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Automation of Mini Lathe for Production of Soldering Iron Bits

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Abstract: The increasing demand for automated devices in metalworking industries has driven significant advancements in lathe manufacturing. Conventional lathe operations, involving manual loading of copper and brass raw materials across three separate machines for taper turning, facing, and parting-off, have been observed to be inefficient. These manual processes result in excessive production time, increased labor costs, high raw material consumption due to human errors, and suboptimal product quality, thereby negatively impacting production capacity and overall cost-effectiveness. This study proposes an automated solution that integrates these three machining operations into a single automated mini lathe, enhancing efficiency without requiring a complete structural overhaul of traditional lathe machines. The implementation of automation has demonstrated a substantial improvement in productivity, increasing production capacity from 50 to 125 soldering iron bits per hour while optimizing space, time, and resource utilization. The results indicate that automation in lathe industries can significantly enhance manufacturing efficiency, reduce operational costs, and improve product quality.

Keywords- mini lathe, automation, industry, manufacturing, lathe machines

1. INTRODUCTION

The term automation refers to the integration of modern technology to existing older systems The benefits envisioned in automation include developing a less expensive investment than buying a new equipment. Automation has several advantages including increased performance, cheaper energy costs, and improved accessibility to industrial data [1]. In the metal-removing industries, automation plays a critical role by minimizing human intervention, reducing energy consumption and production costs. Conventional lathe machines, operated manually, pose safety risks and inefficiencies, necessitating the need for automation to optimize productivity. By adopting automation principles, traditional lathe machines can be upgraded rather than replaced, leading to cost-effective improvements.

In today's times, working over conventional machine is very dangerous for a manufacturing industry where machines like lathe machines are operated by humans. Today specific need is to follow the USA principle of automation and accordingly automate the conventional lathe machines to create their best version without replacing entire unit (modification). A computer-controlled machine can be programmed to produce products that look the same in their hundreds and thousands. This has made it easy to achieve mass production of products. By automating the process, a product can be removed after the first operation, turned around and then put back into the machine. This means that the product can by fully machined in one operation. In this way, a lathe with one spindle can machine a finished product like a machine with two spindles [2].

Retrofitting, a key automation technique, is the process of updating an otherwise mechanically sound machine's Computer Numerical Control (CNC), servo, and spindle systems to increase the tool's usable life, thereby extending their operational lifespan. A CNC is computerized operation of machining tools frequently used during remanufacturing and rebuilding retrofit. If the machine tool is mechanically generally in good condition, CNC automation is usually the high cost-effective way than acquiring new machinery to increase an old machine tool's overall performance [3-5].

Much of the work can be finished at the retrofitter's place of business, where subassembly frequently takes place. Reducing the amount of time, the machine is at the site, eliminating expensive machine rigging and shipping costs. Rebuilding often entails replacing or repairing any worn-out mechanical part. Typically, the rebuild is done in the rebuilder's facility, thus there can be extra transportation and running expenses. By implementing CNC automation, industries can eliminate excessive downtime, reduce labor costs, and improve machining accuracy [6,7].

Conventionally operating lathe machine industries are manufacturing soldering iron bits for a soldering iron, where raw material of brass and copper are fed manually onto three different machines to get the final furnished product, by three performed operations namely cutting, facing and taper turning. The entire process is very outrageous which requires more production time, more working hours, more labor, minimum expected quality and rawer material to compensate for human errors while operating, hence directly affecting the production capacity and production cost. During production of soldering iron bits over a conventional lathe machine several anomalies were observed. The process consumes more time for a production and decreases the overall production rate. As operations are performed manually over each machine, there are always some chances that out of 10 work pieces one work piece gets damaged. The use of conventional processes not only increases the procurement of extra material for production but also tend to cause the failure of a tool easily performing lathe operations. This affected the production rate as well as the wastage of brass and copper raw material while machining manually. Due to human labour operating over lathe operations, overall quality and surface finish of a machined job were also not much precise. Production cost and procurement of brass, copper materials increased and accuracy reduced. Such problems faced by small scale industry manufacturing soldering iron bits, where the bits were manufactured in partition over a conventional lathe machine triggered the stimulus for this research.

Many small-scale industries are still using conventional machining operations which leads to the wastage of raw materials and escalate the production cost of the product. At times, small scale industries lack in automation due to which industries are trying to cope up with the increasing global competition. In order to cope up with these problems, automated mini lathe machine seems to be an apt solution. By performing different operations over the single machine automatically would increase their production. The per day production rate up to 40% and also reduces the scrap to 10%. absence of human interaction will create precise and optimistic solder bits [8-10].
The objectives of the study were to reduce production cost, time, scrap as well as to increased productivity, to reduce errors, mishaps and to take control all over process in a real time by implementation of closed control system, to reduce the human interaction leading to shorter working hours for labor, to reduce factory lead times and to achieve manufacturing flexibility.

2. MATERIAL AND METHODS

Automation of conventional mini lathe machine for production of soldering iron bits would overcome the problems during each lathe operations i.e., taper turning and cutting which were earlier executed manually over each machine will now be performed simultaneously over a single machine which would reduce the space and increases the production capacity. As operations perform automatically, due to constant feed rate, effective speed and progressive tool control with the error detection; life of the tool increases and procurement of brass and copper raw material reduces to greater extent. Shorter lead time and shorter working hours during a production with operational accuracy and surface finish will be obtained.
The proposed automation solution involves integrating all lathe operations—taper turning, facing, and parting-off—into a single mini lathe machine. Entire automation of the machine works on a principle that when a control signal is fed into the micro controller, it controls the movement of tool post in x and z direction with the help of motor and round belt pulley arrangement. Round belt pulleys are mechanical devices which transmit rotational motion around an axle. They are used to lift loads or to apply/transmit power. The round belt pulley accommodates a belt, cable, or rope in a groove around the circumference of the device to guide the drive element. Round belt pulleys are very efficient (approx. 95%) [3]. Feedback sensor i.e. the encoder is a mounted on the tool posts hand wheel which counts the exact sheave rotation, which will provide the exact co-ordinates of a tool which will help to perform next operation progressively ensuring precise tool positioning, minimizing errors and material wastage.

2.1 Working Principle

Automation includes, control over movement of tool post in both x and z direction with the help of 120 watt Permanent Magnet DC Motor, round belt pulleys coupled to motor with help of a couplers. The drive from motor is given to pulley mounted, as hand wheel of a tool post thereby rotating the hand wheel sheave the linear movement of tool post is possible.

An actual rotation of hand-wheel pulley is measured with the help of rotation counter, which provides actual position in terms of signal to the micro controller. The micro controller is connected to three motors, the main rotating chuck motor and two 120-watt PMDC motor to control linear movement in along two axes. Several provisions were also made to control speed and torque of motors.

Codes generated from part programming of required job size are fed into micro controller with the help of computer, these codes will then give commands to effectively control the two motors mounted orthogonal to each other to control the movement of a tool post and thereby tool movement.

First operation is taper turning, as micro-controller provides the input; first, the coolant pump will get switched on, after the main hub motor will turned on. in order to perform taper turning the required coordinated position in terms of rotation are given to motors which will accurately rotates lead screw mounted below tool post, according to given coordinated position to perform first operation.

First operation might be performed in multiple feed cuts to achieve better surface finishing and to avoid tool from getting overheat. Second operation is parting- off, as per mentioned coordinates in terms of rotation, the lead screw below the tool post causes tool position to be effectively achieved.

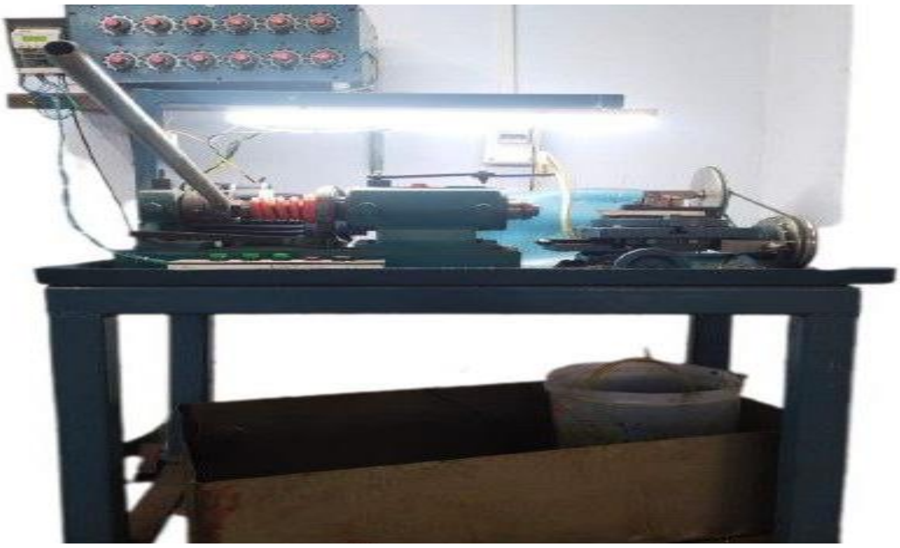


Figure 1. Final Working Model (Front View)

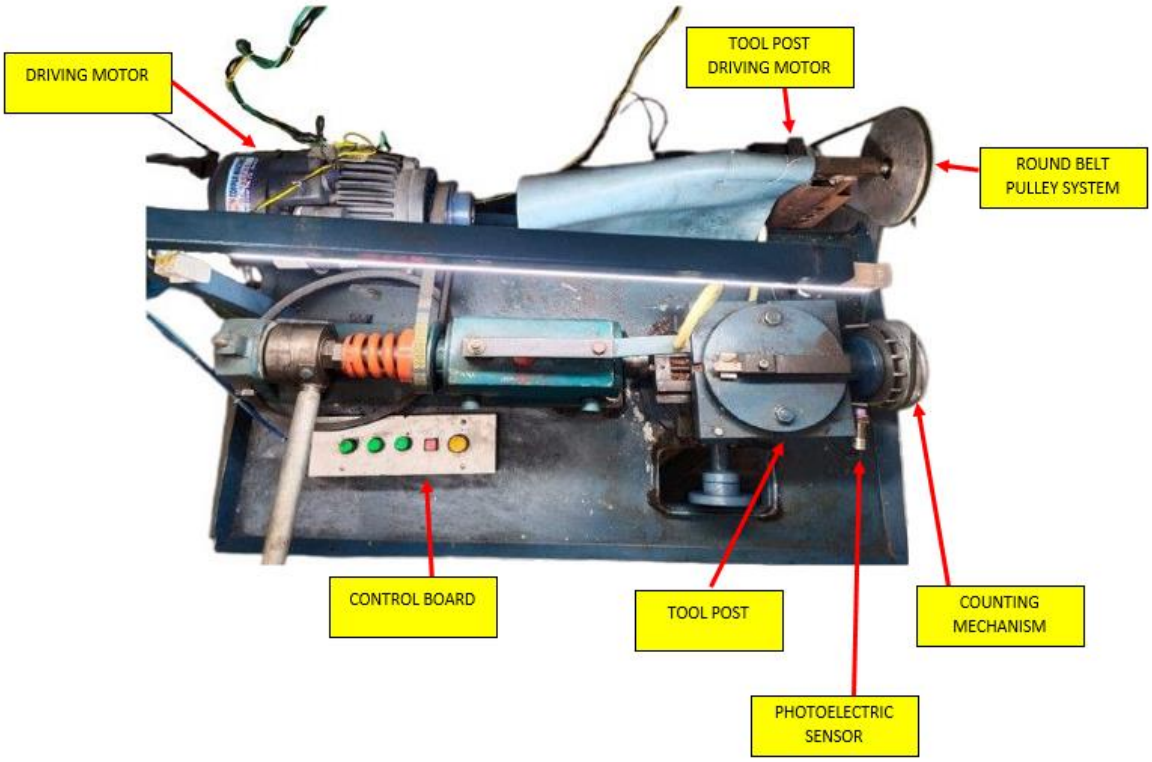


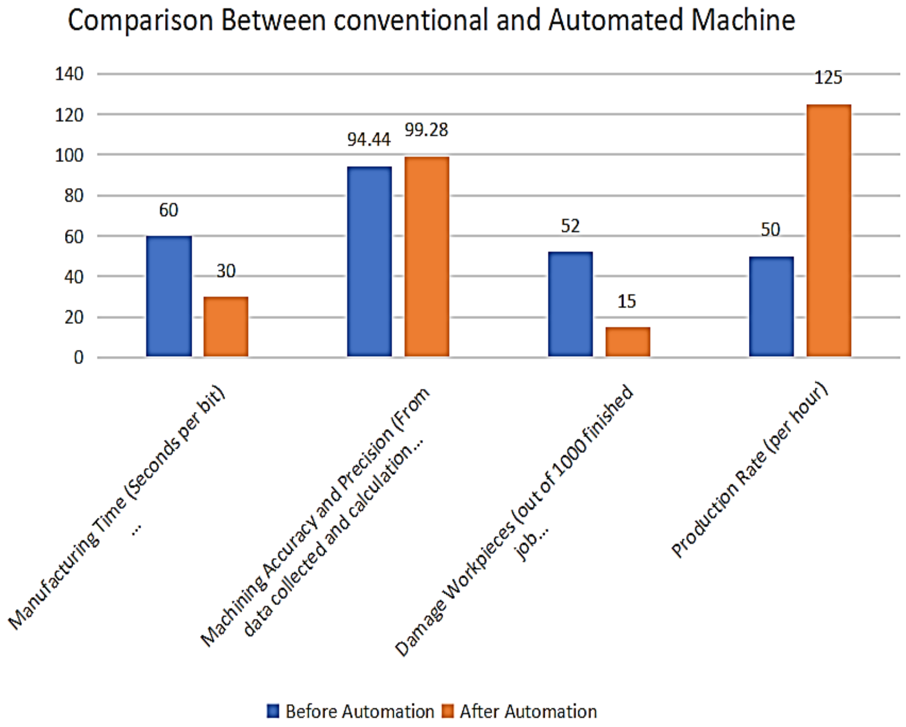
Figure 2. Final Working Model (Top View)

3. RESULTS

Over a past year, the manufacturer manufacturing soldering bits had been using conventional lathe machine to carry out different lathe operations, with which he faced major loss in opportunity due to low production rate and high maintenance cost. To overcome the anomalies a required automation in a conventional mini lathe machine was done. Tables 1 and 2 depict the machines parameters compared to validate the significance of current automation. A comparative analysis of conventional and automated lathe operations demonstrates significant improvements in efficiency and cost-effectiveness. Figures 1 and 2 highlight key performance metrics before and after automation.

Table 1. Machine Comparison Parameters

Comparison	Before Automation	After Automation
Manufacturing Time (Seconds per bit)	60	30
Machining Accuracy and Precision (From data collected and calculations)	94.44	99.28
Damage workpieces (out of 1000 finished jobs)	52	15
Production Rate (per hour)	50	125



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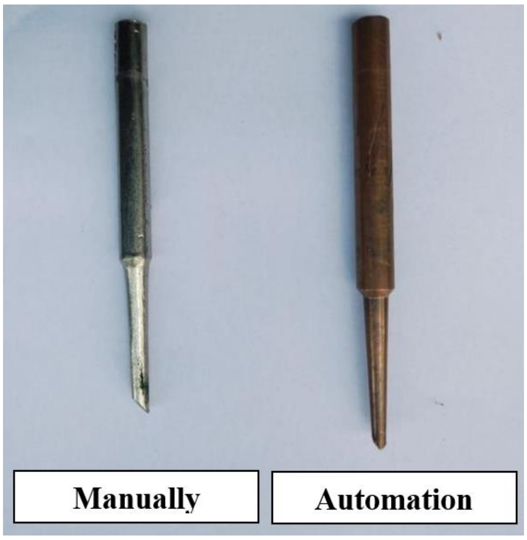

Figure 2. Product Comparison between manual and Automated Job Manufacturing

Table 2. Machine Comparison Parameters

(*Cycle time = Machining set up time + time required to mount the job in chuck + Machining time + job removal time + visual Inspection)

Comparison Parameter	Before Automation	After Automation	Assessment Technique and Equipment
Manufacturing time	60 sec/per bit	36 sec/per bit	Manually
Machining Accuracy and precision	Less	Significantly increased	From Calculations
Damaged work pieces and damage tools	 Bend due to improper cutting force at the tip while taper turning  Improper profile roughness Approximately 52 components were seen a manufacturing defects out of 1000 components. Like bending, excessive rubbing, uneven profile roughing the tool, excessive heat due to variable feed rate, overheating single point cutting tool (working life decreased) etc.	 No bend and Even profile roughness. Percentage rejection, 15 in 1000 components. Even depth of cut, constant cutting speed, Tool life considerably increased, approximately all anomalies were resolved	Job inspections with the help of dial gauge and vernier caliper and Profile Projector
Production rate (per hour)	50 finished solder bits/hour	1000 finished solder bits/hour	From Calculations Chart
Lead time	As single operations performed over individual machine which thereby increased the machine ideal time, work piece transferring time etc.	Combined operations reduces the machine ideal time thereby boosting the production rate.	Visual analyses with the help of a digital timers.
Thermal stresses induced (tool life)	Due to uneven feed rate and miss judgement, over a period of time tool life decreases. Excessive heating also causes the thermal expansion of copper bits resulting in uneven geometrical profile. 	Due to constant speed and invariable tool movement, Adjustable coolant rate product manufactured with minimum bend like sagging and hogging. 	Visual analyses, Dial gauge
Cycle time*	(60 sec + 2 sec + 60 sec + 4 sec + 6 sec) Total 138 seconds required to finish work piece.	(10 sec + 2 sec + 36 sec + 4 sec + 2 sec) Total 56 seconds required to finish work piece.	Clock, timer

4. CONCLUSION

Automating lathe operations significantly enhances productivity and reduces manufacturing costs. By integrating multiple machining processes into a single automated system, production rates have increased, defects have decreased, and overall efficiency has improved. Automated machines help to automate repetitive commands, hence save time and reduce the likelihood of errors compared with running commands manually. The rate of automatically generated solder iron bits produced per day is comparatively high than traditional method. Automated machine can manufacture 1000 components per day with error rate of 2 defective jobs per batch of 400 bits. Multiple operations like cutting, boring, taper turning, rimming, perforating, parting off, knurling, grooving, drilling, stamping etc. can be archived with the help of automation which would there by performed over same single machine, which in saves manpower for handling the resources and also reduces cost along with a lead-time. The automated mini lathe offers a cost-effective solution for small-scale industries, enabling them to compete in the global market. The future of metalworking lies in automation, with further advancements expected to revolutionize precision machining and industrial efficiency.

5. FUNDING / SOURCES OF SUPPORT

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6. CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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