechanical, electrical, electronics, and computers to operate and control production. Pneumatic driven systems are widely used in industrial automation, mainly for relatively simple tasks with open-loop control system. The current project work is carried out for "Design and development of pneumatic pick and place unit for automatic loading and unloading of blades on a DMG machine". In the present situation, the loading and unloading of the blade is done manually by human interference in DMG VMC. This manual interference has led to high manufacturing lead time, high loading and unloading time, low machine utilization and low productivity. All these problems demanded for a material handling system.

Key words: Low Cost Automation, CNC machine, Steam turbine blade, Fixture

I. INTRODUCTION

Low Cost Automation (popularly known as LCA), is the introduction of simple pneumatic, hydraulic, mechanical and electrical devices into the existing production machinery, with a view to improving their productivity. These would also enable the operation of this equipment by even semiskilled and unskilled labour, with a little training. This will involve the use of standardized parts and devices to mechanize or automate machines, processes and systems. Utilizing a human being as a source of energy is an inefficient method, in addition to being boring and monotonous to the worker. It is estimated that it costs approximately 400 times as much for a man to supply 1 kWh of energy as it does to get this from electrical power. Similarly, using an operator as a sensing device is not only uneconomical but also would result in excessive fatigue.

It is considered as a new tool in the hands of management to dispense with the workers. It is feared that introduction of automation would lead to large scale unemployment and hence, considered as an enemy of the working class. As a regard to the fear of increased unemployment it is true that indiscriminate application of automation on a large scale would result in increased unemployment problem. But, it is worth remembering here that it is not the automation itself but the application that is to be blamed.

Low cost automation, which unfortunately has not received as much attention as it deserves, perhaps because of lack of publicity, knowledge and understanding, does not lead to retrenchment as is feared by many. Low cost automation results in improvements in production processes, systems etc. And any improvements would result in reduced time for the work being done and, if the quantum of work remains the same, requirements of labour would reduce. But, in a growing economy the demand for commodities are rarely met. Therefore, if the amount of time taken to do a job is reduced, more number of jobs can be done in a day, a month or a year. This means that there would be increased productivity with attendant reduction in the unit cost of production. No doubt there would be some minor displacement of workers, but this would not result in retrenchment of workers as the increased output and increased market demand would definitely not only absorb whatever workers have been found surplus, but also provide employment opportunities to some more. But shunning away from improvement, thinking that it would result in displacement of some workers from their existing place, would, in the long run, affect the company in the smaller sense and the economy as a whole in the broader sense. One should not lose sight of the long term benefits of increased productivity, which is essential for achieving prosperity. Another argument one comes across is that 'our labour is cheap; So why go in for LCA?' This is a clear case of misunderstanding between 'cheap labour' and 'low labour costs'. The point that should be remembered is not how much we pay a person but how much output we get for each rupee we pay.

Therefore being said, Low Cost Automation means any compact, easily available, simple but very effective manufacturing piece of equipment which is designed and assembled internally by a group of employees, in house.

A steam turbine is a heat engine, which enables the pressure and temperature energy of steam to be transformed into useful work. This transformation is achieved by expanding the steam through nozzles giving a high kinetic energy, which is converted into useful work by impinging on moving blades (changing the direction of the steam), mounted on the rotor. In order to convert large amounts of energy into useful work with maximum efficiency, it may be necessary to expand the pressure energy of the steam in a series of steps. Each such step contains a set of nozzles and moving blades and is referred to as a stage. A simple steam turbine and moving blade is shown in Fig. 1.

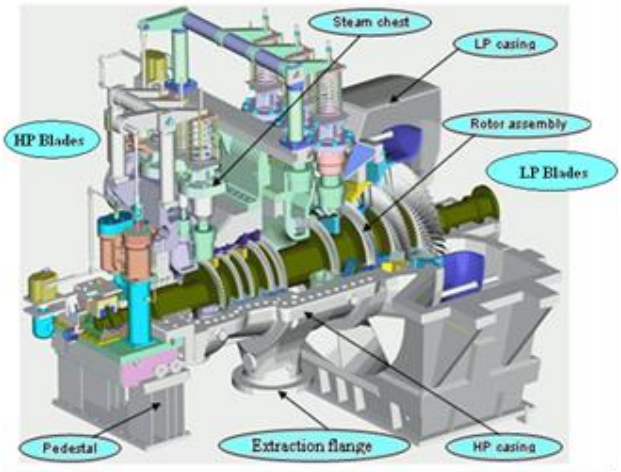

Fig. 1: Simple Steam turbine and moving blade used in Industries

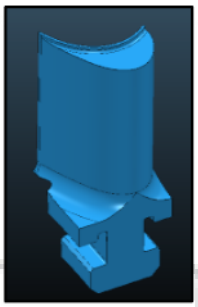

Fig. 2. Impulse Blade

The high pressure stage moving blades are machined from solid bar material by milling operation on VMC machine. The process of manufacturing the high pressure steam turbine blade is shown in fig.3.

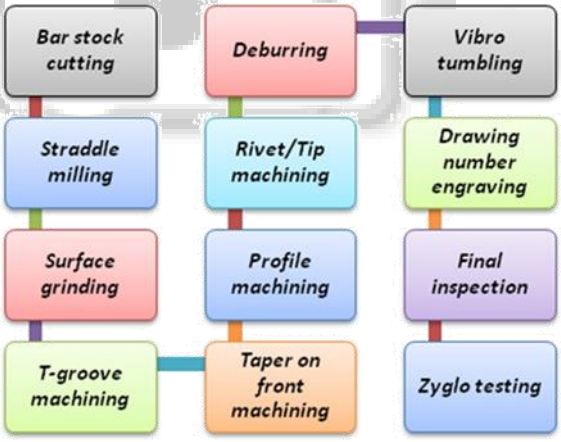

Fig. 3: Process flow chart for machining high pressure blade

The vertical Machining Centre is a 3 axis machine X, Y, Z axis respectively. These HP blades that are machined on this VMC comes in 4 different variants:

1) 19.05mm (0.75 inch blade)
2) 25.4mm (1.00 inch blade)
3) 31.75mm (1.25 inch blade)
4) 38.1mm (1.50 inch blade)

The VMC has a single station fixture, where single component are loaded in horizontal position by human interference. The component is butted and held rigidly during machining. The cycle time for machining each kind of blade depends on its size and profile where it also involves the time taken for loading and unloading operation along with the clamping of the component to the fixture. For every two machine one operator is employed. If operator is doing loading & unloading at one machine & at same time if other machine also completes the cycle then, second machine has to wait, this reduces the production & adds the fatigue to operator. To resolve this problem company is looking forward to reduce the human dependency by adopting the low cost automation on vertical milling machines.

II. Problem Definition

One of the major Concerns is that, the loading and unloading of the component is done manually by human interference. In the present process, a component is loaded one by one into the machine fixture, due to this there is an increase in manufacturing lead time, decrease in productivity and resulting in high labor cost.

The present project work is to be carried out for Automating DMG machine for machining steam turbine high pressure blade by an application of pneumatic pick and place system at Triveni Turbine Ltd. Bangalore, where the 18 components can be loaded and unloaded without human intervention to overcome the above problem.

III. Objective of the Study

The scope of work is to design & develop automated loading unloading setup which is needed to perform the necessary pick and place operation thereby reducing the overall cycle time resulting in high volume batch production.

Following are the aims that need to be fulfilled at the end of this study:

1) To implement Low cost Pick & Place unit to perform loading & Unloading of High Pressure blades of steam turbine.
2) To design and develop the feeder mechanism for pneumatic pick and place unit.
3) Design optimization and verification of the selected automation setup universally for all kind of blades.
4) Integration of Pick & Place unit with vertical milling machine.
5) To increase productivity through automation, reduce cycle time and nullify skillful labour.

IV. Literature Review

Low cost automation has been finding its glow ever since industries have been facing insufficient man power and their respective skills required for the job. Therefore, a number of studies are carried out in this aspect which leads its path to the development and study of technical automation and its performance with their respective regards.

Nirosh Jayaweera [1] - The application of robotics to the assembly of large aero-structures had been limited by the large size and inherent compliance of the components involved. His paper aimed to solve this problem by using a noncontact sensing system to measure part deformation and misalignment in real time. His research work showed that robots, when combined with non-contact metrology can be used for the assembly of compliant aero structure components within required tolerance limits.

M.L. Fitzegerald [2] - A possible low level control interface for a robot manipulator, which described the capabilities and limitations afforded by the use of interfaces and a proposed system modularization that supports interface

specification. He had proposed three possible low-level robot control interfaces within that system and each will elaborate a specification of the interface information and its use, timing considerations and potential limitations.

D. Brown [3] - The conceptual design, development, application of a sensor-equipped, and computer-controlled robot end effectors are commercially available and parallel jaw pneumatic gripper is retrofit with tactile, force, torque, and position feedback and interfaced to an industrial robot. The integrated system is applied to a variety of typical robot task. His work demonstrated that the retrofit of a standard pneumatic robot gripper with sensor feedback and servo control is an economically and technically viable alternative to the purchase of a commercial unit.

Yang Yuan-Zhao [4] - Pneumatic driven system is widely used in industrial automation, mainly for relatively simple tasks with open-loop control. Because of the pneumatic system's compressibility and few stop positions, it was considered hard to control in a precise motion control system. With the help of newly developed pneumatic servo control technology, using servo-pneumatic positioning controller now is just as easy as using electro-servo system. His research work showed that pneumatic devices could serve as accurate position control and be controlled through the Web.

Graham Kendall [5] - Optimization can play a major role in improving the throughput of surface mount placement machines. His research work had reported on improving only the assembly cycle time. His main aim is to minimize the robot assembly time, the feeder movements and the PCB table movements to provide flexibility to his approach and integrate three weighted parameters into the triple objective function such that one can vary the importance of each factor to be minimized. His experimental results showed that his approach gives good robot assembly time and less movement of the feeder carrier.

Stefano Chiaverini [6] - Controlling the interaction of a robot manipulator with the environment is crucial for accomplishing a variety of tasks in industrial applications. His paper aimed at presenting a survey of robot interaction control schemes for a manipulator, the end effector of which comes in contact with a compliant surface. They have performed tasks on only three-DOF end effector and future efforts will be devoted to extending the work to six-DOF tasks with inclusion of end-effector orientation and contact moment.

M.P. Groover [7] - Industrial Robots are now accepted weapons in the production engineer's arsenal, and the list of applications is growing rapidly. The fundamental characteristics of robot types are discussed, including articulation, control systems and programming method. The integration of robots with sensors is considered and this is a source of some disagreement in the industry. Finally, the design of process and product t suit robot-base, manufacturing cells had been discussed with examples. Industrial robots have progressed in the estimation of production engineers from mere flights of fancy ten years ago, through to exotic indulgencies seven years ago, to being realistic manufacturing tools today. The robot population and the applications are becoming more diversified. The use of robots for spot welding, paint spraying and injection moulding is routine practice; the developing areas include assembly, inspection and hazardous/sterile product handling.

Rakesh.N [8] - His paper proposes a cheap and effective method for design and manufacturing of a three degree of freedom revolute jointed robotic arm. By considering the mechanical arm's performance objectives, the design starts with modeling the integration of all the individual links constituting the manipulator. The effective design and manufacturing of 3 degree of freedom pick and place robot has been performed. The operation of various arm linkages and the end effector has been extensively tested and the required corrective measures were taken. Hence it's been proved that the manufacturing and running cost of robot is less which helped them to cut down the labor cost and improve profits at very low investment.

L.J.George [9] - Robots represent a flexible source of automation in a variety of manufacturing processes today. As a result of this, robots are being increasingly used as an alternative for automation in a large number of manufacturing concerns. The present trend has been to link these islands of automation together with efficient material handling and computer control to attain to totally automated environment, what is commonly referred to as the "Factory of the Future". In this paper he had discussed the role of robots in such a factory and draws upon a case study to illustrate the varied aspects that one deals with in robotization in such an environment.

V. PROPOSED FLOW OF WORK & METHODOLOGY

1) Study regarding presently working machines, various techniques of low cost automation and simulation software, concept design and development of various components of automation.
2) Selection of the feeder mechanism concept, concept validation by trials, design and development of various components of feeder mechanism.
3) Design of electro pneumatic circuit and PLC programming.
4) Selection of pneumatic components (e.g. pneumatic cylinders, direction control valves, grippers etc) based on the operating conditions and the sequence of operation.
5) Generate a 3D model of the machine along with conceptual design of automation using CATIA V5 software to represent implemented components after the design and development process.
6) Manufacturing and assembly of pick and place unit.
7) A life cycle cost analysis to be carried out at the end to compare between existing machines and the newly developed automated machine.

VI. CONCLUSION

Being known the area of work simple methodologies were taken up in order to avoid any conflicts during further development stages. The machining sequence were first studied so that one comes to know the beginning and end of the process. Eventually machine capabilities and the space around it were considered to build the automation unit. This formed the major concern of work where knowing the space constraints helps to bring up the outline of the setup. The cause for making the process automated whether be it the machine or the man is known so that respective work is

carried in that way in order to avoid those mistakes again which leads to an improvised working condition for both the man and machine. Taking all these into considerations only then the necessary implemental concepts are developed and further fine tune it to our benefit our end purpose.

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