

A Review on Productivity Improvement in Manufacturing Processes

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Abstract - Productivity is a matter of some debate since it is directly related to the GDP growth of a specific company or manufacturing firm. Productivity is the lifeblood of any industrial company's profitability. The product that is not produced in sufficient quantities results in lower-income because there is simply less to sell. Prices may need to be raised if production levels are low in order to earn the necessary profitability for survival. However, if buyers can find a lower price elsewhere, this move is likely to drive them away. Productivity is one of the most important markers of success in the manufacturing industry. In truth, most factories' primary goal is to produce enough items to grow and meet customer satisfaction. In this review, we have discussed various factors which influence the productivity of the workplace. Furthermore, methodologies adopted by several authors, previously in the sector of enhancing the productivity of a particular machine or a workplace, have been discussed. This review is focused on the assessment of different projects executed in order to improve the productivity of a particular machine like VMC or CNC or a workplace for a manufacturing company.

Key Words - Productivity, VMC, CNC, Production, Customer Satisfaction.

1. INTRODUCTION

Productivity is an important determinant of the performance of companies and nations in terms of production. Increasing industrial productivity can enhance standards because greater real income improves the industry's ability to purchase quality goods and services.

The manufacturing cycle time of a job is the total time required to convert raw materials into finished products. It is comprised of operation time, loading/unloading time, setup time and idle time. Out of these, only during operation time value addition takes place and the loading/unloading, setup and idle times come under the label 'downtime'. Downtime per job unit can be reduced by increasing batch quantity, or by reducing the set up/machine idle times. Down time and hence the cycle time reduction is considered as the one of best options as an industry attempts to enhance productivity, cut down cost with customer response time. [6]

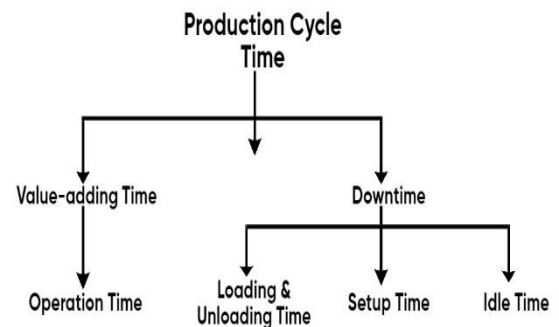


Fig. 1: Production Cycle Time

The demand placed by customers, especially in the manufacturing industry is about mainly two things one is the lead time and another one is price. In a production system, the highest profit can be obtained by eliminating waste elements in the manufacturing system. In the manufacturing industry, there are three primary ways to eliminate waste:

1. Establish machine performance capabilities before actually starting the manufacturing activities.
 2. In-process inspection.
 3. Automate non-value-added tasks such as tool setting and workpiece set-up. [7]
- ❖ **Production:** In simple terms, 'Production' is the process of manufacturing or fabricating or producing certain types of goods, semi-finished or finished, input being basic raw material or semi-finished products or sub-assemblies. [11]
 - ❖ **Productivity:** Biggest and most challenging task faced today by any organization is "PRODUCTIVITY". It is the measure of the combined efficiency or integrated efficiency of employees, machines and other devices and equipment, nature of raw material inputs, performance of the management, efficiency of the whole production system. Productivity can be computed and expressed as the ratio of average acceptable output per period by the total costs incurred through various resources (Labor, Input material, consumables, power utilized, capital, energy, material, personnel) consumed in that period. It is nothing but a measure of efficiency of the integrated system consisting of resources like Money, Men,

Materials, Machines (4 Ms of an industry) and time etc. [11]

- ❖ Cycle time: Cycle time is defined to be the time that takes to load, run, and unload on work piece. Production quantities in an industry dictate that the more work piece you run, the more important it is to achieve the goal of lowering the cycle time. [10] It can also be defined as the period required for completing one cycle of operation or completing a job or a task from start to finish. Various elements of cycle time are set up time, parts movement time, inspection time and rework time. Thus, mathematically 'cycle time' can be given by equations (1), (2) and (3) [7], [14];

$$\text{Cycle Time} = \frac{\Sigma (\text{Setup time} + \text{Machining time})}{\text{number of components produced}} \quad (1)$$

$$\text{Cycle Time} = \text{Service time} + \text{Idle time} \quad (2)$$

$$\text{Cycle Time} = \frac{\text{Useful production time available per day}}{\text{Output per day}} = \frac{T}{Q} \quad (3)$$

- ❖ Setup time: The time taken to prepare the manufacturing processes and system for production. [10]
- ❖ Ideal time: It could also be associated with computing, and in that case, refers to processing time. [10]
- ❖ Component changeover time: The time required to place the work piece and clamping it in the fixture of machine tool after one operation cycle completes is called component change over time. [10]
- ❖ Cycle time reduction: To minimize the cycle time in these areas, there are two ways in which this can be achieved. The process engineer must select an appropriate machine tool, cutting tools, fixturing, and machining order in a way that it matches the number of work pieces to be machined that will be based on the production quantity. The cycle time will be a reflection of the processes being used to machine work pieces. To optimize cutting operations for this would involve properly selecting cutting tool materials, feeds, and speeds to machine work pieces as efficiently as possible with the current process. [10] Cycle time reduction (CTR) stands in the side of minimizing CT which can be done by recognising and employing more efficient and proficient (effective) techniques in accomplishing systematically defined tasks. Cycle Time Reduction is the tactic of dropping the total accumulated time foregone to accomplish a specific process with the intention of improving the company's productivity. [14]

- ❖ Significance of productivity:

1. Prosperity:
 - a. Higher production
 - b. Reduced cost per unit
 - c. Higher wages for workers
 - d. Higher profit for organization.
 - e. More employment opportunities.
 - f. Improvement in standard of living.
2. Economic growth:
 - a. Products available at reduced rate.
 - b. Better customer acceptance for the products.
 - c. Increased sales for the organization
 - d. Increased export
 - e. Improvement in foreign exchange reserves
 - f. Leads to economic growth of the country
 - g. Increased share for the shareholders of the company
3. Scrap reduction:
 - a. Reduction in raw material requirement
 - b. Reduction in idle time of men and machines
 - c. Reduction in space requirements
 - d. Reduction in poverty and unemployment. [11]

In a production system, productivity is the ratio of output to the input. Productivity can be improved by following ways;

1. Reducing input required for getting desirable output
 2. Increasing output with provided fixed input.
 3. Achieving higher output with marginal increase in input. [7]
- ❖ Relationship between Cycle Time and Productivity: The process of plummeting the 'cycle time' cannot just increase productivity. In order to increase productivity, there should be an associated change and commitment to the workforces or upsurge of the output as the reason to increase the company's productivity. In general, for any manufacturing to survive, the productivity ratio must be at least 1. So, the manufacturing firm must identify the way to improve productivity to the highest possible level. One of the strategies which can increase the output of the production is a reduction of cycle time so as more outputs can be produced for a short time. Achieving this to the standard way can help to improve the productivity ratio of the manufacturing industries. The concept of 'cycle time reduction' can be influenced by numerous factors - the most outstanding one being through reduction of the 'process' cycle time of the manufacturing unit. For example, when there is cycle time reduction, there is an increase in the total throughput of the particular manufacturing plant. Such output raises the number of outputs. When trying to reduce cycle time, there are numerous tools which are most important. [14]

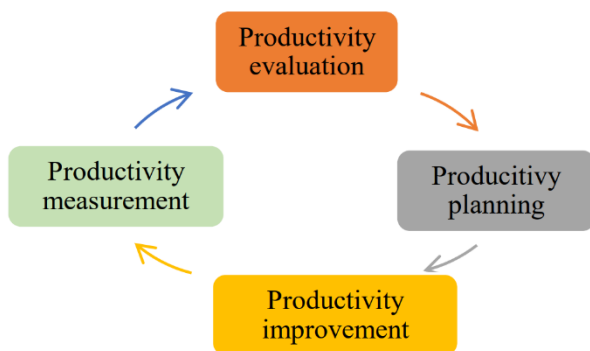


Fig. 2: Productivity Cycle

- ❖ Difference between a CNC and VMC: There is no difference between the two machines. A VMC is a machine with a CNC (Computer Numerical Control) controller, the cutting head in this milling machine is vertical, and is a type of milling machine where the spindle runs in a vertical axis known as the “z” axis. They are typically enclosed and most often used for cutting metal. [1]

2. SYSTEMATIC REVIEW

This review article is focused on emphasizing the works of various authors who aimed to improve the overall productivity of a machine, workplace, or manufacturing organization by introducing a new approach or improving the existing work system layout. In this assessment, we looked at a frequent parameter used by the authors to attain their goal of increased productivity. The common parameter that has been mentioned is nothing more than the strategy or the method that they have used in their research work to deal with production challenges and inflate production rates.

Thus, the types of methods implemented in various research works are;

1. Setting an advanced fixture
2. Implementation of a new tool
3. Lean Manufacturing
4. Improved programming technique
5. Analysis using dedicated software

Now, let us see a detailed review of different research works based on their implemented methodologies:

2.1 Setting Advanced Fixture:

Fixture is a work holding or support device used in manufacturing industry. Fixtures are used to securely locate and support the work ensuring that all part produced using fixture will maintain conformity and interchangeability. Using a fixture improves the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement for skilled labor by simplifying how work pieces are mounted and increasing conformity across the production run. [1] By using fixture, responsibility for accuracy shifts from the operator to the construction of machine tool. [3] Fixtures and clamping devices are an essential part of machining systems for material removal processes. But their importance is often neglected or underestimated during the layout of manufacturing machinery and processing solutions. The relevance of fixtures regarding productivity, efficiency and quality is mostly not considered properly, e.g., with respect to the planning of production systems and related costs. [4] Fixture design plays an important role in the setup planning stage. Proper fixture design is difficult for developing product quality in different terms of accuracy, surface finish and precision of the machined parts. The costs associated with fixturing can account for 10–20% of the total cost of a manufacturing system. These costs relate not only to fixture manufacture, assembly, and operation, but also to their design. [5]

Designing of fixtures depends upon following factors:

1. Study of workpiece and finished component size and geometry.
2. Type and capacity of the machine.
3. Provision of locating devices in the machine.
4. Available clamping arrangements in the machine.
5. Available indexing devices, their accuracy.
6. Evaluation of variability in the performance results of the machine.
7. Rigidity and of the machine tool under consideration.
8. Study of ejecting devices, safety devices, etc.
9. Required level of the accuracy in the work and quality to be produced. [5]

Main tasks of fixtures are:

1. to define the location (position and orientation) of a clamped workpiece in the workspace of the machine tool.
2. to maintain this defined location even under the influence of static and dynamic mechanical and thermal loads.
3. and to guide these loads as an integral element of the machine structure inside the force flux. [4]

A fixture's primary purpose is to create a secure mounting point for a work piece, allowing for support during operation and increased accuracy, precision, reliability and interchangeability in finished parts. It also serves to reduce work in time by allowing quick setup. Economically speaking the most valuable function of fixture is to reduce labor costs. [1] It is used in inspection welding and assembly. Fixture does not guide the cutting tool, but is always fixed to machine or bench. [3] The fixture is a special tool for holding a work piece in proper position during manufacturing operation. For supporting and clamping the work piece, device is provided. Frequent checking, positioning, individual marking and non-uniform quality in manufacturing process is eliminated by fixture. This increase productivity and reduce operation time. Fixture is widely used in the industry practical production because of feature and advantages. [1] Fixture shows great time saving in the production. [2] When a few parts are to be machined, workpiece clamp to the machine table without using fixture in many machining operations. However, when the numbers of parts are large enough to justify its cost, a fixture is generally used for holding and locating the work. [3] A fixture should be securely fastened on the table of the machine upon which the work is done. Though largely used on milling machines, fixtures are also to do this, a fixture is designed and built to hold, support, and locate every part to ensure that each is drilled or machined within the specified limits. The difference is in the way the tool is guided to the work-piece. Fixtures vary in design from relatively simple tools to expensive, complicated devices. Fixtures help to simplify metalworking operations performed on special equipment. [5]

Hydraulic fixture provides the manufacturer for flexibility in holding forces and to optimize design for machine operation as well as process function ability. [1] A fixture differs from a jig in that when a fixture is used, the tool must move relative to the workpiece; a jig moves the piece while the tool remains stationary. [3] Flexible fixtures allow an adaptation of the clamping interfaces to the workpiece geometry. Active fixtures enable an actuated movement of clamping points, e.g., for adaptation to distorting workpiece shapes or to excite the workpiece in order to improve process conditions. [4]

Principles of Fixture Design –

1. Clamps & Locators –

To locate and immobilize work pieces for machining, inspection, assembly and other operations fixtures are used. A fixture consists of a set of locators, clamps, supports and the actual fixture body. Locators are used to determine the position and orientation of a component, whereas clamps exert clamping forces so that the work piece is pressed firmly against locators. [1]

- a. Locator: A locator is a fixed component employed to institute and upholds the location of a part in the fixture through restraining the part's movement.
- b. Clamp: A clamp is a force-activating fixture device. The forces put forth through the clamps grasp a part firmly in the fixture as opposed to every other exterior force.
- c. Support: A support is a permanent or adaptable fixture's element. As critical part dislocation/re-direction is predictable subject to the engagement of obligatory fastening and dispensation forces, props are appended and located underneath the work member in order to avoid deformation.
- d. Fixture Body: Fixture body is the most important structural constituent of a fixture. It preserves the spatial association between the fixturing constituents and the machine tool on which the part is to be dealt with. [6]

2. Satisfying FRs & Cs –

It is a fundamental and well-known engineering principle should that, the functional requirements and their associated constraints should be the first input to any design process. A relevant issue when considering requirements, taking this as a general concept, is to make explicit the meaning of two main terms:

Functional Requirement (FR) and Constraint (C). Functional Requirement (FR), as stated by different authors, 'represents what the product has to or must do independently of any possible solution'. Constraint (C) can be defined as "a restriction that in general affects some kind of requirement, and it limits the range of possible solutions while satisfying the requirements". [2]

3. 3-2-1 Principle –

Fixtures are designed based on the 3-2-1 principle which describes the degrees of freedom in the design. Any free body has a total of twelve degrees of freedom. Six translational degrees of freedom, namely; +X, -X, +Y, -Y, +Z, -Z and 6 rotational degrees of freedom, namely; clockwise and anticlockwise around X, Y and Z directions. All the 12 degrees of freedom must be fixed except the three transitional degrees of freedom (-X, -Y and -Z) in order to locate the workpiece in the fixture. So, nine degrees of freedom of the workpiece are needed to be fixed. [1],[6]

2.2 Implementation of new tool

The materials having high-tensile strength and resistance to wear and impact, which are frequently used in the aerospace and nuclear industries, are generally difficult to machine. High manganese steel is one of these materials. For the machining of high manganese steels, the cutting tool materials must be harder than the workpiece materials. These types of materials can be machined with sintered carbide tools and speed steels with cobalt. Due to the high cost of changing and sharpening cutting tools, different machining methods are being used. Machining by softening the workpiece is a more effective method than strengthening the cutting tool. It is suggested that these materials should be machined by heating. The heating of the workpiece is not a new method for making easy the properties of the machinability of materials. For machining, it is necessary to choose the best heating method to heat the materials. Selecting the wrong heating method can induce undesirable structural changes in the workpiece and increases the machining cost. In the published works, there are different heating methods described which are used for heating the workpiece. Electrical resistance, plasma arc and other heating methods in hot machining have been used. [8]

By minimizing the non-value-added activity (e.g., inspection, set-up, adjustments, tool breakage, etc.) we can maximize productivity and profits. Five Steps for improvement of machine capability are listed below:

1. Determine the accuracy as per need
2. Establish a baseline.
3. Identify and rank the sources of error.
4. Eliminate or calibrate the errors.
5. Re-establish a new baseline. [7]

Principles used while selecting a new tool –

1. 5W and 1H technique –

In order to minimize the cycle time, 5W and 1H technique has been used for new tool selection. In this analysis technique, for selecting new tool, various questions asked were;

- a. What type of tool is used instead of existing tool?
- b. What properties of tool we required to get output?
- c. What speed and feed it should adhere?
- d. Why to use specifically this tool?
- e. When does it give required output?
- f. How does we can effectively use the life of given tool?
- g. Who is responsible for given finish? [7]

2. Taguchi Method –

Taguchi Method is developed by Dr. Genichi Taguchi, a Japanese quality management consultant. The method explores the concept of quadratic quality loss function and uses a statistical measure of performance called Signal-to-Noise (S/N) ratio. The S/N ratio takes both the mean and the variability into account. The S/N ratio is the ratio of the mean (Signal) to the standard deviation (Noise). The ratio depends on the quality characteristics of the product/process to be optimized. [8]

2.3 Lean Methodology

Lean manufacturing is a production approach that aims to reduce both production time and response times to customers and suppliers. The strategy seeks to improve efficiency by removing waste, streamlining processes, and lowering costs. By creating only what is in demand and without overstocking, the method allows for reduced waste and inventory expenses. The approach boosts productivity and profits by shortening the manufacturing process.

It is important to reduce the Non Value Added Activities from the Process. [9]

Principles of Lean Methodology –

1. 5S system -

The 5S system is a lean manufacturing technique for increasing workplace productivity and reducing waste. The system consists of five steps, each beginning with the letter S:

- a. Sort
- b. Set In Order
- c. Shine
- d. Standardize
- e. Sustain

5S helps facilities avoid lost production due to delayed work or unplanned downtime by offering a systematic foundation for organisation and cleanliness.

Benefits from 5S -

- a. Unwanted scrap & Materials out of Plant creating more space for effective utilization.
- b. Material / Tools searching time reduced which is decrease in production time.
- c. Less Waste Equals Improved Efficiency.
- d. Less Space Used for Storage Equals Reduced Costs.
- e. Clean Equals Improved Maintenance & Less Down Time Implementing 5S
- f. Equals Improved Safety.
- g. Improved Quality [9]

2. Kaizen -

Kaizen is a method of producing continuous improvement that is founded on the premise that tiny, continual positive adjustments can yield substantial results. It is typically founded on cooperation and commitment, as opposed to techniques that employ drastic or top-down reforms to achieve transformation. Kaizen is the foundation of lean manufacturing and the Toyota Way. It was created in the manufacturing industry to reduce defects, minimize waste, increase production, foster worker purpose and accountability, and stimulate innovation.

Benefits from Kaizen -

- a. Kaizen reduces waste: In areas such as employee skills, waiting times, transportation, worker motion, over production, excess inventory, and quality and in process.
- b. It improves product quality, use of capital, production capacity, communications, and space utilization and employee retention.
- c. Kaizen provides immediate results. Instead of focusing large scale improvements, which involve capital intensive, Kaizen focuses on creative investments that continually solve large number of small problems. [9]

3. Employees' survey focusing on workers' productivity –

Significant factors affecting workers' productivity;

- a. Product design characteristics
- b. Process plans
- c. Available machines & other equipment and their condition
- d. Scheduling
- e. Technology updation and Automation
- f. Working environment
- g. Standard time estimated
- h. Non availability of right material
- i. Non availability of standard cutting tools
- j. Non-availability of jigs and fixtures
- k. Inspection delay
- l. Assembly problems
- m. Workers related issues
- n. Lack of supervisory support
- o. Working hours
- p. HR & IR related matters [11]

2.4 Improved Programming Technique

CNC machines provide faster throughput even for complex geometries with reduced machining time using a deterministic machining solution for precise execution speed of program parameters. The objective is to gain knowledge and to make the parameters of the program operator friendly and reducing the cycle time in order to increase productivity. The main focus of

manufacturing industries is to produce extreme quality and higher productivity of the product. In order to increase the productivity of the product computer numerical control machine tools play major role during the past decades. However, there are many parameters need to be considered while machining such as feed, tool geometry and cutting speed, machining time, lead time, surface quality, surface roughness, depth of cut, spindle speed and diameter of tool plunger rate, part program execution speed and efficiency. Moreover, the optimization of these parameters depends on automation of machining center and accuracy of the part program. Different algorithms are used for optimizing different process parameters in various machines. [12]

2.5 Analysis using dedicated software

Finite element analysis (FEA) is the process of modelling a part's or assembly's behavior under specified conditions so that it may be evaluated using the finite element method (FEM). Engineers utilize FEA to model physical processes and so eliminate the requirement for real prototypes, while also allowing for component optimization as part of a project's design process. To comprehend and quantify the impacts of real-world conditions on a part or assembly, FEA employs mathematical models. These simulations, which are carried out using specialized software, enable engineers to identify possible flaws in a design, such as areas of tension and weak spots.

Analysis of the machine tool structure for the various purpose by the analytical method is the more time consuming and very complex method also it doesn't give the precise way for the analysis because of its complexity but by using the FEA software we can get better results with the more precision and more accurately than analytic method and also in this FEA, Static and Dynamic analysis of machine tool structures plays an important role on the efficiency and job accuracy of the machine tool. Static analysis is useful for estimating stresses strains and deflections, and also improving structural stiffness whereas dynamic analysis deals with the prediction of natural frequencies and corresponding mode shapes, which will in turn, prevent the catastrophic failure of the machine tool structures. [13]

3. DETAILED REVIEW

Overview of the various methods deployed for productivity increment has been done in a tabular form as;

Author	Method Implemented	Machine	Methodology/Principle	Result	Conclusion	other objectives achieved
Apurva Patil	Designing & manufacturing of hydraulic fixture	VMC machine	3-2-1 Principle of fixture design	Reduction in loading & unloading time = 90 sec per component; Reduction in setting time = 10 min	A hydraulic fixture was designed & manufactured for 4th axis VMC machine	Reduction time in individual marking point & frequent checking
Chetankumar Patel, et al	Designing & manufacturing of hydraulic fixture	VMC machine	Satisfying FRs & associated Cs for fixture design	Reduction in clamping and declamping = 20 seconds per clamp	A hydraulic fixture assembly with 8 cylinders & 4 workstations was designed and manufactured for boring YOKE on VMC machine. Components of fixture assembly included collet, stopper & V-block. Fixture has an expandable collet as a main fixturing element.	Reduction in operators' fatigue; Reduction in wear & tear of fixture components due to automatic clamping
M Rajmohan, et al	Designing of Turning fixture	Turning Centre machine	Locating and Clamping / Four phase design method	Reduction in operation & cycle time = 5 min 50 sec; Cost saving per month = Rs 23,165	A turning fixture for Turning Centre machine was designed for machining the filter head instead of using a VMC machine	Reduction in non-production time, i.e., set-up time = 50%

Utkarsha Dabade, et al	Improved tool selection & new line balancing layout for machining of oil pan at a known machining unit, Kolhapur	VMC & HMC machines	5W and 1H technique; 5S Principle	Overall reduction in cycle time for machining of oil pan = 7.02 min per job; Increase in production capacity from 2000 to 2900 jobs per month	CBN cutters & spot facing tools were identified as new and improved cutting tools for VMC & HMC for machining of oil pan (Oil pan is one of the important components of IC engine); U-type machine layout to balance the production line was implemented to minimize travel time within working area of the machining area.	Reduces operators' fatigue to lift extra load by lifting the oil pan; Reduction in rejection rate & chances of damage; New layout is helpful in 5S audit.
Sharda Nayse, et al	New tool selection for turning operation at Sahayog Engineering, Aurangabad	CNC machine	Taguchi Method of L9 Orthogonal Array designs; Gray Relational Analysis	Reduction in cycle time = 49%; Reduction in Production cost = 27%, Improvement in Productivity = 15%	PCBN insert carbide tool was used for turning operation on H-13 steel in a CNC machine.	Effects of speed, feed & depth of cut were observed as significant factors in CNC turning operation.
Nikunj Kumar A. Parmar, et al	CPM for lean manufacturing through time study at Cosmos Impex Pvt. Ltd., Vadodara	VMC machine	Lean Manufacturing, 5S Principle, Kaizen	Non Value Added Activity (NVA) were reduced by 80%	Improvement in the productivity of VMC machine manufacturing was achieved by adopting Lean manufacturing	Lot of space for material handling got available in the industry
Rajesh Gadekula, et al	Improved programming techniques on Computer Numerical control	VMC machine	Comparison between old & new parametric part program cycles	Reduction in total cycle time = 90 min; Reduction in machining cost = Rs 1199.73	A new improved CNC program control technique Canned cycle, which includes R-parameters & subroutines, was used over XYZ part program in VMC machine for machining Radial Drill Head Feed Box Housing. Operations included were face interpolation. milling, drilling & boring.	29% breakdown time per month was optimized

A. Vetrivel, et al	Lean Management	CNC machine	SMED method (Lean Tool)	Reduction in cycle time = 70%	Setup-time reduction, cycle time reduction using Solid CAM & automobile holding fixture, and I-machining processes were introduced.	-
Hans-Christian, et al	Design of Intelligent Fixtures	Milling machine	FEA & Process Simulation	Experimental and theoretical results regarding the dynamic process behaviour reveals the relevance of intelligent fixtures with respect to machining performance and workpiece quality.	Experimental and theoretical results were calculated for the influence of clamping setup and workpiece characteristics with respect to machining performances; Vibration, deformation and alignment of work piece were discussed for development of sensor and actuator integrated fixtures using European research project INTEFIX with two examples.	-
Atul Patil, et al	Design & development of hydraulic fixture for drilling operation	SPM machine	Locating and Clamping & FEA	Increase in production = 20%	A hydraulic fixture, for manufacturing of knuckle pin drill operation on SPM machine for machining axle of Ashok Leyland, was designed. CAD model was prepared using Creo software and analysis was done using ANSYS software.	Dimensional accuracy and more output per day were observed.
Gajendra Dudharejiya, et al	Static and Dynamic analysis by ANSYS	VMC Bed	FEA	There are different methods to increase the rigidity of VMC bed by introducing ribs.	Analysis & optimization of VMC Bed by using FEA method was mentioned. 3D CAD model was prepared using CREO software & Analysis was done using ANSYS software.	-

B. Lathashankar, et al	Design & modelling of dedicated fixture for tack welding operation	Welding machine	3-2-1 Principle for fixture design	Cycle time reduction for front chasis = 20%; Cycle time reduction for rear chasis = 18%	A dedicated fixture was designed for tack welding of 4Ton Compactor's front and rear chasis. Design of fixture was based on 3-2-1 Principle & modelling was done using Catia V5 R20 software.	It eliminated marking for each job and positioning separately by trial-and-error method. hence calls for semiskilled labor instead of skilled labor, reducing labor cost for improved production rate. Reduction in production of defective components.
M D Sreekumar, et al	Field survey to find out factors affecting workers' productivity	-	Personal interviews of employees & officers at different factories	Delay in ensuring the availability of right material in right time in different production shops affects the productivity of workers to the maximum extent	A field survey was done in which around 100 employees from six different Rail coach and Machine tool factories were asked for personal interviews to find out the factors affecting workers productivity.	-

4. CONCLUSION

This review article is a summarized work of several efforts made for the sake of productivity improvement. It consists of multiple definitions required to acknowledge the concepts used in those research work papers. To simplify the described methodologies, we bifurcated the main topic into a few common parameters and built a table that narrates the overall explanation of all the papers.

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