Design and Fabrication of Step Feeder automation Machine for the Automobile Steering Ball joints

G M Oorappan¹, A Jeevanandham², R Sivabalakrishnan³, S. Sudhahar⁴

¹, ³ Assistant Professor, Bannari Amman Institute of Technology, Department of Mechatronics Engineering, Erode, Tamilnadu, India.
² Professor, Sri Krishna College of Engineering and Technology, Department of Electrical and Electronics Engineering, Coimbatore, Tamilnadu, India.
⁴ Assistant Professor, Bannari Amman Institute of Technology, Department of Electronics and instrumentation Engineering, Erode, Tamilnadu, India.

oorappan@bitsathy.ac.in, jeevanandhama@skcet.ac.in,
sivabalakrishnan@bitsathy.ac.in, sudhahars@bitsathy.ac.in

Abstract. Automation feeding machine helps to replace the manual feeding of the components to achieve the production rate. Even so, all industrialists have been trying to get 100% efficiency from every machine and to give more production. The production rate of the machine is depended on certain factors like feeding, accuracy, Manpower, etc. However, feeding is the most important factor, because the production will be fast only while the component is federal quick. This paper is providing an automation solution of feed ball joints for an automotive industry when the vehicle gathers the steering assembly. There were many feeding mechanisms available. Still, the ball joint is such a large component and should need a certain interval to feed it correctly as required. In this machine, the hoppers to be a trapezoidal tanks stores the sorted of long components. The two-step feeders consist of cylinders, which make the movement of steps. The steps that are used the EN-8 materials are used to make the feeder assembly, and those are connected with the cylinders that are used to construct the up and down movements, when the cylinder makes the forward and retracts motion. The steps scoop up the components and feed them to the additive chute. The linear chute transfers the properly oriented components to the singling unit feeds the components to the machine for making further operations.

Keywords: Hopper, Step feeder, Linear Chute, Singling unit, PLC.

1. Introduction
Auto feeders are the easy way to feed and use the components without any time lag. Those are low cost when compared to robots and gantry systems. From starting to end of the machine, all the works are important. Initially, the design plays a major role in any machine. It is only way to interact with company mates and analyse the problem and how to found the solution should be discussed among the team of the company. However, the solution is simple that some companies will provide it Hence this machine provides certain solution of the problem will occur during the production process[1]. Same as like, this solution named STEP FEEDER AUTOMATION (which feeds ball joints) for an automobile company.

The features of step feeder are:
Machine involve in various sections, which are designing, manufacturing and assembly, programming, wiring and finally testing[2]. Design involves (every single and every part to be carried) whole design setup. To design the feeder SOLIDWORKS software is used. SOLIDWORKS is a conceptualization-designing tool for speedily creating many industrial design concepts with unique tools for design and manipulating.

This software is only to design the mechanical components and assembly section. PLC involved another part in the machine for proper controlling. This will be very useful for understanding of control wiring. When problems occurred, a new person can solve the problem easily using this PLC[3]. For this, the work involves in addition selecting a PLC (Programmable Logic Controller), calculating the SMPS (Switch Mode Power Supply) rating and MCB (Miniature Circuit Breaker), Control panel board design, programming part. This is the replacement of manual operation with increase in safety purposes.

2. Methodology

The alternating vibrations create a motion that guidance the raw components to proceed up the steps on the inside curved surface of the feeder product machine. The downward step feeder path has been custom-made fiduciary, so it allows the components in the prearranged orientation to make it to the next process[4]. The damaged or unwanted components get back from the machine because good components will reach the proper aligned position only after the several short-circuit trips in the feeder. The energy of vibration propelling the components to go into the spiral motion more than it leaves to the downward, indeed the components of the motion defied the gravity.

![Figure 1. Block diagram of step feeder automation](image)

The above block diagram Figure 1. shows that the process flow of step feeder, where the methodology says about the working process. First, the programmed control unit controls the whole process PLC (The Programmable Logic Controller) unit controls the feeding machine. In addition, it controls the vibratory controller, sensor, pneumatics and other functional units. Since this is a closed-loop control system, it will be having a feedback for each operation these feedbacks will help to the conventional method of using power and flexible way of feeding.

Surface mounted technology (SMT) manufactures produced great no of components more than 40,000 per hour to make this many large components[5]. Conventional XY-YZ assembly machine and improved feeding mechanism by reducing the feeding distance the step feeder is involved in feeding larger components such as vacuum tubes, etc.
3. Design and construction
The design is important part of any machine because if the design part invokes any failure the whole machine will drop down. Then it have to start the work/process from starting point. Hence, thus leads to unwanted work had to done and waste of money, labour and material. In this machine, various components are to designed and some samples are provided here[6].

![Figure 2. Post- design of step feeder machine for ball joint](image)

At first, the design was made as in the Figure 3. but due to some of the problems raised like cost, space convenience, it has to change the design. So the design was made as per the picture in the Figure 2.

This step feeder is the compact ignoble noise alternative to a bowl feeding machine. In many occurrences, the components can be tooled without the aid or air such a way that the Hooper constructed in the step feeder machine. A very low filling height can be loaded manually. The components are collected from the Hooper by elevating plates; pre-sorted and feed to the top feeding technique is used to reach the desired transfer height. This system is manageable, low-cost, absorbs less power, and it be an easily operable so that the user can freely use this machine to feeding the steering ball joint in the automobile industry.
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Linear cylinders play major role for step feeding and for singling purpose. Machine has two types of cylinders one is “15 25”, the other is “60 110.”. The bigger one is used for feeding purpose. Small one is for singling. The rotary positioning pneumatic drive is used for positioning the ball joints before the singling cylinders are activated. This positioning drive is capable of higher accuracy as a servo drive does. The Filter, Regulator and Lubricator (FRL) unit is used to clean and lubricate the air inlet to the cylinders. This FRL unit is capable of regulating 50mpa of an air inlet. The valve terminal series is a combined unit of 5/2 valve. This valve terminal used in this machine consisted of series of 10 5/2 valves.

PLC is one of the main electric devices used to control the whole machine set up. It has two couples of 17in 17out PLC to control the unit. An eight channel relay system is capable of switching lines to control the unit as per the PLC program command is given. There will be six relay channels is used in
this setup. The fuse ac and dc are used to save the sensors from higher frequency since the machine works at 460-volt supply. Table.1 shows the important devices of step feeder and their specification details.

| S.No. | Important Device of Step Feeder | Specification | Size of the Components |
|-------|--------------------------------|---------------|------------------------|
| 1     | Bowl                           | Capacity in litre | 5                      |
|       |                                | Discharge height in cm | 17                     |
|       |                                | Width of track in cm | 18                     |
|       |                                | Track pitch (Spiral Distance in cm) | 8                      |
|       |                                | Bowl weight in kg | 9                      |
|       |                                | Total Discharge height in cm | 82                     |
|       |                                | Fixing | Central |
| 2     | Level Controller               | Inductive Sensor diameter in cm | 1.2                   |
|       |                                | Operating voltage | 10-30 VDC or 90 – 250 VAC |
|       |                                | Capacity of the sensor | 130mA or 200mA         |
|       |                                | Total cable length in cm | 150                    |
| 3     | Drive Units                    | Drive unit height in cm | 6.5                    |
|       |                                | Drive unit diameter in cm | 6                      |
|       |                                | Pitch between mounting/No. of bores | 40/2                   |
|       |                                | Drive unit weight in kg | 8                      |
|       |                                | Rating in Amps | 4                      |
|       |                                | Length of connection cable in m | 4                     |
|       |                                | Vibration frequency | 100Hz                 |
|       |                                | Protective casing | Steel                 |
| 4     | Base Plate                     | Plate Diameter in cm | 21.8                   |
|       |                                | Position of control box mounting in cm | 12.5               |
|       |                                | Fixing hole centre in cm | 14                     |
|       |                                | Plate height in cm | 2.3                    |
| 5     | Top plate                      | Plate Diameter in cm | 40                     |
|       |                                | Plate height in cm | 53.5                   |

The fuses are categorized as AC & DC for typical sensors. The variable frequency drive is used to drive the whole units’ power supply and controls the sensor power supply too. A switched-mode power supply (SMPS) is used to convert the AC to DC in a way to control the power level of supply from the main supply. The vibratory coil will provide vibration for the linear shoot to move the components from step to singling unit. It has 110-volts for this coil. The terminal blocks are used to connect the sensors, PLC, relay channel, SMPS, etc.

3.1 Determination of the bowl feeder force:

The assembly of the bowl feeder contains two main parts, a conveying element with a trapezoidal(T) form and a supporting cylindrical(C) element. Both parts are linked by springs and they are uniformly spread around their rotational axes $y_T$ and $y_S$. Three flat spring packages are used here. Three flat spring packages are used here. Each package was inclined by an angle $\beta_{TC}$ to the axis plane. It had its stiffness, and the total values of all springs packages were interpreted as $k_{TC}$. The total damping coefficient was specified by $b_{TC}$.

The conveyancing element was described by its mass $m_T$ and by its moment of inertia $J_Ty$ around rotational axis $y$. The supporting element had mass $m_C$, the moment of inertia $J_Cy$, and it was placed
on springs with total stiffness $k_{CRx}$ and $k_{CRy}$, and with total damping coefficients $b_{CRx}$ and $b_{CRy}$. The entire mechanism was settled with a rigid connection to the frame.

The movement of the bowl feeder mechanism can be characterized with help of four coordinates, two translations $y_N$, $y_S$ and two rotations $\varphi_{Ny}$, $\varphi_{Sy}$. The relative movements of both parts are defined:

$$y_{TC} = y_T + y_C$$  \hspace{1cm} (1)

and

$$\varphi_{TCy} = \varphi_{Ty} - \varphi_{Cy}$$ \hspace{1cm} (2)

In these aims, four differential equations specifying the movement of the bowl feeder system can be written:

$$m_T y_{TT} + F_{bTCy} + F_{kTCy} + F_{VM}\cos\beta_T = F_{TC}$$ \hspace{1cm} (3)

$$I_{y\varphi_{Ty}} + M_{bTCy} + M_{kTCy} - r_{VM}F_{VM}\sin\beta_T = 0$$ \hspace{1cm} (4)

$$m_C y_{TC}^2 + F_{CRy} y_C - F_{bTCy} + F_{CRy} y_C - F_{kTCy} - F_{VM}\cos\beta_T = -F_{TCy}$$ \hspace{1cm} (5)

$$I_{Cy\varphi_{Cy}} + b_{\varphi_{CRy}}\varphi_{Cy} - M_{bTCy} + k_{\varphi_{CRy}}\varphi_{Cy} - M_{kTCy} + r_{VM}F_{VM}\sin\beta_T = 0$$ \hspace{1cm} (6)

Where force $FVM$ is a connection force between the conveying part and the supporting part, which is transferred by the joint mechanism of both parts. Force $F_{TCy}$ is the exciting force between the conveying part and supporting part.

4. Working principle

Auto loader is to load the components to the grinding machine. The machined components are drawn from it and finally load to container box. The detailed operation of an auto loader is involved through the gravity feeder, escapement valves, and conveyor. Initially, the components are loaded in the gravity feeder only[9]. The name itself indicates that, it feed the components to the conveyor with help of gravity. According to Newton's gravity laws, the components with certain mass always attracted towards the ground. The gravity feeder is at the angle of 40°, through the sliding force one by one the components will come to next position. In the gravity feeder, the guide strips are provided to avoid external problems and easy adjustment for varying lengths of components loading conditions[3].

To control the components to be fed on conveyor, escapement valves are used. Escapement valves are acts as a blocker of whole remaining components. In auto loader, machine consists of two escapements. These two escapements are operated with cylinder performances, which are controlled by PLC.

Auto loader consists of three conveyors are in-feed conveyor, Out-feed conveyor and External conveyor. All these conveyors are used to transfer the component from one place to another[10]. In-feed and out-feed conveyor is of round belt conveyor, uses an induction motor for running with help of pulley & the External conveyor is the flat belt type. Figure 5. Shows the finalized manufacturing machine of stepper feeder automation of ball joint. The already loaded component in the gravity feeder is fed to the conveyor through, the escapements' sequence the sequence as follows.

Escapement 1-up → Escapement 1-down [all components in the gravity feeder stepped down to one-step].

Escapement 2-up → Escapement 2-down [a single row of aligned components fed to the conveyor].

The above-mentioned sequence will operate with help of proximity inductive flange type sensor. After the components are in the conveyor crossed the sensor, the next sequence starts. The proximity sensor is also placed in out-feed to verify all the components arrived or not.
Singling unit is a functional mechanical unit where the ball joint is positioned and pushed to final location of the feeder, this is done by two singling cylinders and a rotary cylinder.

Initially, the testing components are arranged on the gravity feeder in a proper manner. In this machine, there was the operation is controlled by two modes, which are manual and auto.

The operation type is selected by switch the specific mode. If the operation is in manual mode, the parts moment of the machine is controlled by the human with the help of HMI screen. If the operation is in auto-mode means to click cycle start option only on the HMI screen. The escapement 1 and escapement 2 are used to allow the testing components to the conveyor by the alternative up and down moments of the escapement cylinders.

![Figure 5. Finalized manufacturing machine of step feeder automation](image)

Apart from designing, assembly plays a crucial role in working of machine. If mechanical components must be fitted according to design. The error may happen at machining or in design, the assembly section finds the problem occurred and also to discovery a suitable solution for the problem. This problems and solutions are discussed later.

In this machine, three components are used. Those vary according to the diameter namely 10 mm, 12.5mm & 25mm. For each diameter size the guide way to be varied. Actually, the auto loads' component to the grinding machine for this purpose guide way is provided and also for better accuracy. The guide consisted of the strip provided with slot.

Spacer in the guide way is used to align the centre of in-feed and out-feed with grinding machine spacer in escapement cylinders is used to hold the components according to size as mentioned.
Escapement is to be changed according to component size. This is provided because if escapement is same for all means can damage the component.

5. Result and Discussion

This paper presented problems occurred during the testing of an auto loader. From all problems mentioned below are identified with the help of repeating testing and evaluation of the research manner. When the components fed from a row to the conveyor through in the sideway escapement, single component or more than one turns and fell into the conveyor in wrong direction. The space between gravity feeder and conveyor is varied (about 4mm distance) when the adjusted the conveyor, the problem vanished. In a row, there will be four components, but only three components will fall down to the conveyor, and one stuck in gravity feeder causing escapement error in HMI. After this problem, identified a bur in the edge of gravity feeder. This problem will also occurred if distance between the slide-way strips is uneven. Some component contains oil, adhesion problem existed. The components should not be grouped together while feeding.

For same position, the length of the round conveyor uneven belt helped to escape the components from the row. Rework took place. For many components, the rework is done [for example, Guide-way of 12.5 mm, escapement spacer of 25 mm, nylon strip (hole misaligned). Torque is not enough to pull the loaded components in conveyor, stacking of three or four components in the conveyor itself. Increase the length of in-feed conveyor.

This paper is give the solutions for the all researched problems of the machine after the continuous testing and at last machine is completed and successfully finalized.

6. Conclusion

In this paper, a conceptual foundation for automatic step feeding machine for ball joint has been presented. The framework introduces feeding aspects that cover how production is increases in automobile industry, and how the feeding process can be conducted for steering ball joint mechanism. The demonstrated work is expected to raise the reactiveness of automobile production companies, in terms of reducing the development time of production systems and Manpower.

The essential focus of the paper is to express how automatic step feeding mechanism can be sequence’s ball joint, for which a sensing-based matchmaking procedure is used to conduct the identification of the steering wheel. Through the designs provided in this paper, the technological approach is rowed to be a satisfied approach to the modelling ball joint feeding mechanism, since it equips the modelling of constraints between abilities and proposal’s continuous incorporation of steering wheel mechanism. Future work will be concentrated on stretching the capacity model for different parts feeding, together with implementation of the matchmaking procedure. Furthermore, since the modeling approaches only been used to design part feeding resources, further research has to be highly organized to corroborate the innovative approaches against other types of resources.

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