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Design And Development Of Semi Automatic Jig In Horn Assembly To Reduce Cycle Time

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Abstract

Jig's purpose involves providing accuracy, repeatability, and interchangeability in the manufacturing processes while machining. Jig is a work-holding device that is utilized in holding, supporting, and locating the workpiece and guiding one or more tools to perform an intended operation. Generally, increasing productivity is one of the foremost goals among the manufacturing industries. Implementation of automation and techniques to increase the operators' efficiency are some of the strategies adopted by the companies to achieve these goals. During the recent years, industries in developing countries like India, are adapting to the various types of automation systems. This study aims to improve the overall productivity in a horn manufacturing industry assembly line, by eliminating the bottle neck in the manufacturing process. In the Vibromini horn assembly line used in the industry, once the testing is over , the tuning pin marking and providing of the thread locker are carried out manually , which cause a bottleneck in the whole operation, thereby decreasing the productivity. To overcome the above mentioned problems, an automated jig has been designed in this work, which reduces the overall cycle time of the operation. SOLIDWORKS 2014 software has been used to design the 3D model of the jig.

Keywords— *Automation, SOLIDWORKS, Jig, Pneumatic.*

I.INTRODUCTION

Automation is the procedure that is used to carry out any process with minimal human assistance. It uses various control systems for the operation of the equipment such as factories, machinery, boilers, and heat treating ovens, aircraft and submarines, and other applications. The application of the automation varies from simple household control systems to thousands of input sensors and

output control signals. In the case of the complexity, it varies from simple on-off control to various industrial standards high-level algorithms. The mathematical modeling of controlling automation began in the 18th century and advanced rapidly in the 20th century. Automation can be performed by using various means such as mechanical, pneumatic, hydraulic, electrical, and electronic devices. Complicated systems such as aircraft use combined techniques. The implementation of automation is very beneficial to the industry, those include the reduction of electricity costs, labor costs and improve the quality, accuracy, and precision. The various industries that the automation benefits include manufacturing, transportation, utilities, defense, facility operations. Automation is evolving rapidly and business intelligence applied in the applications is a new form of high-quality automation [1]. However, despite the advantages in the automation, minimal manual intervention is always appreciated. While incorporating the suitable automation system, it should be safe as well as comfortable. The essential factor to be considered while employing the automation system is the energy consumption.

The goal of concept screening and scoring is to filter the concepts before getting into the development of detailed design work. Screening and scoring are about reducing many ideas into a smaller and more manageable set. The quality of ideas in the final set depends on the quality of ideas in the initial set. Therefore, it's important to place good effort into the front processes of customer research and ideation. The suitable automation type is arrived by using the various concept screening techniques such as Pugh Matrix and Weighted Pugh Matrix. The design of the jig, in this work, is carried out by considering the product dimensions and suitable design principles.

II. NEED FOR AUTOMATION

A. Process Flow In the Vibromini Horn Assembly:

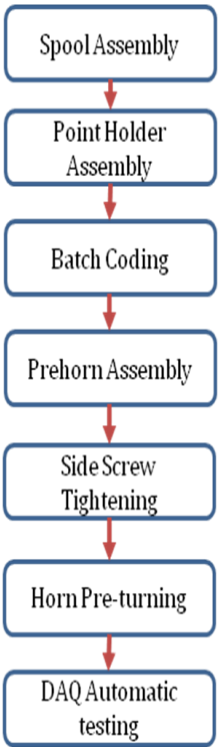


Fig. 1. Process Flow in the Vibromini Horn Assembly.

The process flow followed in the Vibromini horn assembly is shown in Figure 1. After the DAQ Testing the following three operations are carried out : applying thread locker, tuning pin marking and sticking drain hole sticker. These operations that are being carried out manually by a single worker, in contrast to the automated testing process preceding it, results in the varying operation cycle time, which as consequence, leads to bottleneck of the assembly. Thus, the following operations like visual quality inspection and packing are further delayed, leading to a decrease in productivity. In order to avoid this bottleneck problem and to increase the productivity rate, an automated system has to be designed in this work, to perform the above mentioned operation in a much faster rate with high precision and accuracy.

The objectives of this work of reducing the bottle neck to improve the productivity of the company are accomplished by the following:

- Designing and developing a semi-automatic portable product to carry out the two operations at once i.e., thread locking and tuning pin marking according to industrial standards.
- Successfully reducing the cycle time effectively than that of manual operation.

Figure 2 shows the thread locker, tuning pin and drainhole sticker arrangement.

Fig. 2. Operation Description

III.METHODOLOGY

The methodology, shown in figure 3, in this work begins with defining the problem , followed by a literature survey and market research. Subsequently, the conceptual designs are generated to arrive at various concept solutions and the generated concepts are evaluated to select the best concept by PUGH chart and weighted matrix. After the conceptual design, embodiment design activities are carried out. In the embodiment design, the selection of material, dimensions and specifications are determined. The embodiment design also includes the formulation of product architecture, which details about the general layout of the design. It is the stage in which the type of architecture like modular architecture or integral architecture is chosen. The embodiment design stage is followed by detail design stage, in which the 3D CAD model of the design is generated along with its 2 dimensional view. In this work Solidworks has been used to model the design. Once the CAD model of the concept

is designed, the motion and pneumatic simulation are executed using Solidworks. These simulations are used to determine the cycle time of the operation carried out by the designed product. The simulation is followed by prototype development and its final fabrication. The automated process is finally compared with the manual work to prove that the proposed method is better than the manual task that had been carried out by the industry thus far.

Fig. 3. Methodology

The second step in the process is to collect the variables involved in the operation, followed by a literature review . Then market research is carried out in order to find the market availability of mountings and fixtures in the local market. Then the product design is carried out by creating few concept arts and then finalizing the feasible concept.

IV. PRODUCT DESIGN

B. Concept Screening:

The goal of concept screening and scoring is to filter the best design concepts, before the embodiment and detail design phases in the product design and development process. Screening and scoring deal with reducing many ideas , that have been generated as concepts during the conceptual design stage, into a smaller and more manageable set. In this work, two methods namely – PUGH chart and weighted matrix- have been used to screen the best concepts from all the available conceptual designs. Table 1 shows the PUGH Chart Method that has been used to select the best concept. In this method, all the alternative concepts are compared with the existing concepts and scored accordingly. .is adopted to finalize the automation type to be implemented in the design.

TABLE 1 PUGH CHART METHOD

	Mechanical	***Semi-Automatic Pneumatic System***	***Fully Automatic Pneumatic System***	***Electrical***
Portability	-	+	0	+
Ease of Handling	-	-	0	+
Ease of Use	+	+	0	-
Durability	-	0	0	0
Ease of Manufacture	+	+	0	-

Table 2 shows the weighted matrix concept screening method, in which the weightages are assigned to all the criteria based on their importance. An individual score is given to each criteria of a concept design and the product of the weightage and the individual score of the criteria is calculated. The concept design that has scored the maximum is considered to be the best concept. As the weighted matrix assigns weightage to all the criteria based on their importance, this method is considered to be an accurate method in choosing the best concepts.

TABLE 2 WEIGHTED MATRIX METHOD

	Weight	***Mechanical***	***Semi-Automatic Pneumatic System***	***Fully Automatic Pneumatic System***	***Electrical***
Portability	20%	4	8	0	7
Ease of Handling	30%	7	9	0	8
Ease of Use	20%	8	9	0	9
Durability	15%	9	8	0	6
Ease of Manufacture	15%	6	8	0	6
TOTAL		**6.75**	**8.5**	**0**	**7.4**

Table 3 shows the key characteristics of the individual concepts and the challenges involved in designing and implementing them. Based on the concept scoring methods, it has been found that semi automatic pneumatic system is the best concept design when compared with the other available concepts.

TABLE 3 CONCEPT SCREENING

S.No	*Name of the concepts*	*Key characteristics*	*Challenges involved*	*Ranking*
1	Semi-Automatic Mechanical System	Using Hydraulic Piston System with a Switch	Compressed fluid has to be changed	**3**
2	Semi-Automatic Pneumatic System	Using Pneumatic Piston System with Switch Control	Individual pneumatic control for adhesive and base plate	**1**
3	Fully Automatic Pneumatic System	Using Pneumatic Piston System with Closed Loop System	Control System has to be frequently calibrated	**NA**
4	Semi-Automatic Electrical System	Using Gears and Motors to generate the operating stroke	Frequent maintenance is required	**2**

The overall scores for the various automation types determined by the weighted Matrix Method are as follows:

Mechanical Motors - 6.75

Semi Auto Pneumatic Cylinders - 8.5

Full Auto Pneumatic Cylinders - 0

Electric Actuators - 7.4

The overall scores for the various automation types determined by the PUGH chart is as follows:

Mechanical Motors - -3, +2

Semi Auto Pneumatic Cylinders - -1, +3

Full Auto Pneumatic Cylinders - 0

Electric Actuators - -2, +2,

With the MPE algorithm, the pneumatic and electric actuators' final ranking is (0.78, 0.33). In the actual working field with the same working conditions, the pneumatic actuator is efficient than the electric actuator in their application [3] [4]. Therefore Pneumatic System has been chosen.

Therefore using Semi Automatic Pneumatic Cylinders is the best choice for the design of the product.

C. Pneumatic Systems:

Pneumatics is that the science and technology of pressurized air—using piped, compressed gas (or an identical gas, like nitrogen) to transmit force and energy [9].

The basic components required in the pneumatic systems are:

- A Compressor.
- A Reservoir.
- One or more valves.
- A circuit.
- An actuator or motor.

Figure 4 shows the working principle of pneumatic systems that has been used in this work.

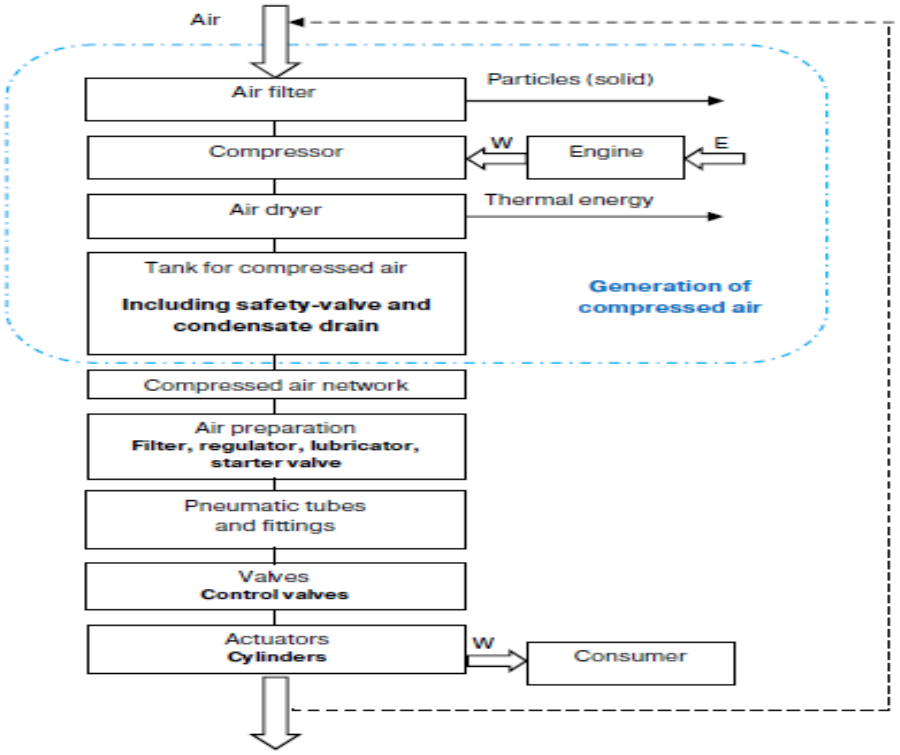


Fig. 4. Working of Pneumatic Systems [9]

The most important elements at the machine-level are:

- Cylinder.
- Flow Regulators.
- Control Valve.
- Air preparation units, short-form: FRL

D. Concept design:

Concept design is the method of illustrating the idea of the product. The main goal of the concept design is to convey a visual representation of the design or idea before it is put into the final product. Figure 5 shows concept design 1, in which the base plate moves vertically up and down by a pneumatic cylinder which is held by a separate fixture.

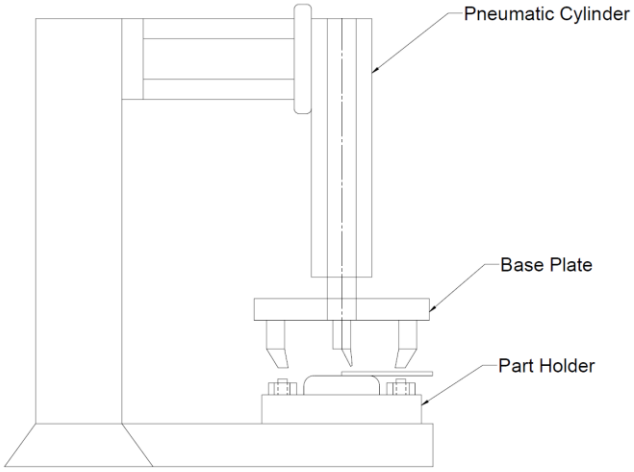


Fig. 5. Concept design 1

Fig. 6.

Figure 6 shows the conceptual design 2 , in which the work holder is fixed and the pneumatic cylinder moves lateraly from left to right by a sliding fixture with servo motors.

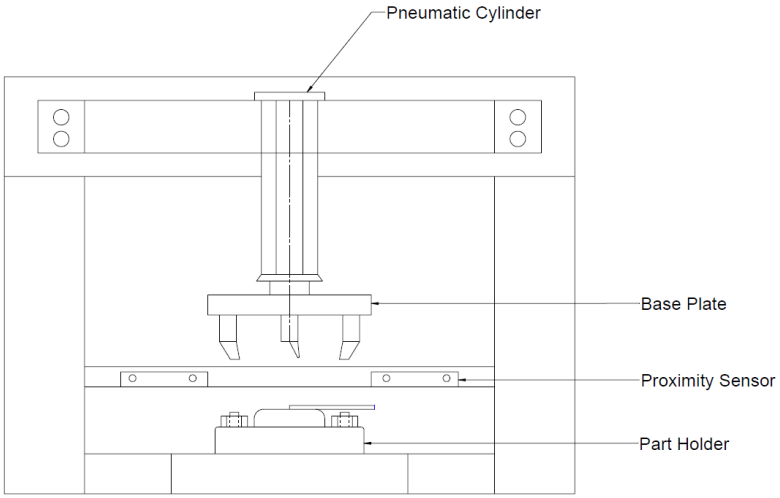


Fig. 7. Concept design 2

Figure 7 has the concept that has the base plate below an upper plate that supports the pneumatic cylinder. The bottom holder comprises of various plates and pillars which can be easily mounted and dismounted for relocation.

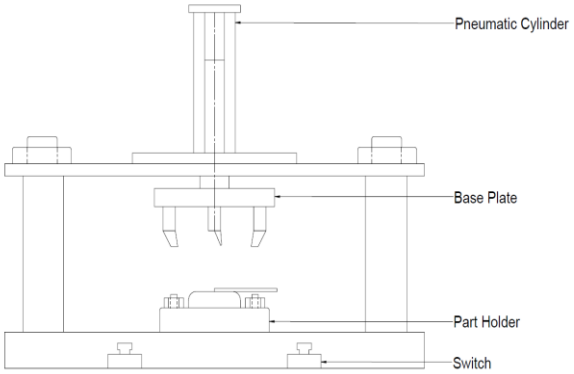


Fig. 8. Concept design 3

Considering the portability constraints and ease of manufacturing, assembly and operation, Concept 3 has been selected.

E. Concept Design:

According to Concept 3, the various components involved are:

- Fixture Plates.
- Pneumatic Cylinder.
- Dispensing Valves.
- Dispense Valve Controller.
- Adhesive storage tank.
- Pressure Control Valves

1) Fixture Plates: The fixture plates include a bottom plate to hold the workpiece and the pillars. A top plate is placed on the pillars to hold the pneumatic cylinder. A moving plate has been attached to the piston of the pneumatic cylinder in order to bring the adhesive dispensers to contact with the workpiece with minimum clearance. The fixture plates have been designed with appropriate tolerances based upon their type of fit in the assembly [5].

2) Pneumatic Cylinder: Pneumatic cylinders are used to generate motion or force for OEM equipment. They can push, pull, lift, lower and rotate by clamping them into a fixed plate. It is classified into two types, single acting cylinder and double acting cylinder. The bore diameter of the pneumatic cylinder can be chosen by the required force output. The theoretical force of a pneumatic cylinder is calculated by the formula [9].

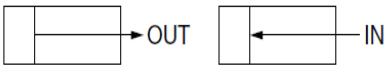
$$F = P*A \qquad (1)$$

where,

F is Force in N,
P is pressure in Mpa,
A is cross section area of bore in mm^2 .

Also the theoretical output force can be calculated using the table 4 shown below.

TABLE 4 THEORETICAL FORCE OUTPUT [10]



Unit: N

Bore size D (mm)	Rod size d (mm)	Operating direction	Piston area (mm^2)	Operating pressure (MPa)					
				0.2	0.3	0.4	0.5	0.6	0.7
20	8	OUT	314	62.8	94.2	125.6	157	188.4	219.8
		IN	264	52.8	79.2	105.6	132	158.4	184.8
25	10	OUT	491	98.2	147.3	196.4	245.5	294.6	343.7
		IN	412	82.4	123.6	164.8	206	247.2	288.4
32	12	OUT	804	160.8	241.2	321.6	402	482.4	562.8
		IN	691	138.2	207.3	276.4	345.5	414.6	483.7
40	14	OUT	1257	251.4	377.1	502.8	628.5	754.2	879.9
		IN	1103	220.6	330.9	441.2	551.5	661.8	772.1

* Theoretical outpt (N) = Pressure (MPa) x Piston area (mm^2)

3) Dispensing Valves: The dispensing valve shown in figure 9 is used for micro-shot dispensing, precision quantity of fluid dispensing etc. In order to choose the right dispensing valves the MSDS of the fluid has to be considered. The fluid type used in the system is ANABOND 124 Wicking Grade. The MSDS of the fluid is sent to the Dispensing Valve manufacturer to get the suitable type of Dispensing Valve. Nordson EFD 752V Diaphragm Valve is used in the system [8].

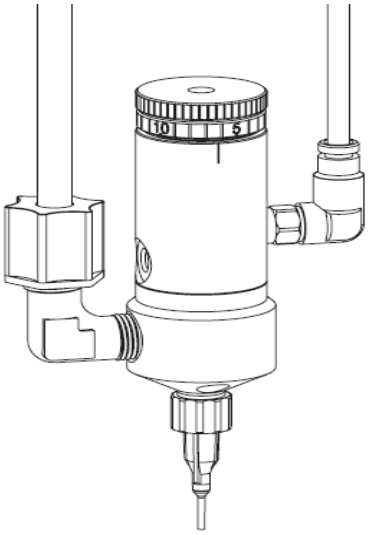


Fig. 9. 752V Dispensing Valve

4) • *Dispense Valve Controller:* In order to control the deposit size of the fluid flowing through the dispensing valve dispense valve controller as shown in figure 10 are used. Nordson EFD Valvemate 8000 has been considered in this work. Valvemate 8000 has been used in this work , as it is capable of operating up to four dispense valves independently or simultaneously.

Fig. 10. Nordson EFD 8000 Valve Controller [11]

V.PART MODELING

The modeling of the parts has been carried out by using Solidworks. The CAD files of various standard components such as pneumatic cylinders and dispensing valves have been downloaded from their respective manufacturer websites. The assembly model has been made by using Solidworks 2014 Assembly Feature. Figures 10a and 10b show the semi automatic system assembly modeled in Solidworks.

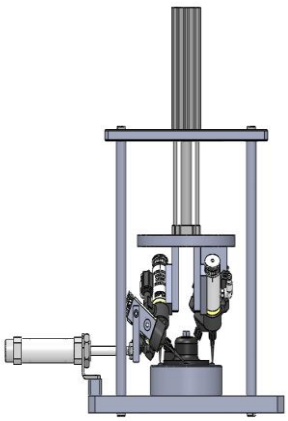


Fig. 10a. Semi Automatic System Assembly

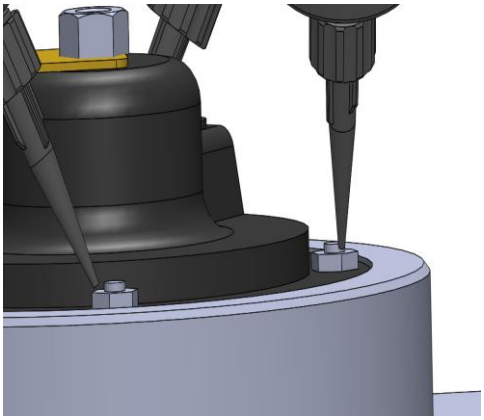


Fig. 10b. Semi Automatic System Assembly

VI. CONCLUSION

In this work, the reasons for bottle neck and reduction in productivity in operations of Vibromini horn assembly line in an industry have been identified and implementation of an automated system to overcome these challenges has been proposed. The best concept design to automatically dispense the thread locker and tuning pin marking has been designed, and chosen using the concept scoring methods like PUGH chart and weighted matrix, by assigning weightages and scores for each criterion under a design concept. Also, the cycle time comparison has been done between the manual and proposed automated work to prove that the proposed method reduces the bottle neck, improves productivity, and works efficiently than the currently used manual operation, that employs Stop Watch Observation method. The pneumatic cylinder motion simulation of the proposed system has been done using Solidworks. The results of the simulation prove that the proposed automation in the manufacturing process improves the productivity rate when compared to the manual work employed in the process, which has been followed till date in the industry.

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