International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Investigation of Automation Strategy and Its effect on Assembly Cost: A Case Study on Ball Pen Assembly Line.

Bhavya R. Gajjar[Á*], Saurin Sheth[Á]

[Á]Mechatronics Engineering Department, G. H. Patel College of Engineering and Technology, Vallabh Vidyanagar, Gujarat 388120, Anand, India.

Accepted 18 March 2014, Available online 01 April 2014, **Special Issue-3, (April 2014)**

Abstract

Automation is found to be an efficient way to achieve cost-effective solution in different parts of manufacturing, as well as in the process industry and other industrial areas .Production assembly is generally the largest single cost element of production manufacturing. Ball pen manufacturing requires too many parts to be assembled together, so assembly cost is major component in overall cost of the product. To reduce overall cost of the product it is required to observe each and every assembly process, and analyzed each process with various parameters like efficiency, productivity, lead time, delivery precision, investment cost, capacity, maintenance, running cost. Based on this analyses decision would be made either adopt automatic or manual method for particular assembly process.

Keywords: *Ball pen assembly, Automation, Assembly cost.*

1. Introduction

To survive in corporate war of global economy, manufacturing companies continuously effort to increase productivity and to reduce the manufacturing cost of their products. This can be done by various ways for e.g. reducing the inventory cost, increasing machine utilization and/or reducing the direct labour cost. If productivity can be improved for instance by reducing the labour content of the process, this should help to reduce the manufacturing cost of their products.

Product assembly is generally the largest single cost element of production manufacturing. It has been estimated to account for to account for 50 per cent of manufacturing cost and can employ more than 40 per cent of workforce (G Boothroyd, et al, 1987). Consequently, when manufacturing cost savings are concern, attention on this aspect of production should be a prime consideration. Automation has proven to be an efficient way to achieve cost-effective solution of production in discrete parts manufacturing, as well as in the process industry and other industrial areas (J frohm, 2008). In general, automation has also relieved humans from heavy, dangerous, complex, boring and time-consuming tasks (Parsuraman R, et al, 2000). Automation has also been extensive not only in the actual production process but also in supportive tasks (e.g. material handling, transportation and storage) (J frohm, 2008). Further, automation may offer solutions in highly time-critical situations in which there is insufficient time for a human operator to respond and take appropriate action or in other types of situations where the human being proves insufficient in one or more aspects (Parsuraman R, et al, 2004). Even if the ambition was in some cases to create so-called lights-out factories with complete automation in every step of production (Mital A, et al, 2004), most of those automated systems in production are still semi-automatic, where the automated system consists of a combination of automated and manual tasks together. This is especially true in assembly, which has generally been more difficult to automate at a reasonable cost (G. Boothroyd, et al, 1987).

However, automation also has its limitations. Although it has been very efficient and productive, automated production and assembly systems do have their drawbacks. Research has shown that most of the industries which are using advance manufacturing techniques facing the problems of frequent production disturbances related to machines and equipment.(Ylipaa 2000). Many studies indicate that most automation decisions emanate from the top, and often the outcome is not what was expected after making the investment. When top management initiates automation, often with the aim to reduce manufacturing cost, the decision on automation tends to be the only concern, i.e. automation is the manufacturing strategy (Winroth M., et al, 2007). If the decision is pushed on the organization, without linkage to the manufacturing capabilities, such investments may become real failures. Level of technology is one of several decisions constituting the manufacturing strategy content (Skinner W, 1969; Hill T, 2000). Here, however, the question is automation or not, and the appropriateness of different levels of automation in different situations is not treated.

*Corresponding author: Bhavya R. Gajjar

This view of automation is also noticed by Sheridan (2002) as the ‘‘all-or-none fallacy’’, especially common among the non-technical public.

When planning and implementing automated manufacturing systems, there are number of issues to be considered. In contrast to the process industries, systems in the manufacturing industry are rarely fully automated. A common solution is to merge manual and automated operations into semi-automated manufacturing systems. Automation can involve automation of activities both at facilities level and on support systems level (Groover M.P., 2001),. In order to fully utilize the capabilities of both humans and machines in a semi-automated manufacturing system, the interaction between them needs to be well conceived. Such interaction has traditionally been described in human factors engineering in the terms of function allocation, implying a system design process where functions are allocated to humans or to machines, respectively. The resulting function allocation may be described as the level of automation, ranging from entirely manual operations to full automation (Sheridan T.B., 2002).

2. Process description of assembly line

Research presented in this paper was carried out at Anchor Enterprise, valsad. Anchor is well known brand name in electrical accessories since 50 years. Company recently entered in the market of writing instrument and introduces wide range innovative product to meet the demand of today’s customer.

Pen making process consists of several steps. It starts with raw materials, such as ink pen cartridges, pen barrels, caps and plugs by assemble this parts end with ready-to-use ballpoint pens. Pen assembly process consists of following steps as shown fig.1.

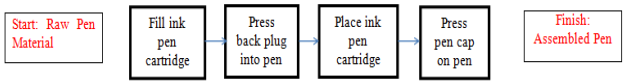

Fig. 2.1 Ball pen assembly process

Pen assembly starts with to fill the cartridge with ink. It is most difficult process of entire pen assembly line. It contains several sub assembly process like insert nob in the cartridge, fill ink in the cartridge and finally insert follower which can prevent the ink to flow backward. After that back plug put at the top of the barrel and press either manually or pneumatically. Internal slots are given in the back plug which can hold the cartridge. Filled cartridge insert into the barrel from the bottom and at last insert the cap which completes the pen assembly process.

Each assembly process required men and machine to support the assembly line but those support structure of assembly line carry some cost which can affect the overall cost of the product. To survive in competitive environment in global economy, manufacturing companies continuously effort to reduce the manufacturing cost of their products. It possible by two ways either reducing use of support structure or by increase the productivity. Assembly cost (in rupees) associated with each process of ball pen assembly line is given in form of chart as shown in fig 2.

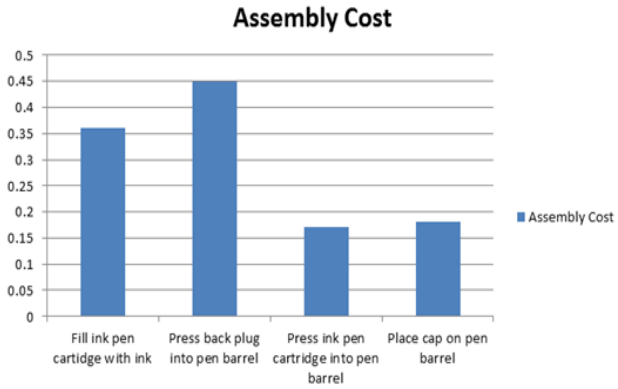

Fig.2. Cost analysis of ball pen assembly process

At present only one “cartridge filling with ink” process is done automatically and fully automatic machines are available for this process. Other than this all assembly process are done manually. It is clearly shown from the fig.2.that instead of “cartridge filling with ink” which is most complex and difficult process of entire ball pen assembly line cost of “back plug press fitting” is high. Assembly cost of “Insert cartridge into the barrel and “Place pen cap on the barrel” is lower than first two assembly process.

3. Analysis of pen assembly process

To find out current method used for assembly process is appropriate or not we observed each and every process of ball pen assembly and analyzed those processes with various parameters like efficiency, productivity, lead time, delivery precision, investment cost, capacity, maintenance, running cost (K Safsten, et at, 2007). In Analysis + sign indicates for favourable parameter and ++ sign indicates for strongly favourable parameter and - indicates for unfavourable parameter and -- sign indicates for strongly unfavourable parameter. After the end of each analyzed process total number of + and – are calculated for both manually and automatic method. For each process in pen assembly line which method got more + sign compare to – sign that method is favourable to that particular process. The result of the analysis is shown in the table given below.

3.1 Fill ink pen cartridge with ink

Ink which is used in cartridge is toxic and for filling ink into the cartridge and to fix small dimension of the nob in the cartridge required more accuracy and precision. It is quite difficult to do this process manually. It requires more number of workers, jigs and fixtures to match the co-centricity of the cartridge and nozzle of ink filling instrument. Although productivity and efficiency is not up to the mark and also waste of the ink is increase. While in case of automatic process high productivity of process is

compensate the initial investment of the automatic machine. Also running cost of the process is quite low compare to manual process. By comparing this process with various parameters shown in Table.1 sum of favourable parameters in automatic method are more compare to manual method. So we strongly recommend that this process should be done automatically.

Table 1 Results of analysis for Fill ink pen cartridge with ink

Affecting Parameter	Manually	Automatically
Efficiency	--	++
Productivity	--	++
Lead time	+	-
Delivery precision	-	+
Investment cost	++	--
Capacity	--	++
Maintenance	++	--
Running cost	--	+
Sum	5+/9-	8+/5-

3.2 Press back plug into barrel

Table 2 Results of analysis for press back plug into pen barrel

Affecting Parameter	Manually	Automatically
Efficiency	--	++
Productivity	-	+
Lead time	+	-
Delivery precision	-	+
Investment cost	++	-
Capacity	--	++
Maintenance	++	-
Running cost	-	+
Sum	5+/7-	7+/3-

This process is quite simple. The task is to put back plug on top of the barrel and press it. If we want to do this process manually it requires jigs to hold the barrel and hand or paddle operated pneumatic punch to press the back plug. Workers are needed to perform the operations like insert the barrel into jig, put back plug on the top of barrel, put this jig under the pneumatic punch and press the pedal and empty the jig which increase the running cost of the process and also productivity is low compare to other process which may create unbalance in overall assembly line. Although in case of automatic process quite simple mechanism are used which can restrict the initial investment and maintenance cost. Productivity is also high which can reduce the running cost and balance the assembly line. By comparing this process with various parameters shown in Table.2 sum of favourable parameters in automatic method are more compare to manual method. So we strongly recommend that this process should be done automatically.

3.3 Place ink pen cartridge into the pen barrel

In this process the task is to insert the filled cartridge into the barrel from the bottom because back plug already block the top of the barrel and it is also used to hold the cartridge into the barrel. If we want to do this process manually no external device requires. Also due to simplicity of the process number of worker needed to maintain the productivity of assembly line is less. In case of automatic process mechanism is require to coincide the centre of barrel and cartridge and push cartridge into the barrel. Productivity of manual and automatic process is nearly same; on the other hand initial cost and maintenance cost of automatic method is higher than manual method, So by comparing this process with various parameters shown in Table.3 sum of favourable parameters in automatic method are less compare to manual method we strongly recommend that this process should be done manually.

Table 3 Results of analysis for press ink pen cartridge into the pen barrel

Affecting Parameter	Manually	Automatically
Efficiency	-	+
Productivity	+	+
Lead time	++	--
Delivery precision	-	+
Investment cost	++	-
Capacity	-	+
Maintenance	++	-
Running cost	+	-
Sum	8+/3-	4+/5-

3.4 Press cap on the pen barrel

Table 4 Results of analysis for press cap on the pen barrel

Affecting Parameter	Manually	Automatically
Efficiency	-	+
Productivity	++	++
Lead time	++	--
Delivery precision	-	+
Investment cost	++	-
Capacity	-	+
Maintenance	++	-
Running cost	+	-
Sum	9+/3-	5+/5-

This is the simplest process in whole pen assembly line. In this process the task is to put cap on the top of the barrel and press it. If we want to do this process manually no external device requires. Also due to simplicity of the process and dimension of the cap time required for match the centre of cap and barrel is less. Also number of worker needed to maintain the productivity of assembly line is less. In case of automatic process mechanism is require to coincide the centre of barrel and cap and press the cap on the barrel. Productivity of the process is nearly same in manual and automatic method, on the other hand initial

cost and maintenance cost of automatic method is higher than manual method, so by comparing this process with various parameters shown in Table.4 sum of favourable parameters in automatic method are less compare to manual method. So we strongly recommend that this process should be done manually.

Conclusions

By comparing the current method and recommended method of each process we conclude that for the processes of "cartridge filling with ink", "press cartridge into the barrel" and "place cap on the pen barrel" current methods and recommended methods are same, so no need to change the current methods of these processes. For the process of "back plug press fitting" currently it is done by manual method but recommended method for this process is automatic. So by changing the current method of this process assembly cost will be reducing which can affect the overall cost of the product. So instead of going for fully automatic machine available for ball pen assembly only recommended processes will be done automatically and other processes will be done manually. By integrated manual and automatic method for assembly line we can balance between the initial cost and running cost.

Acknowledgement

The authors would like to acknowledge Anchor Enterprise pvt. Ltd. N.H 8, gundlav, Valsad for providing information and infrastructure

References

K. Safsten, M. Winroth ,J. Stahre, (2007), The content and process of automation strategies" International journal of production economics pp.25-38.

G. Boothroyd and P. Dewhurst, (1987), Product Design For Assembly. Wakefield.

J frohm, (2008), Levels of Automation in Production Systems, Thesis for the degree of doctor of philosophy, Department of Product and Production Development Production Systems, Chalmers University Of Technology, Goteborg, Sweden.

Parasuraman, R., Sheridan, T.B., Wickens ,(2000), A model for types and levels of human interaction with automation". IEEE Transactions on Systems, Man, and Cybernetics Part A: Systems and Humans 30 (3), pp 286–297.

Parasuraman, R., (2000), Designing automation for human use: empirical studies and quantitative models. Ergonomics", Vol. 43, No. 7, pp. 931-991.

Mital, A, and Pennathur, A, (2004), Advanced technologies and humans in manufacturing workplaces: an interdependent relationship". International Journal of Industrial Ergonomics, Vol. 33, No. 4, pp. 295-312.

Ylipää, T, (2000), High-Reliability Manufacturing Systems". Chalmers University of Technology, Goteborg, Sweden.

Winroth, M., Sa¨fsten, K., Stahre, J, (2007), Automation strategies – Existing theory or ad hoc solutions?" International Journal of Manufacturing and Technology Management 11 (1), pp 98–114.

Skinner, W., (1969), Manufacturing—missing link in corporate strategy". Harvard Business Review May–June, pp 136–145.

Hill T., (2000), Manufacturing Strategies", third ed. Irwin McGraw-Hill, Boston.

Sheridan, T.B., (2002), Humans and Automation": System Design and Research Issues. Wiley, Santa Monica.

Groover, M.P., (2001), Automation, Production Systems, and Computer-Integrated Manufacturing", second ed. Prentice-Hall, Englewood Cliffs, NJ, USA.

Ballpoint pen assembly device created for NPA employee with severe mobility limitations executive summary – team redundancy team ,unpublished.

http://www.myanchor.in/pens.htm.