Quality Defects Inspection System

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Abstract - The goal is to create a QDI system with a marking system that is based on an electrically controlled sensor. The automated visual inspection system that replaces human knowledge in continuous, round-the-clock inspection is the main component of the enhanced quality flaws system. Our project's key goals are to boost efficiency while reducing the amount of human labor required. A human inspector will be slower than a machine, susceptible to fatigue, unable to maintain a high level of error trapping for extended periods of time, and inconsistent across inspectors. In contrast, a vision system may work continuously and moves more quickly on average than a human. These systems are extremely reliable.

***Key Words*:** QDI system, Defects, Human labour, Vibration, flash and the surface finishing sensors.

1.INTRODUCTION

Quality defects inspection system is multipurpose quality inspection unit in which various sensors selected to detect the error, stepper motor to rotate the part. This unit in our project will involve for quality inspection parameter checking system such as color of the part, dimensional stability, gas and burn marks, flashing and gloss of the parts. In this system piezoelectric vibration sensor selected to check the mechanical stability of part, light dependent sensor for flash and bun marks on product, and surface finishing sensor for surface and flow lines on parts. These all sensors detect their respective defect, when part is mounted on stepper motor and rotate in specific angle, where sensors sensing zone and after detecting all defects, part goes under the marking system. Multipurpose quality marking unit will make use of the heat treatment to mark on readily molded plastic parts. These marks should be long life in nature with no additional quality damage to the parts. If the part will not ok and QDI system detects them, marking system won't mark on it. Here in marking system, we use various mechanical components like flexible aluminum coupling to rotate the lead screw mechanism and give linear movement or upward and downward to heat insulation has Quality mark die which is linked with leadscrew

2. LITERATURE REVIEW

Automated Vision Inspection System for a Plastic Injection Mould Component R Deepa, S Usha, P V Shashi Kumar, Automated Vision Inspection System for plastic Injection Mould Component 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) December 12th–14th, 2014, The present invention relates to an Automated Vision Inspection System for a plastic injection mould component in which they have used high resolution cameras. The AVI systems comprise of camera, lighting, optics and the application software to make precise detection and classification. The application software is based on processing the images acquired with the camera and as such these automated visual inspection systems are built for specific application. In an automated visual inspection system for detection and classification of defects encountered in production of molded plastic products was presented. Algorithms were developed for detection of the shape defects like flash and short molding and surface defects like jetting in Carty and welding lines. Shape defects were identified with boundary tracking, calculations of pattern vectors followed by comparison with the prototype. Surface defects were identified with differential gradient operator and local gray-scale inhomogeneity for line detection and spot detection respectively. The core idea of this work was to develop an automated vision-based defect sorting and inspection system for a plastic injection moulded component called a retractor retaining bush (shown in Figure 2.1), which is an automotive component. The retaining bush is a component with complex shape and is produced at the rate of 2000/hr. and currently the components are being inspected manually at the rate of 18000- 20000 components/ day necessitating the use of such an automated system. The proposed work is challenging because of the complex shape of the component and the various types of defects which the component can encounter. About 250 good samples and 250 defective samples were tested to ascertain the reliability and validity of the developed algorithms to variations in the nature of defects and its effectiveness in the factory environment where there will be environmental changes which could affect the performance. The performance of the defect identification system is about 10% of the total defective components were classified as good components. This false classification is mainly due to the limitation of the system. in identifying the smallest defect. Keeping in mind the industry requirement, the cost factor and the low frequency of occurrence of such small defects, the system had to be designed with a minimum tradeoff on the accuracy of the defect identification system. Using cameras with higher resolutions to cater to defects of smaller sizes is expected to improve the accuracy of the defect identification system. The inspection rate of the vision system is 2 components/ sec. This paper presents an automated vision-based defect inspection and sorting system for the retaining bush. The retaining bush is a plastic injection mould component which develops various types of defects during its production. This system is able to capture defects like partial part, component discoloration, burn marks, flash etc., which generally occur in an injection mould component. System can be tuned to include other surface defects like porosity which occur due to injection moulding. Algorithms for detection and sorting of defective components and measurement of the critical dimensions were developed. A vibratory feeder and linear feeder were integrated with the vision system for part presentation. A Graphical User Interface was developed for operating the system. Various types of sensors and actuators were interfaced with the vision hardware and the part handling mechanism to complete the total automated vision-based inspection system for defect inspection and sorting of the retaining bush.[1]

CNN-Based Defect Inspection for Injection Molding Using Edge Computing and Industrial IoT Systems Ha, H.; Jeong, J.CNN-Based Defect Inspection for Injection Molding Using Edge Computing, Appl. Sci. 2021, 9 July 2021, the proposed model of overall architecture is composed as shown in Figure Image data are acquired by means of a vision camera that scans the photographing unit and sends it to the edge box. The defect inspection is done in the edge box. If a defect is detected, the number of the defective cell is transmitted to the PLC, which plays the role of removing defective products from the PLC. Image data are acquired using lighting and a GigE vision camera. Lighting minimizes how much the difference between day and night affects quality inspection. It is configured in the form of a conveyor belt that connects the rails in a cylinder. The advantage of these rails is that the product to be inspected is rotated while the product is being inspected so that one can inspect the quality of all surfaces of the object rather than one. In system design, the product is inspected twice, improving the existing deep learning inspection method by means of CNN. Figure is a picture of the product taken by the vision sensor on the rails. The algorithms done in the edge box. First, when a raw image comes by means of the vision sensor, it is cropped as an image of a product for defect detection. Then, it does defect detection and finds out how many times the product in the cell was defective. These data would be transferred to the database via the cloud. Finally, it communicates with the PLC. If the time from the n-th cell to the discharge port is calculated and transmitted to the PLC, the defective product is discharged in the final quality inspection. They designed the automated system. Current inspection process, the worker manually inspects the product. But after the invention it showed more than 90% accuracy.[2]

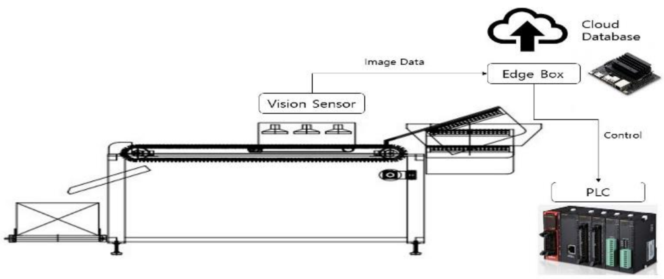


Figure 1: CNN-Based Defect Inspection for Injection Molding Using Edge Computing and Industrial IoT Systems

Mechanical vibrations, 3rd edition, V P Singh, 423–426. In order to build an appropriate spring for vibration fault analysis in a QDI system, we investigated the fundamentals of helical springs as well as their overall stresses and dynamic properties.[3]

Design machine element, V B Bhandari, Fourth Edition, 397-399. To choose the best and most appropriate material for the spring component, we have investigated essential material characteristics and material structure.[4]

3. Poke Yoke System

The word "mistake-proofing" or "inadvertent error prevention" is poka-yoke in Japanese. Any process device known as a poka-yoke serves to aid a machine operator in avoiding errors and flaws by forewarning, correcting, or highlighting human faults as they happen. Shigeo Shingo included the idea in the Toyota Production System, formalizing it and adopting the phrase. Poka-yoke was previously known as poka-yoke; however, because this word also implies "fool-proofing" (or "idiot-proofing"), the name was altered to poka-yoke. Poka-yoke is an abbreviation for poka-yoke, a phrase used in shogi and go to describe avoiding an absurdly terrible play. In a broader sense, the phrase can apply to any constraint that shapes behavior and is built into a process to stop users from performing actions inadvertently.

4. IMPLIMENTATION IN MANUFACTURING

Poka-yoke can be used at any point in the production process where something could go wrong or an error could be made. As an illustration, a fixture that holds pieces for processing may be changed to only permit pieces to be held in the proper orientation, or a digital counter might track the amount of spot welds on each piece to make sure the worker performs the right number of welds. For detecting and preventing faults in a mass manufacturing system, Shigeo Shingo identified three different varieties of poka-yoke. By examining the product's form, size, color, or other physical characteristics, the touch approach can detect product flaws. The operator is warned using the fixed-value (or constant number) approach if the required number of moves are not performed. switch. Whenever a spring persisted.

- Identification of the need
- Identification of possible mistakes
- Management of mistakes before satisfying the need

5.Quality Defects in Plastic

Production in Industry Professionals in quality control often divide quality flaws into three categories: minor, major, and critical. Which of the three categories a fault falls into depends on its type and degree. The number of each kind of defect that importers are willing to accept in their final goods is up to them. The number of units per SKU that an inspector would check during an inspection would depend on this tolerance.

6.1 Minor Defects

Minor defects are usually small, insignificant issues that don’t affect the function or form of the item. In most cases, the customer wouldn’t even notice a minor defect on a product. And the customer wouldn’t likely return an item due to a minor defect alone. Importers often set the highest tolerance or AQL, if applying that standard for minor defects in their inspected sample size. But an item can still fail inspection if the number of minor defects found exceeds the limit set by their tolerance.

6.2 Major Defects

Significant differences between major and minor flaws. A product with a substantial flaw differs materially from the buyer's requirements. Major flaws are ones that may negatively impact a product's performance, functionality, or aesthetic. The client may easily identify these flaws. And in reaction to these flaws, a consumer is likely to return the item, complain, or ask for a refund. In their examined sample size, the majority of importers established a lower limit for significant problems than minor errors. They frequently accept orders with just a few significant flaws. But if there are too many serious flaws detected during inspection, they're likely to reject an order or ask their supplier to postpone it or fix it.

6.3 Critical Defects

Of the three defect classes, critical faults are the most dangerous. Critical flaws render a product utterly useless and/or put the user or others in the area at risk of damage. Businesses are seriously at danger of product liability difficulties, litigation, and product recalls as a result of these flaws. Due to this danger, many importers have a "zero tolerance" policy for key order problems. In many cases, if a single serious flaw is discovered during product inspection, the entire order will fail.

7.TYPES OF QUALITY DEFECTS IN PLASTIC MOULDINGPRODUCTS

Depending on the materials used, the manufacturing procedures, and the standards used, various quality flaws might occur in various goods. The examples of minor, major, and critical flaws in various product kinds are shown below.

SR. NO	TYPE OF DEFECT	APPROPRIATE SENSOR
1.	VIBRATION DEFECT	PIEZOELECTRIC VIBRATION SENSORFOR VIBRATIONS
2.	FLASH DEFECTS	LIGHT DEPENDENT SENSOR
3.	BURN MARKS	LIGHT DEPENDENT SENSOR
4.	SURFACE FINISHING DEFECT	SURFACE ROUGHNESS SENSOR

Table 1. Defects and Sensors

7.1 Vibration Defect

Due to the different materials of each product, it is often the case that defective products may occur during the injection moulding process. For example, vibration marks often appear on rigid plastic products, comes extra mass on surface like curve surface which gives a result as vibration. For this defect we have selected piezoelectric sensor.

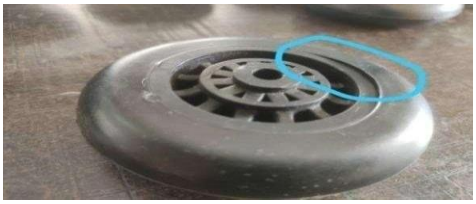


Figure 7.1 Vibration Defect

7.1.1 Piezoelectric Sensor for Vibration Defect

In essence, it has been chosen to identify vibrations in the plastic moulding product, which is the plastic wheel used in transportation bags, and to find a suitable solution. The piezoelectric sensor is another name for the vibration sensor. These flexible sensors are used to measure a variety of operations. This sensor converts changes in acceleration, pressure, temperature, force, or strain into an electrical charge by using the piezoelectric effects. By instantly determining capacitance and quality, this sensor is also utilized to determine airborne smells.

7.1.2Working Principle

The vibration sensor is a sensor that uses various optical or mechanical principles to detect system vibrations, according to its operating principle. These sensors typically have sensitivities between 10 and 100 mV/g, while lower and greater sensitivities are also available. Depending on the application, the sensor's sensitivity can be chosen. Therefore, it is crucial to understand the range of vibration amplitude levels to which the sensor will be subjected during measurements.

7.1.3How Vibration Sensor Works

Three fundamental forms of vibration have been chosen for measurement: displacement, velocity, and acceleration. Displacement sensors track changes in the distance between the spinning component and the fixed housing (frame) of a machine. In order to measure displacement, displacement sensors use a probe that threads into a hole that has been drilled and tapped in the machine's frame, right above a spinning shaft. Contrarily, velocity and acceleration sensors measure the velocity or acceleration of the element to which they are connected, which is often an outside machine frame component.

Figure 7.2 Piezoelectric sensor

7.2 Flash Defect

Flash, commonly referred to as burrs, is an excess polymer melt that appears as a thin lip or rim at the product's edges. It is visible because molten material overflowed the designated flow channels and into the space between the cavity plate and core plate. Flash is often subtle, but it is regarded as a serious flaw in products that are readily apparent. Moulds that are not properly clamped are a primary cause of flash. Flash is also a result of extremely high injection pressure and mould temperature. During production, there was a significant flash flaw at the barrel portion, as demonstrated in the failure of the mould separating surface, insufficient clamp force, excessive melt temperature, and flow limitation for additional cavities in a multi-cavity mould are all potential causes of flash. The main way to avoid flash is to use more clamp force. When some molten plastic escapes from the mould cavity, flash is a fault in the moulding process. The separating line or ejector pin placements are typical escape routes. As the extrusion cools, it stays affixed to the final product. Flash can happen when the mould is not tightly held together (with enough force to withstand the opposing forces created by the molten plastic flowing through the mould), allowing the plastic to leak out.

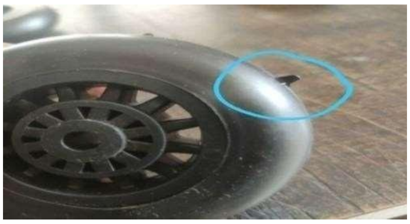


Figure 7.3 Flash Defect

7.2.1 Remedies

To guarantee that the mould components stay closed during shoots, increase the clamp pressure. Make sure the mould is maintained and cleaned correctly (or replaced when it has outlived its usefulness). Adopt ideal moulding circumstances, such as the correct gas vent, injection pressure, mould temperature, and injection speed.

7.3Burn Mark

Burn marks are generally appearing as dark colored staining on a face or edge of a moulded plastic part, which seems to be burned. Burn marks generally do not affect part integrity, except that the plastic is burned to the extent of degradation. In injection moulding the entrapped air may cause a small explosion due to the compression of air and polymer vapor, so this is called as diesel effect. Because of this the tool will erode and plastic parts are ejecting with burn marks. Well-designed proper venting system can give the good filling of mould and required injection pressure will be maintained by lowering of counter pressure. Burn marks are discolorations, usually rust colored, that appear on the surface of the injection moulded prototypes.

7.2.1 Remedies

- Reduce injection speeds.
- Optimize gas venting and degassing.
- Reduce mould and melt temperatures.

7.4 LDR Sensor for Flash Defect and Burn Mark

The LDR Sensor Module is used to measure light intensity and detect the presence of light. In the presence of light, the module's output increases, while in the absence of light, it decreases. Using a potentiometer, the signal detection's sensitivity may be changed. The Light Dependent Resistor (LDR), as the name suggests, is made of an exposed semiconductor material, such as cadmium sulphide, whose electrical resistance changes when light strikes it from several thousand Ohms in the dark to only a few hundred Ohms. The overall result is an increase in conductivity with less resistance and lighter. Additionally, it takes a photo resistive cell several seconds to react to a change in the intensity of the light. Lead sulphide (PbS), lead solenoid (PbSe), and indium antimonite (InSb), which detect light in the infrared spectrum, are materials used as semiconductor substrates. Cadmium sulphide (CdS), however, is the most widely utilized of all photo resistive light sensors. Since its spectral response curve closely resembles that of the human eye and can even be adjusted using a simple torch as a light source, cadmium sulphide is employed in the production of photoconductive cells. Therefore, it typically has a peak sensitivity wavelength (p) in the visible spectral region between 560 and 600 nm.

7.4.1 Features

- Can detect ambient brightness and light intensity
- Adjustable sensitivity (via blue digital potentiometer adjustment) Operating voltage 3.3V-5V

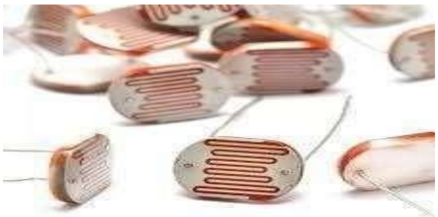


Figure 7.4 LDR Sensor

This is a 5 mm-sized light sensor whose resistance alters in response to the amount of ambient light that hits its surface. An LDR, also known as a photo-resist or light dependent resistor, is a sensor whose output fluctuates in proportion to the amount of light it receives. The resistance of the LDR reduces as the amount of light falling on it rises, making this form of LDR the most prevalent. In other words, the resistance is inversely proportional to the amount of light falling on the LDR. When it comes to automated outdoor light ON/OFF switches or indoor automatic light switching, LDR (Light Dependent Resistor) photocells are an ideal choice of photocell type. The sensor functions optimally in both darkness and light.

7.4.2 Advantages and Disadvantages of LDR: -

- The frequency response (the ability of the device to detect the fast-changing optical signals) is very low.
- The internal photoelectric effect has nothing to do with the electrodes that are; DC power supply can be used.
- The linearity of photoelectric conversion under strong illumination is poor.
- The frequency response (the ability of the red-light dependent resistor to detect the fast-changing optical signals) is very low.
- It is affected heavily by the temperature and has a low response speed. The delay time between MS and S is affected by the illumination of the incident light (photodiode has no shortcomings, and photodiode sensitivity is higher than LDR Sensor), which is a consumable material.

7.5 Surface Defect

Visible defects on the surface of a moulded part appear as dull, glossy, or hazy areas, or as a rippled surface, called orange peel. Common points of occurrence include near the sprue or behind sharp edges in areas away from the sprue. The mould and the moulding process are the best places to seek out and identify the causes of these effects. As we can see lots of flow marks are on surface of wheel as shown in fig 6 Enabling quick and easy inspections of surface profile within a regular coordinate measuring machine (CMM) program, the Profiler miniature roughness.

Figure 7.5 Surface Roughness Sensor

Figure7.6 Flow Lines in Part

8. SELECTION CRITERIA

8.1 Motor Selection

- Stepper motor selection Torque 48 kgmm

  Nmax 4000 RPMV12V (DC)

- Moment of inertia about y- axis Iy=1/4m (D1^2/4+ 12/3)

  0.125*(75^2/4+20^2/3)

  Iy= 48.11 kgmm

- Toque = I × A (Acceleration Rate) A =0.05 rev per sec T = 48.11 × 0.05 = 2.4055 kgmm
- Motor shaft Selection = Motor shaft diameter = 6mm
  Wheel inner diameter = 6mm
- Helical compression spring design:
  Coil diameter (d): - 1.5 mm

Length of spring: - 40 mm No. of coils (N): - 3 Inner diameter: - 21 mm Outer diameter (D): - 25 mm Pitch: - 11 mm

- Stiffness of spring (K) = Weight on spring / Deflection

- Deflection = 8D^3N / Gd^4
  = 50.4 mm
- Total wt. on springs (P): - 3 N

- Stiffness (K) = 3 /50.4
 = 0.059 N/mm^2

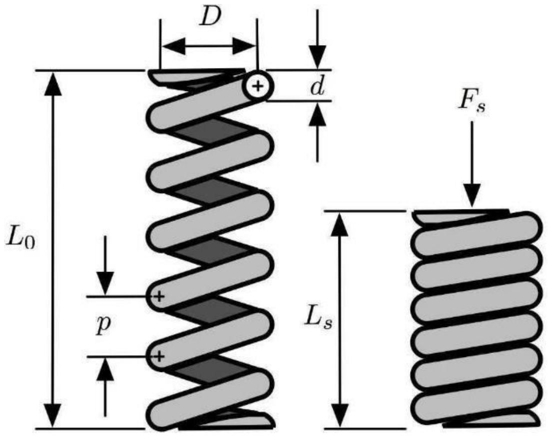


Figure 8.1 Schematic of Spring

9. ANALYTICAL CALCULATIONS OF VIBRATION

ω= √k/m **(Ref V.K Singh, Mechanical**
Were, **Vibrations)**
ω= Angular velocity K= Stiffness of spring= Mass of wheel

1. For Wheel First= 0.5 NK = 0.014
   ω = √ (0.014/0.5)
   ω = 0.1673 rad/sec
   ω= 2πf
   f= (ω/2π)
   f= (0.1673/2*π)
   f= 0.026 Hz (Only for single spring)
   f= 0.1065 Hz (For All Four Spring)

2. For Wheel Second= 0.4 NK = 0.014
   ω = √ (0.014/0.4)
   ω = 0.1870 rad/sec
   ω= 2πFf= (ω/2π)
   f= (0.1870/2*π)
   f = 0.029 Hz (Only for single spring)
   f= 0.116 Hz (For All Four Spring)
3. For Wheel third = 0.55N
   K = 0.014
   ω = √ (0.014/0.55)
   ω = 0.1595 rad/sec
   ω= 2πF f= (ω/2π)
   f= (0.1595/2*π)
   f = 0.025 Hz (Only for Single Spring)
   f= 0.1015 Hz (For All Four Spring)

So, Frequency range of vibration for standard wheel is from 0.1015 Hz to 0.1160 Hz.

- **Practical Reading: -**

M= 0.5 N
K = 0.014
ω = √ (0.014/0.5)
ω = 0.1673 rad/sec
ω= 2πf f= (ω/2π)
f= (0.1673/2*π)
f= 0.026 Hz
f= 0.1065 Hz

10. Observation Table

Sr. No	Mass of Wheel (N)	Analytical reading (Freq Hz)	Practical reading (Freq Hz)	Remark
1.	0.41	0.1106	0.1100	OK
2.	0.52	0.1044	0.1051	OK
3.	0.63	0.0948	0.0952	Not OK

11. Conclusion

While concluding this report, we feel quite fulfil in having completed the project assignment well on time, we had enormous practical experience on fulfillment of the manufacturing schedules of the working project model. In this project accuracy has been approached of the identifying the several kinds of defects in the product within a 20 sec with high accuracy. Problem proofing and inspection is done better than previous has been achieved at least 30% accuracy through system.

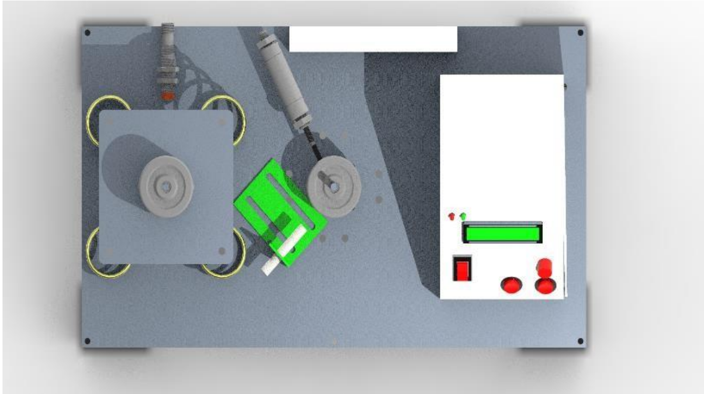
13. Future Scope

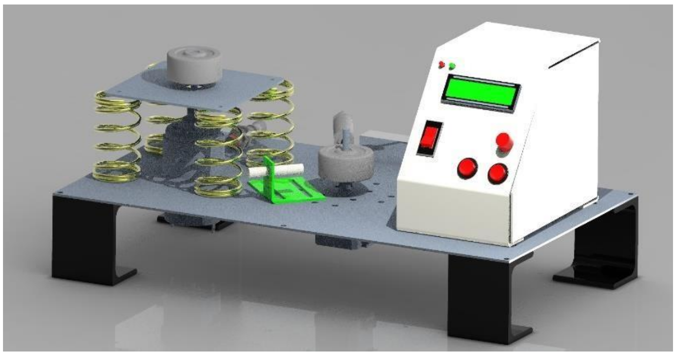
Quality defects inspection system for the injection molding parts, this system which designed to make, avoid frequently production losses due to improper way of quality checking. We can do much automation in the system in future, such as following points

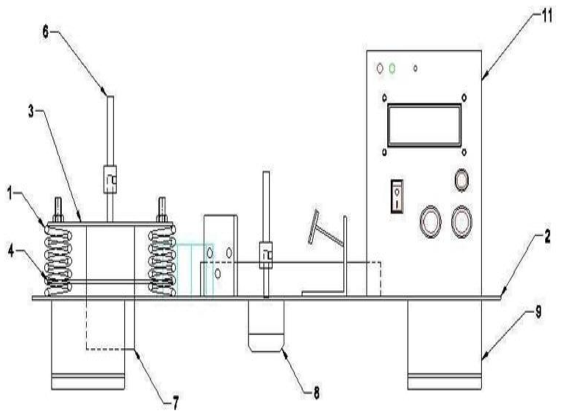
- To maximize quality checking rate and to shorten the cycle time, we will have to change in program, and will make program appropriate according to requirement
- If there is other plastic part and it has more and complicated defects, we can add respective sensor and we can use high

resolution camera for better quality checking.

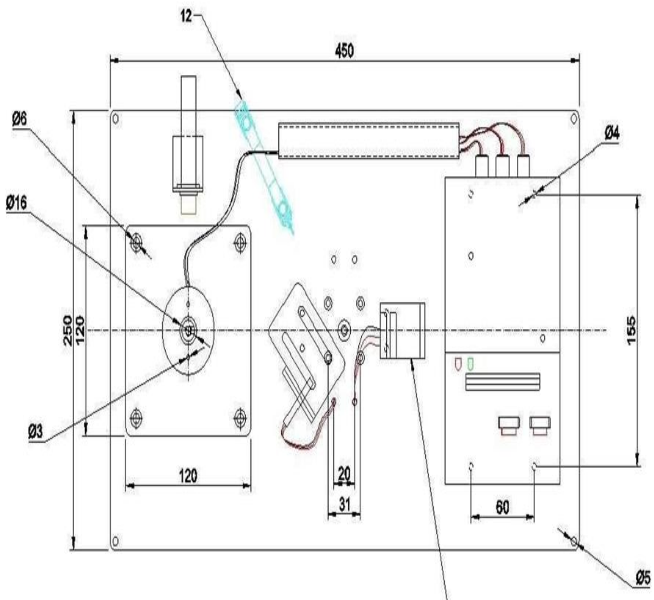
- For easy handling of product and flow of mass production will become fast, we can do automation here in that conveyor, robotic arm etc.
- According to structure here of any plastic production we can change die of OK mark in marking system.
- Design and development of marking system using PLC programming







FRONT VIEW



TOP VIEW

14. REFERENCE

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