"Design and Development of Special Purpose Mechanism to Enhance the Production in Pump Manufacturing Industry"

PANCHAL PARTHKUAMR .N. [1], MR. HARDIKBHAI. PATEL [2]

[1]*Advance manufacturing system Engineering (Mechanical Department), M.E.C, Mehsana- 384315, Gujarat, India*
[2]*Mechanical Engineering Department, M.E.C, Mehsana- 384315, Gujarat, India*

ABSTRACT

In Global Industrial Competition, Major Industrial Problem And The Various Effective Approach ,To Increase Productivity Of Plant V4 And v6 Pump In Manufacturing System In Which Involve Flexible Capacity And Inventory Management Is Couple Of Capacity Management .In Order To Handle Fluctuation In Production Flow Line By Analysis of Cronical Breakdown Issues ,During Workflow In Production Chain For Improvement And Modification Of loop Layout Require, To Implement Several Mechanism. As Per Require Such As Loading and Unloading And Inner Washing Mechanism .Which improve Planning And Inventory Matching of Both Finished And Unfinished Products (Motors).To Increase Productivity Require To Analysis Plant layout Polices And Special Purpose Mechanism /Machines, Which Decrease Several Manufacturing Time And Errors In Production Line Which Also Economical To Company .As A Focus In Future Works Require .To Implement Automation In Bar-coding System And Packaging. For Pumps There Are Lot of Illustrates Example of Flow Diagram .Flow Process Chart Work-Study as Require to Practical Utilization.

1 INTRODUCTION

The structure of this project in following two sections which give a detail description of the inventory flow in plant layout and its work study and other one is the break of loading and unloading mechanism which is other cronical diseases which effect to plant production To be competitive in the market, steel plants need to provide on-time delivery, accurate delivery, and high-quality product. It is also important to have high equipment utilization and low production cost to meet both external market and internal manufacturing requirements. Due to the bulky machines and high operating costs, order planning plays an important role in steel factories. Order planning is to schedule machines and processes in the production line according to due dates, product types, quality requirements, and machine capacity. The quality of order planning can directly affect the performance of a steel factory [w1]

2 LITERATURE REVIEW

Jacques Carliera, Eric Pinson(2003) have studied Jackson's pseudo-preemptive schedule (JPPS) for solving cumulative scheduling problems. JPPS was introduced for the m-processor scheduling problem Pm=ri; qi=Cmax. In the latter problem, a set I of n operations has to be scheduled without preemption on m identical processors in order to minimize the make span. Each operation i has a release date (or head) ri , a processing time pi , and a tail qi . In the cumulative scheduling problem (CuSP), an operation i requires a constant amount ei of processors throughout its processing. A CuSP is obtained, for instance, from the resource constrained project scheduling problem (RCPSP) by choosing a resource and relaxing the constraints induced by the other resources. We state new properties on JPPS and we show that it can be used for studying the CuSP and for performing adjustments of heads and tails using a strategy very close to the one designed by Carlier and Pinson for the 1=ri , qi=Cmax sequencing problem. It con8rms the interest of JPPS for solving RCPSP.

Federico Malucellia, Stefano Pallottino Daniele Pretolani (2008) have studied when piling a set of items in a single stack, one often does not pay attention to the order. Real-life experience suggests that, whenever a specific item is suddenly requested, we need to dig very deep into the stack to extract it. In this paper we investigate stack reordering strategies aiming at minimizing the number of pop and push operations. In particular we focus on three versions of the problem in which reordering can take place in different phases: when unloading the stack, when loading it or in both phases. We show that the first two variants can be solved in linear time, while for the third one we devise a dynamic programming method with quadratic complexity.

Akio Imai, Kazuya Sasaki , Etsuko Nishimura, Stratos Papadimitriou (2004) have studied The efficiency of a maritime container terminal primarily depends on the smooth and orderly process of handling containers, especially during the ship_s loading process. The stowage and associated loading plans are mainly determined by two criteria: ship stability and the minimum number of container rehandles required. The latter is based on the fact that most container ships have a cellular structure and that export containers are piled up in a yard. These two basic criteria are often in conflict. This paper is concerned with the ships container stowage and loading plans that satisfy these two criteria. The GM, list and trim are taken into account for the stability measurements. The problem is formulated as a multi-objective integer programming. In order to obtain a set of no inferior solutions of the problem, the weighting method is employed. A wide variety of numerical experiments demonstrated that solutions by this formulation are useful and applicable in practice.

Damien Trentesaux (2009) have studied this editorial introduces the special issue of the Elsevier journal, Engineering Application of Artificial Intelligence, on Distributed control of production systems. The current technology in communication and embedded systems allows products and production resources to play a more active role in the production process. This new active capacity will generate major changes in organizations and information systems (e.g., Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES)). New approaches are now required for modelling, testing and assessing the features made possible by the decisional and informational capabilities of these new active entities. One among the many possibilities is to use agents and holons, since agent and holon-based approaches assume interaction between intelligent entities to facilitate the emergence of a global behavior. This special issue thus focuses on the possible applications of distributed approaches for the design, evaluation and implementation of new control architectures for production systems. Both fundamental and applied research papers are presented.

L. Monostori1, J. Váncza1,, S.R.T. Kumara (2006) have studied emerging paradigm of agent-based computation has revolutionized the building of intelligent and decentralized systems. The new technologies met well the requirements in all domains of manufacturing where problems of uncertainty and temporal dynamics, information sharing and distributed operation, or coordination and cooperation of autonomous entities had to be tackled. In the paper software agents and multi-agent systems are introduced and through a comprehensive survey, their potential manufacturing applications are outlined. Special emphasis is laid on methodological issues and deployed industrial systems. After discussing open issues and strategic research directions, we conclude that the evolution of agent technologies and manufacturing will probably proceed hand in hand. The former can receive real challenges from the latter, which, in turn, will have more and more benefits in applying agent technologies, presumably together with well-established or emerging approaches of other disciplines.

Yavuz Günalay(2011) have studied Suppliers produce a variety of products to serve both large and small customer orders with unreliable demand information. Furthermore, suppliers also face customer pressure to improve quality, lower cost, and reduce delivery delay. These conflicting objectives lead firms to use both make-to-stock and make-to order production strategies together. These manufacturing strategies were known to be competing policies and in some cases the choice depends on characteristics of the product. In this study, the firms that manufactured multiple-item types are considered to be free to choose either production policy for each product type (no product-specific requirements are present). Then, using the order-arrival characteristics and cost parameters for each product type, the firm wants to decide which production/scheduling policy to use for each product type. Two production policy (MTS vs MTO) and two scheduling strategy (FIFO vs cyclic) are considered in this study. The analysis and numerical study show that there is no dominant strategy neither for production policy, nor product scheduling policy.

Christian Díaz-Ovalle, Richart Vázquez-Román,, M. Sam Mannan (2010) have studied A new approach to determine the optimal distribution of process facilities is presented in this paper. The formulation considers a set of facilities already installed in a given land and a new set of facilities to be accommodated within the same land. In addition, it is considered that a set of facilities either installed or to be laid out presents the possibility of toxic release. Based on previous analysis, the worst-case scenario implies calm wind and stable atmospheric condition. Since these conditions tend to exist during several days of the year, the proposed model is formulated assuming these deterministic values for wind and atmospheric conditions. The final model is formulated as a disjunctive model that is converted into a mixed-integer non-linear program (MINLP) via the convex-hull method. The model is then solved with local and global optimizers in the GAMS package. Using the current approach based on minimum distances for a particular case study results in a distribution with a very high risk whereas the optimal results using this proposed approach indicate large separations between releasing facilities and the inhabited facilities due to the high toxicity of the released material. More elaboration will be aggregated into the developed model to include prevention and mitigation systems to produce more compact but optimal and safe layouts

Prof. Y. Altintas(2015) have studied Manufacturing Automation Laboratory has developed advanced, easy- to-use machining process simulation and measurement software which is used by a number of companies around the world. ShopPro is an integrated, easy to use tap-testing, chatter stability lobe, torque, power prediction as well as giving expert advice to solve machining problems. CUTPRO is advanced software with milling, turning, boring, drilling, spindle, CNC, tap testing, modal analysis and data acquisition modules. MACHPRO imports NC programs from CAM systems; simulates the part machining operations and automatically creates an optimized NC program. NPro simulates and optimizes the tool paths directly within NX CAM system. Machining process simulation modules predict forces, torque, power, bending moment on spindle bearings, dimensional surface finish, vibrations and chatter-free depths of cut and spindle speeds. Machine tool and cutting tool designers can optimize their design choices, while process planners can significantly reduce the machining time while maintaining the accuracy and quality of the parts. The course gives balanced training of basic machining principles and their hands on application on machine tools.

R. Jayachitra and P. S. S. Prasad (2010) have studied in the global industrial competition, layout design and planning is becoming more and more critical due to shorter product life cycles and highly dynamic demand conditions. In this context, traditional layouts such as product and process/functional layouts are considered inferior. Cellular layouts have been proposed as an alternative to these layouts but they need a complete reallocation of resources, which consumes time and money. Hence, it is necessary to verify the performance measures before the design and selection of a certain type of layout. In this context, this paper makes an attempt to study the suitability of a virtual cellular layout (VCL) along with an existing functional layout (FL) of an industry and a classical cellular layout (CL), if considered for implementation. A Genetic algorithm (GA) based intra-cell formation procedure is used in the cellular layout design. To identify the suitability of a particular layout in a given environment, a typical manufacturing system is modeled using the WITNESS 2006 simulation software. Design of experiments (DOE) is used to plan the simulation experiments. The performance of each of the three layouts is analyzed statistically by means of operational parameters such as machine utilization, throughput, average distance traveled by parts and average work-in-process. The results from the simulation experiments indicate that the performance of virtual cellular manufacturing falls between that of functional and cellular manufacturing. Also, we find that the performance of a virtual cellular layout is often relatively superior to that of a functional layout and marginally inferior to a cellular layout.

Maghsud Solimanpur, Mehdi A. Kamran(2013) have studied Facilities location problem deals with the optimization of location of manufacturing facilities like machines, departments, etc. in the shop floor. This problem greatly affects performance of a manufacturing system. It is assumed in this paper that there are multiple products to be produced on several machines. Alternative processing routes are considered for each product and the problem is to determine the processing route of each product and the location of each machine to minimize the total distance traveled by the materials within the shop floor. This paper presents a mixed-integer non-linear mathematical programming formulation to find optimal solution of this problem. A technique is used to linearize the formulated non-linear model. However, due to the NP-hardness of this problem, even the linearized model cannot be optimally solved by the conventional mathematical programming methods in a reasonable time. Therefore, a genetic algorithm is proposed to solve the linearized model. The effectiveness of the GA approach is evaluated with numerical examples. The results show that the proposed GA is both effective and efficient in solving the attempted problem.

Tao Zhang, Qipeng P. Zheng, Yi Fang, Yuejie Zhang (2015), have studied a nonlinear integer programming model which co-optimizes the multi-level inventory matching and order planning for steel plants while combining Make-To-Order and Make-To-Stock policies. The model considers order planning and inventory matching of both finished and unfinished products. It combines multiple objectives, i.e., cost of earliness/tardiness penalty, tardiness penalty within delivery time window, production cost, inventory matching cost, and order cancelation penalty. This paper also proposes an improved Particle Swarm Optimization (PSO) method, where strategies to repair infeasible solutions and inventory-rematching scheme are introduced. Parameters of PSO and the rematching scheme are also analyzed. Three sets of real data from a steel manufacturing company are used to perform computational experiments for PSO, local search, and improved PSO. Numerical results show the validity of the model and efficacy of the improved PSO method.

Amir Sadrzadeh (2012) have studied genetic algorithm-based meta-heuristic to solve the facility layout problem (FLP) in a manufacturing system, where the material flow pattern of the multi-line layout is considered with the multi-products. The matrix encoding technique has been used for the chromosomes under the objective of minimizing the total material handling cost. The proposed algorithm produces a table with the descending order of the data corresponding to the input values of the flow and cost data. The generated table is used to create a schematic representation of the facilities, which in turn is utilized to heuristically generate the initial population of the chromosomes and to handle the heuristic crossover and mutation operators. The efficiency of the proposed algorithm has been proved through solving the two examples with the total cost less than the other genetic algorithms, CRAFT algorithm, and entropy-based algorithm.

Zhi-gang SHAN1, Sheng-jie DI (2013) have studied evaluate the columnar jointed basalts in the dam site of Baihetan hydropower station in southwest China, we developed a basic conceptual model of single jointed rock mass. Considering that the rock mass deformation consists of rock block deformation and joints deformation, the linear mechanical characteristics of the cell (including the elastic joints and the nonlinear mechanical behaviors of the cell) with a combined frictional-elastic interface were analyzed. We developed formulas to calculate the rock block deformation, which can be adapted for multiple jointed rock mass and columnar jointed basalts. The formulas are effective in calculating the equivalent modulus of multiple jointed rock mass, and precisely reveal the anisotropic properties of columnar jointed basalts. Furthermore, the in situ rigid bearing plate tests were analyzed and calculated, and the types of loading-unloading curves and the equivalent modulus along different directions of columnar jointed basalts were obtained. The analytical results are in close compliance with the test results.

3 EXPERIMENTAL SETUP

Phases Manufacturing Process of mechanism:

As shown of The design of the special purpose mechanism ,point of viewing of methodology manufacturing system divide in to the several part .the procedure of turning and facing at particular station for machining outer diameter is common but to load the work piece is much difficult and time consuming then others .in the case of the v4 and v6 machining stator and rotor the mechanism is much capable than 250 kg weight for each part .This mechanism also applicable for v4 and v6 machining process and its implemented on v4 production line.

For accurate and precision purpose The loading and unloading process require careful operation in it .there are the chances to damage the work piece during load on the C.N.C ,here this procedure take more time and going in traditional way .

OPERATING PARAMETERS:

1. Total FIFO Period

The first in, first out (FIFO) method of inventory valuation is a cost flow assumption that the first goods purchased are also the first goods sold. In most companies, this assumption closely matches the actual flow of goods, and so is considered the most theoretically correct inventory valuation method. The FIFO flow concept is a logical one for a business to follow, since selling off the oldest goods first reduces the risk of obsolescence. [w11]

2. Manufacturing time

Manufacturing is undergoing major transformation due to the unforeseen challenges arising from the current trend of miniaturization, the emergence of new materials and the growing interaction between biologists and engineers to learn more from nature and living objects.Traditionally, a "top-down" approach has been used in **manufacturing**. Recently, engineers and scientists have begun exploring "bottom-up" approaches for manufacturing today's highly complex products. Further, these emerging processes are aimed to improve process efficiency and product quality. [w12]

3. Rate of Manufacturing

In manufacturing, the number of goods that can be produced during a given period of time. Alternatively, the amount of time it takes to produce one unit of a good.In construction, the rate at which workers are expected to complete a certain segment, such as a road or building. The production rate will depend on the speed at which workers are expected to operate, generally categorized as slow, average or fast. [w13]

4 Loading / Unloading Period

The time take by operator for load The work piece on the mechanism and take insert the mandrel, this time period call for the loading and unloading period, for loading period there are affect much factor such as such as part size and shape, orientation, the need to invert the part, the need to protect the part from dings, and even the length of time the customer wants to be able to run the CNC lathe unattended.[w14]

5 .Testing Time

Manufacturing Automation Laboratory has developed advanced, easy- to-use machining process simulation and measurement software which is used by a number of companies around the world. ShopPro is an integrated, easy to use tap-testing, chatter stability lobe, torque, power prediction as well as giving expert advice to solve machining problems. CUTPRO is advanced software with milling, turning, boring, drilling, spindle, CNC, tap testing, modal analysis and data acquisition modules. MACHPRO imports NC programs from CAM systems; simulates the part machining operations and automatically creates an optimized NC program. NPro simulates and optimizes the tool paths directly within NX CAM system. Machining process simulation modules predict forces, torque, power, bending moment on spindle bearings, dimensional surface finish, vibrations and chatter-free depths of cut and spindle speeds. Machine tool and cutting tool designers can optimize their design choices, while process planners can significantly reduce the machining time while maintaining the accuracy and quality of the parts. The course gives balanced training of basic machining principles and their hands on application on machine tools.

6 Quality Control And Standard:

Raw material as well as purchased components should be of standard quality. The machined parts should be checked at every stage for its size by measuring instruments. The rotating parts are checked on balancing machine. Inspection & testing of the submersible pump should be carried out as per IS: 8034

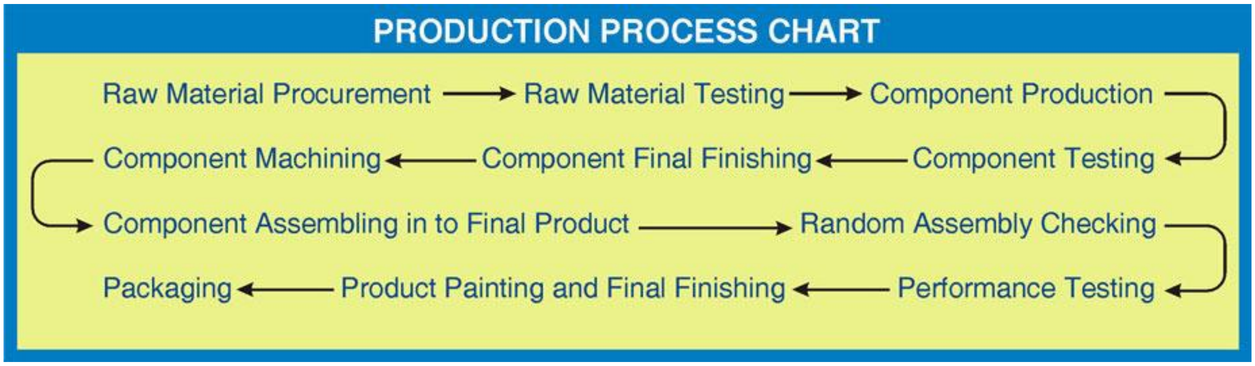

Fig -Production Process Chart

7 Weight Variation

This Mechanism is implement over the production line v4 but the capacity of the this mechanism is workpiece weight more than 250 kg this mechanism is able to load and unload over the work piece, if this mechanism implement over the v6 or any production line of pump and motor production the weight variation issue is neglected factor, but more heaver part require careful loading.

8 Final Cycle Time

The time it takes to do one repetition of any particular task typically measured from "Start to Start" the starting point of one product's processing in a specified machine or operation until the start of another similar product's processing in the same machine or process. Cycle time is commonly categorized into:

1) Manual Cycle Time: The time loading, unloading, flipping/turning parts, adding components to parts while still in the same machine/process.

2) Machine Cycle Time: The processing time of the machine working on a part.

3) Auto Cycle Time: The time a machine runs un-aided (automatically) without manual intervention.

4) Overall Cycle Time: The complete time it takes to produce a single unit. This term is generally used when speaking of a single machine or process.

5) Total Cycle Time: This includes all machines, processes, and classes of cycle time through which a product must pass to become a finished product. This is not Lead Time, but it does help in determining it. [W 15]

GAP ANALYSIS

For make an operation easy of loading and unloading implementation of special purpose mechanism .which change the several phases of the production, here there is one kind of comparison of which condition the mechanism of loading and unloading purpose .before implementation and after implementation .the change of each factor having graphical representation .the factor which change after implement the S.P.M as below.

1. FIFO Time Period

2. Weight Variation

3. Loading time

4 Testing /Measurement time

5. Quality Control

6. Production Rate

[1] FIFO Time Period:

- In this plant every station consider the policy for inventory control which FIFO (First in First out), inventory valuation in cost flow ,assumption That is First good for over all cycle time which Is divide in several time period known as FIFO time period .before implement the mechanism 30 minutes total required time with manufacturing and after implement it would be require only 15 minutes and 17 seconds

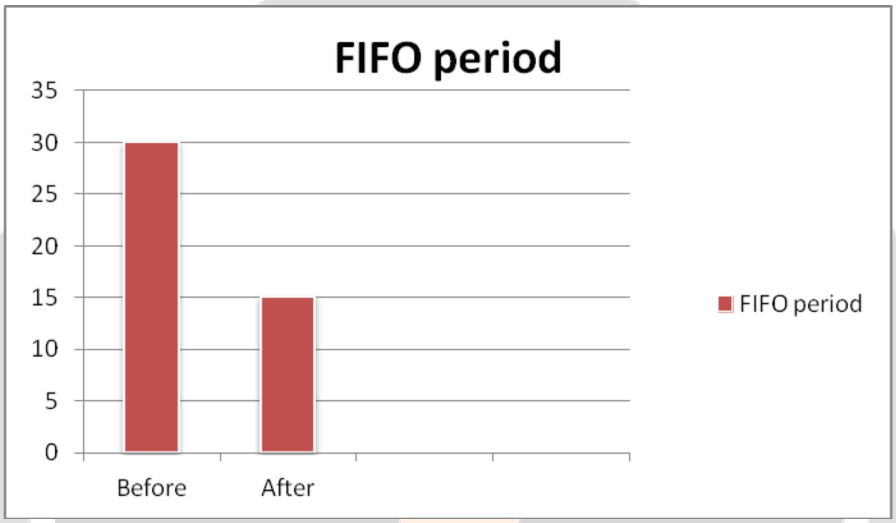

Figure - FIFO Time Period

[2] Weight Variation:

As per point of V4 production and v6 production line the row material weight of v6 is more heavier thane V6 it would be require that much amount of capable mechanism to carry the raw material there are several changes would be require such as Motor and gear box this both a most important component which used in mechanism. So capacity of both of them require to change.

For particular V6 motor and pumps minimum 1.5 HP motor require .in this case the mechanism is design for both of mechanisms, limit of the weight is up 250 kg.

[3] Loading Time:

In this mechanism, the loading time period start from mandrel insert in stator to unload over CNC lathe chuck, this period is called as a loading time and reverse process is called unloading time, loading time for any v4 stator before implement the mechanism 18 minutes and 20 seconds and after 3 minutes and 28 seconds.

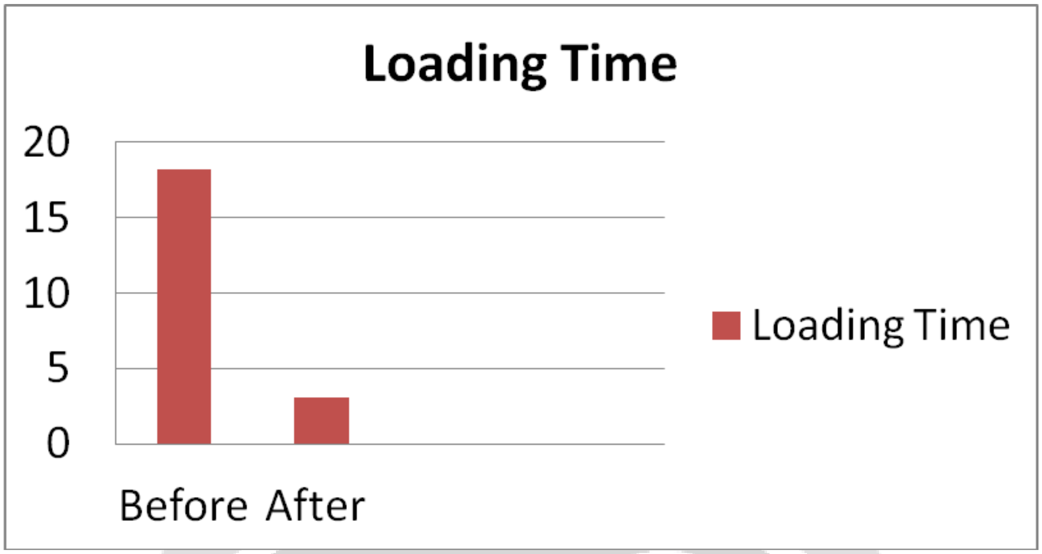

Figure - Loading Time

[4] Testing Time:

In this kind of the plant organization focus over the automation which is economically too much cheaper for advance easy to use machining process simulation and measurement software which is use by number of the companies as a pint of this conical problem

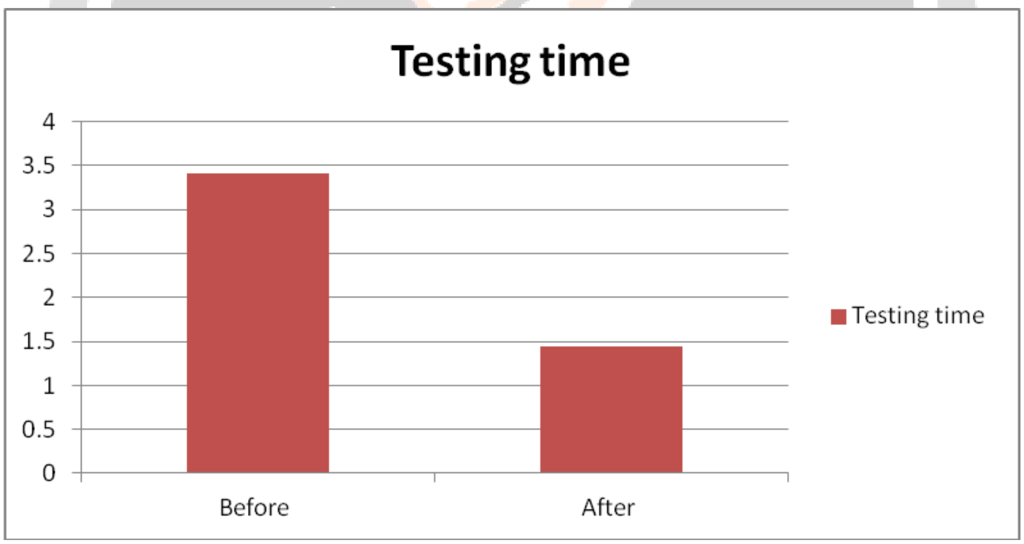

Figure- Testing Time

loading time for any v4 stator before implement the mechanism 18 minutes and 20 seconds and after 3 minutes and 28 seconds for check internal diameter and outer diameter of facing and turning operation taken time by operator before mechanism 5 minutes 37 seconds and after mechanism 1 minute and 48 seconds .which reduce the time .

[5] Quality control:

As a FIFO period start ,the raw material for this station is take place over the mechanism before implement this mechanism loading and unloading process is totally traditional way .use of this mechanism its becomes more easier than others as see further of traditional way .

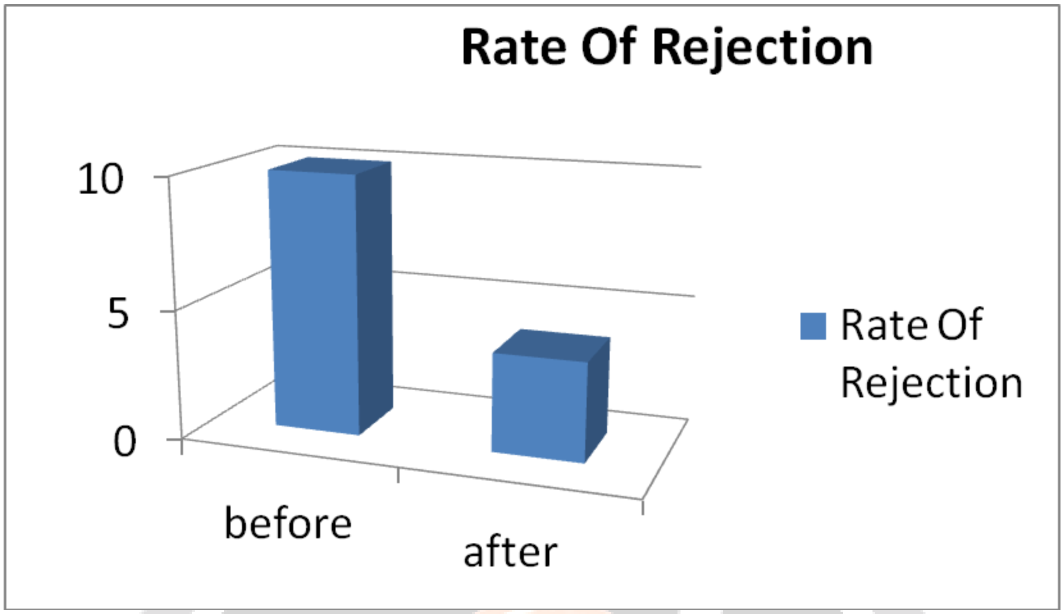

Figure- Rate of Rejection

process of loading and unloading is too much longer process .due to clamping the damage of work piece occur .rate of rejection is higher for batch production quality control .normally 9.68 % rejection ratio when loading techniques is traditional and after modification 3.89% rejection ration .which occur raw material defects.

[6] Production Rate:

In manufacturing, the number of goods that can be produced during a given period of time. Alternatively, the amount of time it takes to produce one unit of a good. In construction, the rate at which workers are expected to complete a certain segment, such as a road or building. The production rate will depend on the speed at which workers are expected to operate, generally categorized as slow, average or fast.

For manufacturing and construction, a higher production rate can lead to a decrease in quality. As machines or employees work to have more product pushed through the production line or more of a building completed, more mistakes are likely to happen. There is thus a point at which a decrease in quality could wind up costing a company more, even if less time is needed to push out a unit. [w10]

4 CONCLUSION

After implement this mechanism, I can conclude that except automation .it can be easy to increase productivity by several way after implement this mechanism it is easy to loading and unloading heavier work piece without any kind of the damage such as fatigue and damage of brittle material.

For measurement purpose .it is much easy than traditional way with use of dial indicator .it would be such difficult then modify way of the loading technique

It can also reduce the rate of rejection which is identify by the acceptance sampling method .most of the percentage can be reduce by this mechanism which affect the outer body of the stator Of stainless steel.

Total manufacturing time which is delay due to loading of the work piece is reduce and other factor such as production rate FIFO time period ,rate of rejection ,weight variation all are reduce production line which break done can recover the time.

5 REFERENCES

1]. Introduction to burnishing - Sodhganga shodhganga.inflibnet.ac.in:8080/jspui/bitstream/.../09_chapter%201.pdf

2]. ISO journal
iosrjournals.org/iosrjmce/papers/vol12issue3/...2/B012321623.pdf

3]. Branko Tadic, Sasa Randjelovic, Petar Todorovic, Jelena Zivkovic, Vladimir Kocovic, Igor Budak, Djordje Vukelic," Using a high-stiffness burnishing tool for increased dimensional and geometrical accuracies of openings, Precision Engineering (2015).

4]. X. L. Yuan & Y. W. Sun & L. S. Gao & S. L. Jiang," Effect of roller burnishing process parameters on the surface roughness and microhardness for TA2 alloy, Int J Adv Manuf Technol DOI 10.1007/s00170-015-8031-0 Springer-Verlag London (2015).

5]. Goutam D. Revankar , Raviraj Shetty, Shrikantha S. Rao, Vinayak N. Gaitonde," Analysis of surface roughness and hardness in ball burnishing of titanium alloy" Measurement 58 (2014) 256–268.

6]. Masato Okada, Shohei Suenobu, Kei Watanabe, Yorihiro Yamashita, Naoki Asakawa," Development and burnishing characteristics of roller burnishing method with rolling and sliding effects" Mechatronics (2014).

7]. K Saraswathamma, G Venkateswarlu, S Venkatarami Reddy," Optimization of surface roughness in the Roller burnishing process using response surface methodology and desirability function, International conference on Emerging Trends in Mechanical Engineering, ISBN: 978-93-82163-09-1,(2014).

8]. Shu Yang, Domenico Umbrello, Oscar W. Dillon Jr., David A. Puleo, I.S. Jawahir," Cryogenic cooling effect on surface and subsurface microstructural modifications in burnishing of Co–Cr–Mo biomaterial, Journal of Materials Processing Technology 217 (2014) 211–221.

9]. Deepak Mahajan, Ravindra Tajane," A Review on Ball Burnishing Process, International Journal of Scientific and Research Publications, Volume 3, Issue 4, (2013) ISSN 2250-3153.

10]. W. Grzesik, K. Z. ak," Producing high quality hardened parts using sequential hard turning and ball burnishing operations, Precision Engineering 37 (2013) 849– 855.

11]. P Ravindra Babu, K Ankamma, T Siva Prasad, A V S Raju and N Eswara Prasad," Optimization of burnishing parameters and determination of select surface characteristics in engineering materials" Indian Academy of Sciences *Sadhana* Vol. 37, Part 4, (2012), pp. 503–520.

12]. Feng Lei Li , Wei Xia, Zhao Yao Zhou, Jing Zhao, Zheng Qiang Tang," Analytical prediction and experimental verification of surface roughness during the burnishing process, International Journal of Machine Tools & Manufacture 62 (2012) 67–75.

13]. Malleswara Rao J, Chenna Kesava Reddy, Rama Rao P," The effect of roller burnishing on surface hardness and surface roughness on mild steel specimens, International Journal Of Applied Engineering Research, Dindigul Volume 1, No 4, (2011) ISSN 0976-4259.

14]. J. N. Malleswara Rao, A. Chenna Kesava Reddy and P. V. Rama Rao," Experimental investigation of the influence of burnishing tool passes on surface roughness and hardness of brass specimens, Indian Journal of Science and Technology ISSN: 0974- 6846 (2011).

15]. P Ravindra Babu, T Siva Prasad, A V S Raju and A Jawahar Babu," Effect of internal roller burnishing on surface roughness and surface hardness of mild steel, Journal of Scientific & Industrial Research Vol. 68, (2009), pp. 29-31.

16]. Binu C. Yeldose, B. Ramamoorthy," An investigation into the high performance of TiN-coated rollers in burnishing process, journal of materials processing technology 207 (2008) 350–355.

17]. S. Thamizhmanii, B. Saparudin, S. Hasan," A study of multi-roller burnishing on non-ferrous metals, Journal of achievements in materials and manufacturing engineering (2007).

18]. H. Hamadache, L. Laouar, N.E. Zeghib, K. Chaoui," Characteristics of Rb40 steel superficial layer under ball and roller burnishing, Journal of Materials Processing Technology 180 (2006) 130–136.