IMPLEMENTATION OF STAGING AUTOMATION SYSTEM FOR METAL INJECTION MOLDED PARTS

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Abstract: Automation is the prime key for the next generation of Industrial work, i.e., Industry 4.0, and based on this, research work has been done on automatic staging of metal injection molded parts in the work cell. Existing work procedure consists of man power for staging of components but the industry requirement is a fully automated working cell. The prime motto is to make work effective and faster without any errors. An important factor to be considered is precise staging of the components where it should not get affected during the next two processes. By taking all these factors into consideration,a new design for automatic staging of components has been done. The design comprises of Robotic arms, shuttle system, conveyor belts, EOAT's etc. Hence without affecting the present working cycle time of the machine, an automatic staging of the components is designed and implemented for the working cell.

Keywords:MIM, Fixtures, Shuttle,Delrin, EOAT (End of arm tool), Cycle Time.

1. INTRODUCTION

The MIM (Metal Injection Molding) process combines the design flexibility of plastic injection molding with the strength and integrity of wrought metals to offer cost effective solutions for highly complex part geometries. The MIM process is typically explained as four unique processing steps (Compounding, Molding, De-binding and Sintering) to produce a final part that may or may not need final finishing operations.

Compounding: Fine metal powder less than 20µ particle size is blended with thermoplastic and wax binders in precise amounts.

Molding: Injection molding is identical in equipment and technique to how plastic injection molding takes place.

De-Binding: De-binding is a process where the binder materials are removed from the molded component

Sintering: The de-binded parts are placed on ceramic setters which are loaded into a high temperature, atmosphere controlled furnace.

Finishing: Depending upon final requirements, certain finishing operations may be performed to the sintered part.

Literature Review

[1]J.M.Mallon: This research involves the process that has identified that sensors to detect parts passing underneath other robots were to be installed to prevent parts from being placed one on top of the other and also to avoid possible robot crashes. It was also identified that robots can package beside each machine but the conveyors require a lot of floor space and inhibit access to the molding cells unless they can be put overhead, in which case they are difficult to service and clean, and parts may not be easy to see. It was then concluded that conveyors to a certain location are best used for similar parts, large parts or easily distinguishable parts that will not require or cannot justify the costs of added-value operations. So, for small parts, air conveyor systems were implemented where the parts were sent to the packaging room or machine in an air stream. Parts were made to eject into a hopper that directed them into a tube and then into the air stream. An air vacuum transport system was designed to size the largest expected part size where a maximum part size of 30mm is common. It was also made sure that the system transported the parts without getting marked or damaged, and also without tangling or causing blockages in the tubes. Hence, the system was designed in such a way that it requires modest floor space and labor.

[2] Neha Sindhe: "Design and Implementation of Robotic Arm based on Haptic Technology":This involves designing a haptic robotic arm, which can be used to pick and place the4 object. In this paper a robotic arm with four degrees of freedom is designed and is able to pick the objects with a specific weight and placed them in a desired location. To facilitate the lifting of the objects, Servomotors with a torque of 11kg are used. The programming is done on ATMEGA-328 Microcontroller using Arduino programming. The input is given using a remote, which is an arm, made of polycarbonate fitted with potentiometers with a certain angle of rotation. The potentiometers detect the angle of rotation and the signals are sent to the Microcontroller accordingly.

[3] Abhishek Chavan: “The Development of Six D.O.F. Robot Arm for Intelligent Robot**”:** The motion is guided by the manually operated controller or a program that guides the appropriate motion and actions of robot. The degrees in which the robotic unit make moves or acquires motion necessarily contribute to improvement of operation. Every added or updated motion represents ease of operation in certain operating context. Hence, the idea that a circular rotatable base may prove very useful as it is less costly and less time consuming for an assembly to rotate rather than to turn it. Care should be taken that this provision does not hamper any other DOF previously considered.

[4] Anmol Jain:“Image processing and Recognition System for a Robot Arm Control”:Image processing (IP) and recognition system is based on continuous monitoring of environment with sensors and responding accordingly. These are considered intelligent as their behaviour is completely based on changes in environmental system and triggered associated programmed action.

Purpose of Study:

The purpose of study which research work hasbeen adopted in the project is that, the designed automation fixture is a gravity oriented fixture and shuttle system to meet the scope of the project which is to mainly reduce man power and also to achieve the cycle time. Here, the production linearity by automatic staging of the parts and also, reduction in damages caused due to human intervention, is achieved. Hence, the machine idle time is also reduced. Research design work includes implementation of two SCARA (4-axis) robots and a two-way shuttle system working in opposite directions, to achieve the required cycle time. Also, a 6-axis robot is being used with a newly designed EOAT (End of Arm Tool) holder for picking and placing the work components into the shuttle fixture.

2. METHODOLOGY

After a lot of trial and error work done to the initial designs, research work hascame up with the final design whichhas a design of a shuttle system which comprises of shuttle track, two cylinders, fixture (Aluminium material fixture) and a frame.

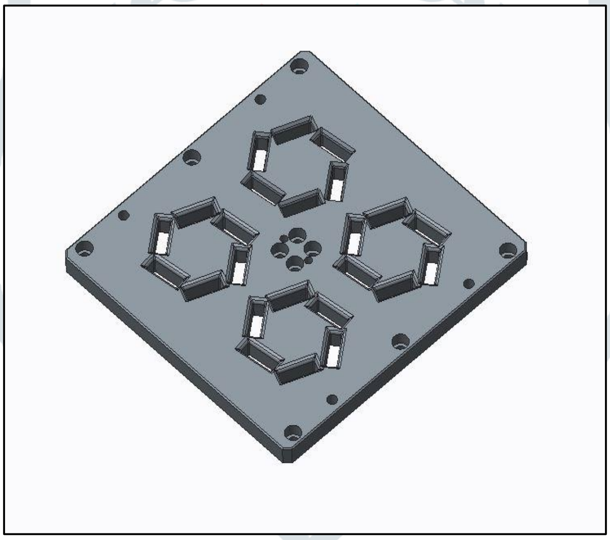


Figure 2.1 Staging Fixture Design

The figure 2.1 shows the design of the fixture cavity that is adopted in the shuttle system. The primary robot picks the molded parts and places them on these cavities as shown in figure2.1. Once the parts gets placed on the fixture, the parts flip and stand vertical in the cavities of the fixture, and flipping takes place due to gravitational force.

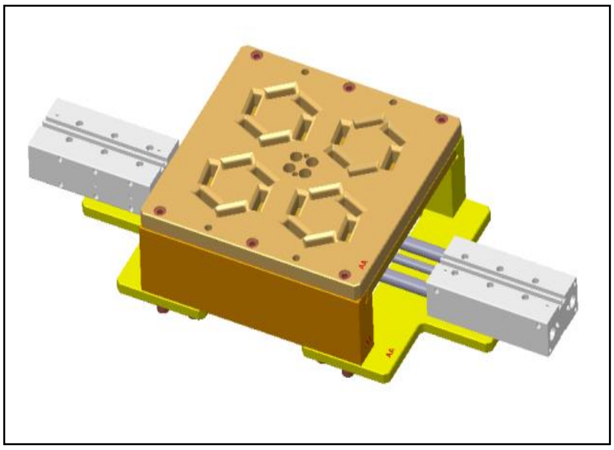
Hence, this is the methodology being used in the design and further processing of the molded parts. Once the part gets flipped into the cavities, the secondary robot will pick them and place them in order with an orientation, on the ceramic plates.

Before implementing the shuttle system, there were approximately 70,000 parts (TRW parts) that were being manufactured in a day, by running the molding machine for 22.5 hrs per day. But, after implementing the shuttle system, the molding machine can be run for 24 hrs without any second thought and by doing so more number of parts can be manufactured per day.

Thus, work done in 26 days, by the machine, before implementing the shuttle system, can be done in just 19 days after implementing the shuttle system. Therefore, the number of parts produced monthly is thereby increased by implementing the shuttle system.

3. EXPERIMENTAL WORK

3.1 Design of Shuttle system along with Staging Fixture



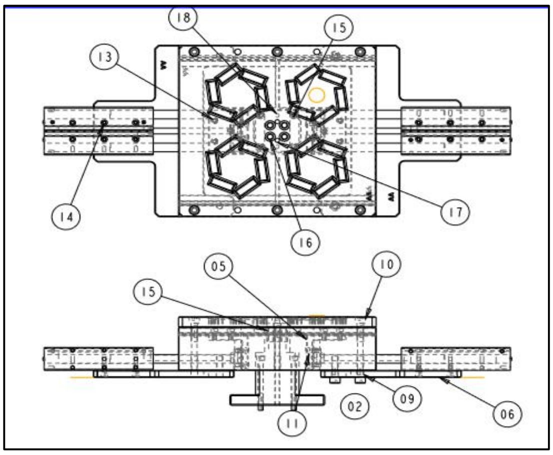


Figure 3.1(a) Staging Fixtures and Sliding plates**Figure 3.1(b)** 2D View of Fixtures & Sliding plates

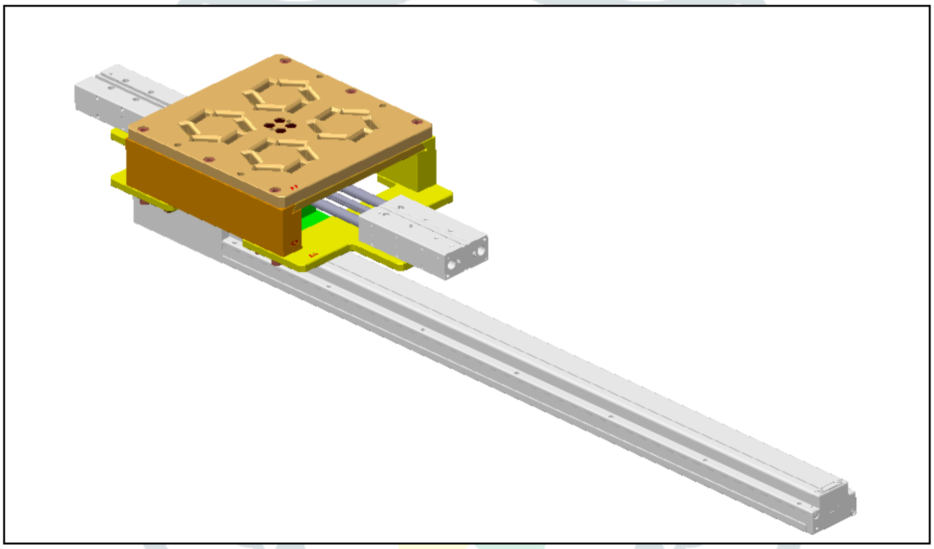


Figure 3.1(c) Shuttle System

The figure 3.1(a) represents the design of staging fixture and sliding plates and its isometric view of staging fixture and sliding plates are represented in figure 3.1(b). The shuttle system assembly is represented in figure 3.1(c)

3.2 Experimental Setup

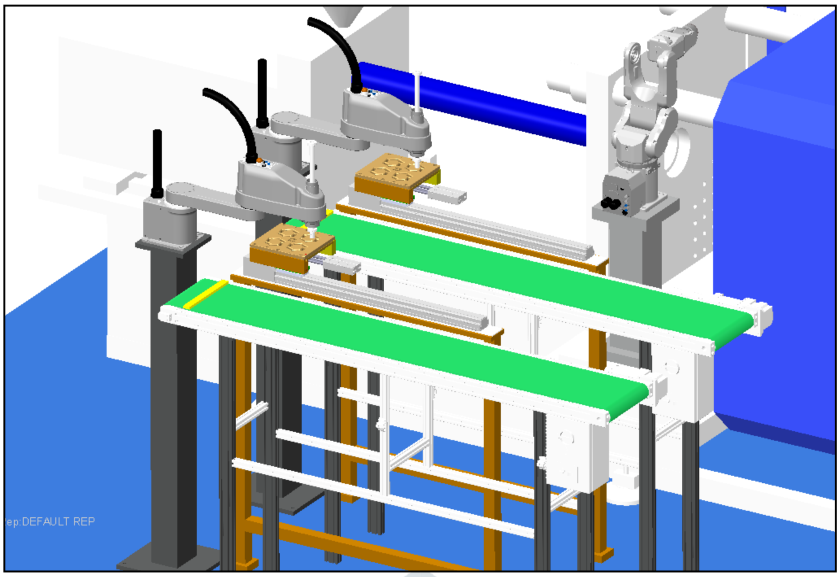


Figure 3.2(a) Cell layout design for experimental setup

3.3 Working Procedure

The working procedure of experimental setup is as follows:

- At first the main robot will pick the molded parts and places it on the staging fixture.
- Staging Fixture assemblyis been mounted on shuttle system.
- Once the parts are molded, the primary robot picks and places it on the fixture.
- Soon after the parts are placed, the shuttle gets activated and moves the fixture to secondary robot unit where staging of the parts are done.
- Once all the parts are been staged a cleaning shot takes place for easy ejection of any left out components inside the mold cavity and thus the shuttle moves back to its initial position to receive the next molded parts .
- During this the main robot will place the molded parts on the second Staging fixture.
- After placing on the second fixture, the shuttle system moves towards the secondary robot for second level of staging of molded parts.
- After unloading the shuttle will go back to its initial position and will be ready to take up the next mold shot for staging purpose.
- Here we have implemented one primary robot and two secondary robotsand two shuttle systems for automatic picking,placing and staging of mold parts in order to reduce the human intervention and to achieve the cycle time.

3.4 Material Selection for Staging Fixture and Sliding Plates

The different parts of the shuttle system are made of different materials. Most of the parts are made of standard material while some parts are made of particular materials.

The main advantages of using aluminium for these above listed parts are:

- Aluminium is easily available.
- It is of less cost compared to other materials.
- Since the parts being handled are green parts, hence they must be handled with care and thus aluminium is found safe to be used.
- Aluminium can be machined easily.
- It has good electric and thermal properties.

The material being used for the slide plates is Delrin material.

Delrin is a crystalline plastic which offers an excellent balance of properties that bridge the gap between metals and plastics and offers unique properties. Delrin possesses high tensile strength, creep resistance and toughness. It also exhibits low moisture absorption. It is a high grade raw material, hence the fixture manufactured will be having long lasting range of components, which gives high durability as well as high functionality.

The main advantages of choosing Delrin over other materials are as listed below:

- Delrin is easily machinable compared to Mild steel.
- Since the parts that are being placed on the fixture are green part, they are required to be handled easily and safely with care. Hence materials like mild steel cannot be used and thus, we are using Delrin material.
- Delrin also has good electrical and dielectric properties.
- It has resistance to chemicals.

- It possesses good impact strength compared to other materials.
- Compare to mild steel Delrin is heat resistive material.
- Delrin is wearresisting, hence it gives longer lifetime.

Hence, after lots of survey, we have concluded to use Delrin material for the slide plates designed.

3.5Calculations

Part 1: Cycle time calculation

1. Time for molding and placing of parts from mold cavity to fixture = 14 sec
2. Movement of shuttle from Primary to Secondary Robot= 1 sec
3. Speed of shuttle = 1 m/sec
4. Staging of parts :-
   Trial 1: Single part at a time = 2 sec
   Trial 2: Two parts at a time = 2 sec

   Therefore in Trial 1 the overall staging of 24 parts used to take 48 sec.

   Hence we implemented another griper in such a way that 2 parts were picked at a time and staged in 24 sec.
5. Overall required cycle time = 28 sec
   Hence we have achieved the cycle time.
   Achieved cycle time = Cycle time for staging + Shuttle movement
   = 24+2
   = 26sec

Part 2: Reduction in man power

Before implementation of shuttle system:

1. Previously with the help of man power per shift, number of workers = 4
2. total workers required/day= 4* number of shifts
   = 4*3
   = 12 members
3. Per head salary = Rs.15000/month
4. Total salary of 12 members = Rs. 15000 * 12
   = Rs. 1, 80,000/month
5. Salary of 12members per one year = Rs. 1, 80, 000 * 12
   = Rs. 21, 60, 000p.a.

After implementation of shuttle system:

1. Cost of one Robot = Rs. 6, 00,000
2. Cost of two Robots = Rs. 6, 00, 000 * 2
   = RS. 12, 00, 000
3. Now per shift only one member is required
   Number of members required per day = 3
   Therefore Salary for three members = Rs. 15, 000* 3
   = Rs. 45, 000/month
   Salary of 3 members per year = Rs. 45, 000*12
   = Rs. 5, 40, 000p.a
   Therefore amount saved in one month = Rs. 1, 80, 000-Rs.45, 000
   = Rs. 1, 35, 000/month
   Amount saved in one year = Rs. 21, 60, 000-Rs. 5, 40, 000
   = Rs. 16, 20, 000p.a
   Therefore here amount saved per annum is profit to company.

Part 3: Production cycle rate

Before implementation of shuttle system

1. Number green parts molded per day = 70, 000(approx)
2. Molding hours per day = 22.5hrs/day
3. Number of parts produced in one month = 20,00,000(approx)
4. Number of days required to produce 20lakhs parts = 26days

After implementation of shuttle system

1. Number green parts molded per day = 70, 000+
2. Molding hours per day = 24hrs/day
3. Number of parts produced in one month = 20,00,000

Number of days required to produce 20lakhs parts = 19days

4.RESULTS

4.1 Production Cycle

Before and after implementation of automatic staging system for metal injection molded parts:

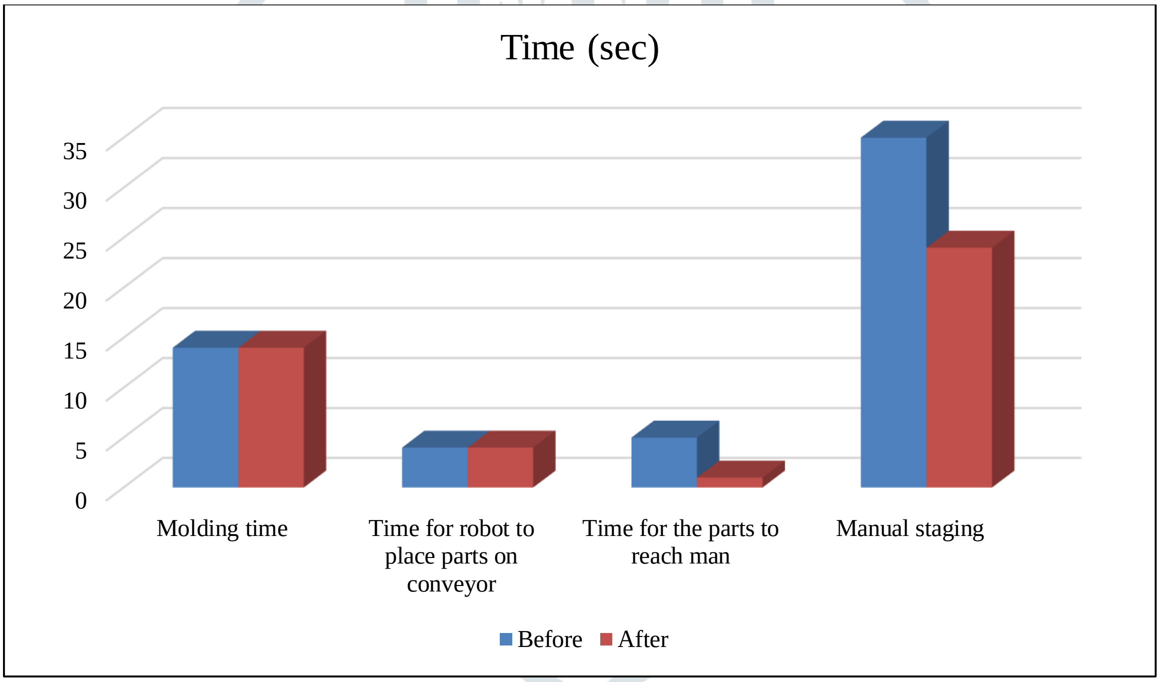


Figure 4(a) Time vs. Various processes

5. CONCLUSION

According to the company requirement, the research work is purely based on "Design and fabrication of External fixtures for Automatic staging of work components".

The following are the conclusions that can be drawn from this research work:

- Error identification in theworking cell and cell layout was done.
- The research work conceptualized the final design of fixture based on trial and error methods as well as literature review.
- This led to the automation in the industry which in turn reduced the human intervention. Also, cycle time was achieved.

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References

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[1] J.M.Mallon, design of air vacuum transport system to size the largest expected part size within the given maximum range of the parts size, and also using sensors to prevent parts from being placed one on top of the other.
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[4] Anmol Jain, Image processing and recognition system for a robot arm control, by continuous monitoring of the environment with sensors and responding accordingly.