Pneumatic Inspection Fixture For Pump Housing Component Using Industrial Plc

Akhilesh BG[1], Kishan Doss[2]
[1]Automation Engineer, Dept of Automation
[2]Director- Operations, Dept of Automation
[1, 2] Searock precision Products Pvt. Ltd., Bangalore, Karnataka.

Abstract- *This research paper focusses mainly on the inspection fixture designed for the K-type pump housings using industrial PLC. The PLC of the fixture uses air pressure as a feedback to inspect the features and dimensions of the part. The purpose of this project is to identify the features of the part and measure the critical dimensions before it reaches the customer. Even though there are gages to identify and measure the dimensions, performing inspection activity over a span of approximately 200 individual parts may lead to operator fatigue. Thus, resulting in rejected parts reaching the customer. Hence, in this project, a stage-wise inspection fixture is conceptualized and designed by identifying critical dimensions and features in the K type part. These concepts are initially proven out by soft machining the fixture to finish dimensions. The position and size of the air holes are drilled in accordance with the features and the dimensions. Analysis has been performed for load bearing shafts. Since, the pump housing has numerous features, designing only a final inspection fixture will not suffice the requirement. Furthermore, immediate identification of the problem is necessary to reduce the scrap or rework. The PLC is programmed using Ladder Logic and master gauges are manufactured to get the pressure count difference between OK and NOT-OK parts. Two master gages are closely machined to lower and higher tolerance limit respectively, with the aim of calibrating the PLC for the both the values and thus creating a bandwidth. The parts that pass in the inspection fixture give a pressure count well within the bandwidth. Anything above or below the pressure count bandwidth is considered as a NOT-OK part. This achieves the main objective of identifying NOT-OK parts*

Keywords- Automated inspection fixture, Industrial PLC, Fuel Injection Pump, Casting, Turning, Sparking, Pneumatics.

I. INTRODUCTION

I. A pump is a mechanical device that converts mechanical energy into fluid energy. Pump housings are casts that simply house the pump. The basic function of the pump is to accept fluid at the inlet with low pressure and sending it through the outlet with high pressure. The pump housing dwells all the components of the pump.

II. Various fuel injection pump are manufactured and assembled at Bosch. These pumps are classified under PFR series of pumps as follows-

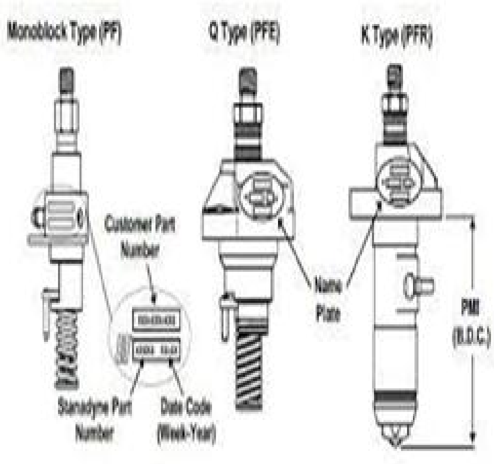


Fig1. Types of fuel injection pump housings

- Mono Block
- Q type
- K type

The project was conducted on K type fuel injection pump housing component. This pump housing component is assembled widely in portable diesel-powered water pump and in commercial vehicles such as ISUZU.

III. CONSTRUCTION OF K- TYPE INJECTION PUMP-

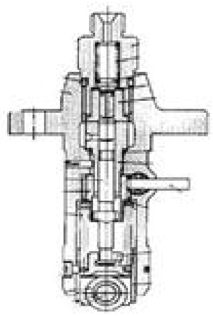


Fig 2. Construction of K- type injection pump.

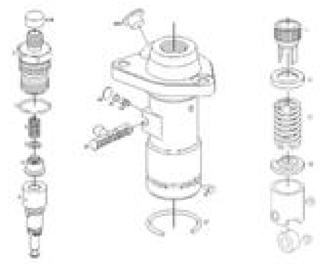


Fig 3. Exploded View of K- type injection pump.

The pump consists of the following parts-

1) Pump Housing
2) Name plate
3) Delivery valve
4) Delivery Valve Holder
5) Plunger
6) Barrel
7) Eccentric pin
8) Roller tappet
9) Fuel inlet
10) Lock Ring

The Function of these parts are as follows-

- **Pump Housing** – Supports the various parts of the pump.
- **Element**- Pressurizes the fuel oil to the required pressure and also regulates the quantity of the fuel. It acts as the piston-cylinder arrangement for reciprocating pumps.
- **Compression Spring**- Provides the required pressure for the pump.
- Fuel Inlet –Provides the fuel for the pump.
- **Delivery Valve**: Allows the flow of oil from element to nozzle in one direction only and its opening & closing is controlled by its own spring.
- **Delivery Valve Holder**: Used to connect the high-pressure fuel line to the pump and to hold the pump elements & delivery valve in the pump housing.
- **Control Rod**: Used to control the flow of fuel inside the cylinder.

IV. WORKING OF K- TYPE FUEL INJECTION PUMP-

This Diesel fuel injection pump works just like the engine combustion process. The fuel gets in the cylindrical space of the housing through fuel intake valve. Then it is pushed to the nozzle at pressure of 750 bar approximately by the plunger. The plunger is of the size – 9mm diameter and 10cm in height. It reciprocates with the help of helical spring which works by the effect of cam follower on the cam shaft. The pressure of the fuel reduces to 300 bar only when it reaches to nozzle for atomization into very fine particles.

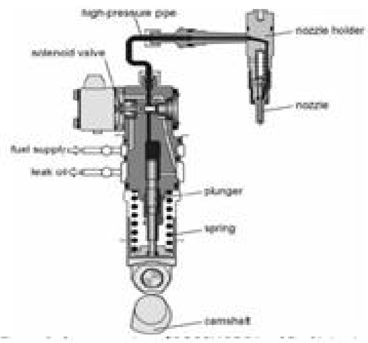


Fig 4. Working of a standard K-Type fuel pump

V. MACHINING STAGES.

The final part is the outcome of different machining stages. Different characteristics are machined in different machines. They are however generally categorized as Turning1, Turning 2 and VMC. The characteristics pf a sample part X162 machined in each stage is as follows

- **CNC-1 (Turning 1)**
  - Outlet thread core drilling
  - Outlet thread tapping
  - Element bore drilling
  - Element counter bore drilling
  - Element seat
  - O- ring bore drilling
  - Fuel chamber drilling
- **CNC -2 (Turning 2)**

- RT bore drilling
- Pinion bore drilling
- RT bore recess drilling
- Hub diameter turning
- Grooving
- Spigot Diameter turning
- Hub chamfering
- Flange face surface finishing

- **VMC Machining**

  - Mounting Hole drilling
  - Mounting Hole Spot facing
  - RT lock hole drilling
  - RT lock hole counter bore drilling
  - Element lock hole drilling
  - Element lock hole counter bore drilling
  - Boss milling
  - Inlet hole drilling
  - Inlet hole spot facing
  - Inlet hole threading
  - CR bore drilling

- Further stages of machining include-

  - Slitting
  - Deburring

The entire factory layout is designed according to this machining stages and they are divided into different zones.

The machined part after the deburring operation is then transferred to Final Inspection, where the parts are visually analyzed, and inspection checkpoints are marked OK or NOT OK before transporting it to the customer.

VI. PROJECT METHODOLOGY

After careful study of the characteristics of the fuel pump housing as well as the operations performed at each stage, different ideas were brainstormed for the automated inspection fixture such as computer vision, pneumatics using Arduino board, pneumatics using PLC. After thorough discussion with the mentor and peers the abovementioned Pneumatics Using PLC was employed as the most reliable and pocket friendly concept. The project is carried out according to the 4-step process of automation –

- Understand the process
- Hardware and software required
- Develop ladder logic for PLC
- Determine the scan times and memory requirements

VII. THEORY OF PNEUMATICS USED IN INSPECTION FIXTURE.

During the first few weeks of understanding the operations performed and the different features of the components, it came to notice the use of different gauges used by the quality department. Various gauges such as:-

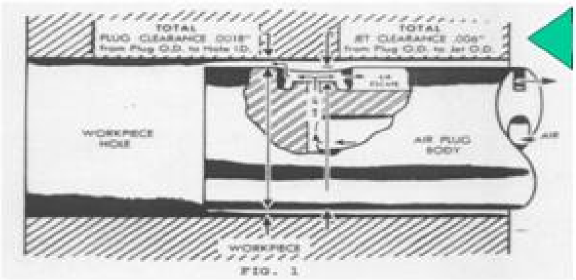


Fig 5. Principle of Air Gauge

- the plug gauges, [GO, NOGO]
- air probes,
- dial gauges,
- snap gauges,
- screw pitch gauges
- thread gauges

With further brainstorming, the concept of using the combination of principles employed in air probe or air gauge and the plug gauges was adopted. he air probe (also referred to as an air plug gage, air spindle or mandrel) consists of a precision ground hardened steel body incorporating two or more air gage nozzles. Air is passed through the probe body to the nozzles where a back pressure is produced by the surface of the workpiece. An air gauge readout (air comparator) senses the resulting back pressure and displays the size of the workpiece.

As shown in the drawing, the nozzle tips are recessed a small amount below the body of the probe. This feature makes the air gage measurement essentially non-contact, consequently wear does not directly affect the accuracy of the gauge measurement. Moreover, the flow of air purges the gaging surface of contaminants making the measurements highly reliable.

Using the opposed set of nozzles, the measurement is made independent of how the operator positions the probe radially within the test bore. This “differential” type of measurement makes it possible to obtain highly accurate measurements with limited operator skill.

Air probe styles vary depending on how close the air jets are to the leading edge of the probe body. "Thru-hole" style probes have gaging nozzles located near the center of the probe body. "Blind" or "Super-blind" probe styles have nozzles located near the leading edge.On the same line of thought, the inspection fixture was employed in 3 different stages namely,

- CNC 1 Inspection fixture
- CNC 2 Inspection fixture
- VMC inspection fixture

VIII. CNC 1 INSPECTION FIXTURE

In the CNC 1 operation as mentioned above certain critical dimensions is needed to be measured. Among these the element seat height is the most critical parameter. This feature is measured only after the CNC 2 operation and not after CNC 1 fixture even though the operation is performed in the latter. Hence, to avoid this an inspection fixture which accurately measures the element seat height is required. Initially a simple piston cylinder setup was thought. Furthermore, the experiment was conducted using a simple pneumatic cylinder and a piston coupled to it. The element seat diameter is 18.4 mm; hence the coupler was deigned to be 18mm with the clearance of 0.2mm on either side. During the operation there are some remnants of chips even after thorough flushing. When the coupler hits the surface of the element seat with a pneumatic pressure of 3 bar, it was found that there were dents formed. The dents are shown in the following images-

Fig 6. Dent indentations on Element seat

The initial fixture consisted of O- ring diameter step measures the diameter of the O- ring bore. The material used was soft mild steel.The initial set up is illustrated in the following images: -

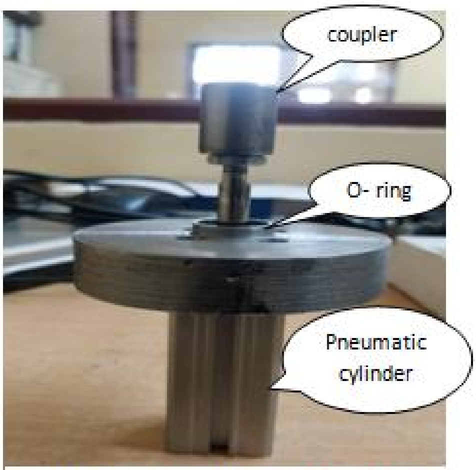


Fig 7.- Initial setup in extension position

Since this method resulted in dents on element seat, a different method was to be deigned. In the seconddesign, the element seat height from the butting surface was initially recorded for 30 parts. The max height was found to be 30.23mmand the minimum value was found to be 30.02 mm. The idea was to restrain any kind of contact to the element seat. Therefore, the principle of air gauge is used. Here, the fixture is designed in such a way that there is always some clearance between the element seat surface and the air jet. The following image will give a better understanding of the fixture.

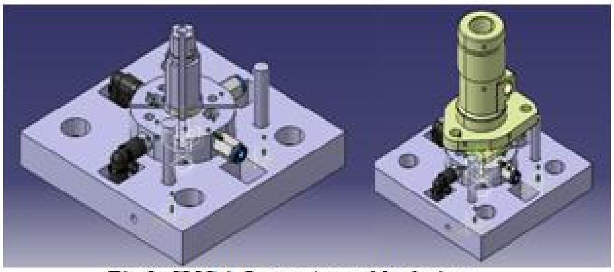


Fig 8. CNC 1 fixture Assembly design

The following drafting specifies the dimensions and the geometrical tolerancing.

In the above drawing, the following points were kept in mind during the designing

1. The run-out is maintained at 0.01 w.r.t A so that the concentricity is maintained in the overall fixture. To maintain the concentricity, centering drills are also provided.
2. Under- cuts are provided so that there room even if there is no chamfer provided.
3. Chamfer at the entry of the feed pump housing is provided.

4. Grinding surface finish is provided for the outer diameter as well as the surfaces.
5. The turning dimensions are such that there is always a clearance between the surface of the component and the fixture to make room for the air jets to give feedback.
6. Furthermore, the air holes are to be provided for the compressed air to enter the fixture. The air is to be maintained at a specific pressure. Here, it was maintained at 3 bar pressures to get the feedback reading in the PLC.

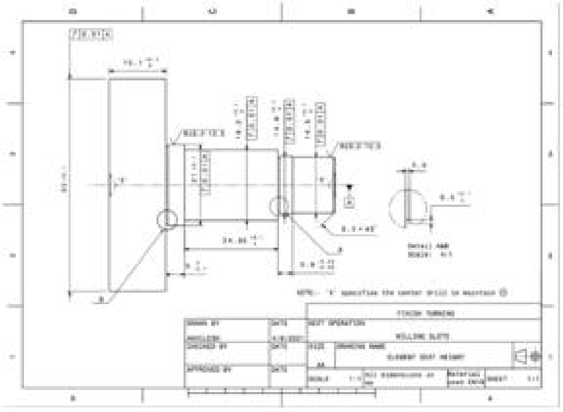


Fig 9. Finish turning dimensions

As seen before all the holes are through holes. It has been observed in other inspection fixtures, through holes give an accurate reading, since the measurement is for the determination of the diameter. In this fixture, the air inlets are coupled with JANATICS one touch fitting air inlets. The models used are straight fittings and elbow fittings wherever necessary. These fittings have M5 thread and are provided in the perpendicular sides of the 55mm diameter shaft for better ergonomics. However, the inlet of the air is perpendicular at least one point. Most of the air jets are drilled as through holes. The bottom end of these holes is blocked with the help of grub screws. Proceeding further, the air jets are of 1.3mm diameter and are stepped up to 3.3mm diameter and then to 4.2mm (M5 thread). This is to ensure better laminar flow at the outlet. In this fixture, as mentioned earlier, the element seat height is a critical parameter. To measure it however, only a land of 3mm is available in the mandrel. A max of 0.8mm hole can be drilled on the land. However, this cannot be done in the conventional VMC since the drill bit has the tendency to slide at the indentation thereby not achieving a accuracy of straightness. Hence, another method of drilling called sparking was employed.

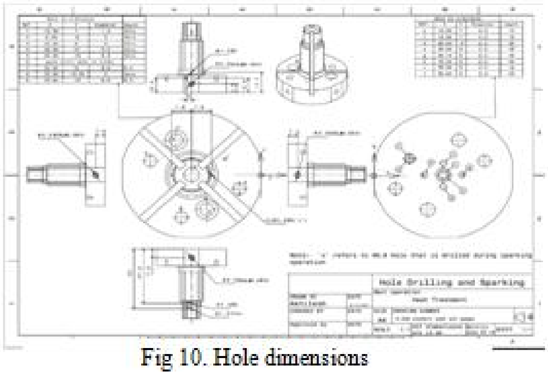


Fig 10. Hole dimensions

In this fixture 0.8mm drill was sparked to a length of 6mm; Beyond this length, the hole was to be stepped up to 2.5mm diameter. This caused another problem. If the axis of the 0.8mm hole and the 2.5mm hole were in line, it would result in the 2.5mm hole going beyond the wall of the mandrel. Hence, the axis of 0.8mm hole and the 2.5mm hole are at an offset, such that the circumference of both are tangential to each other such that the 2.5mm hole is pushed towards the center axis of the mandrel.

As discussed in the principles of air probes, once there is an injection of air inside the workpiece and since it is initially a blind hole, a path for the air to escape out is necessary. Hence the slotting operation was performed as shown in the image. The slots are mutually perpendicular as shown in the image. The purpose of this

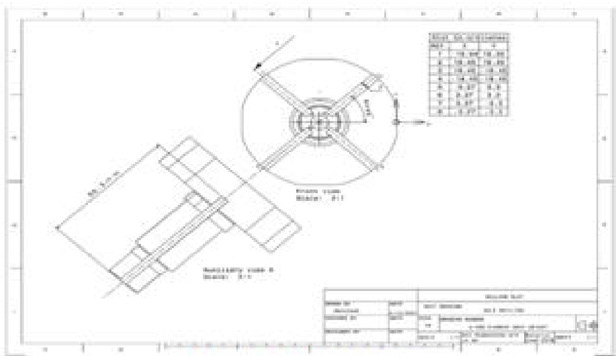


Fig 11. Slot dimensions

project is to achieve accurate dimensions thereby reducing the chances of the rejected component reading the customer. In the concept of air probes, a common error called the DIFFERENTIAL BALANCE ERROR is observed frequently. Balance error is an effect where the gauge does not measure the true diameter of the part. The phenomenon of the error is show in the Fig 13.

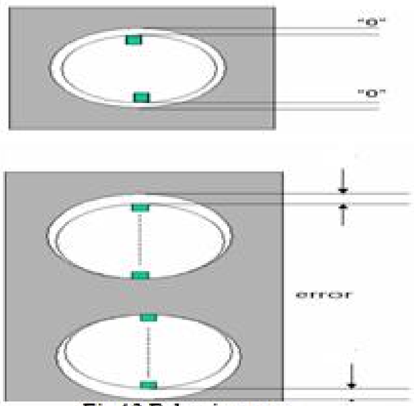
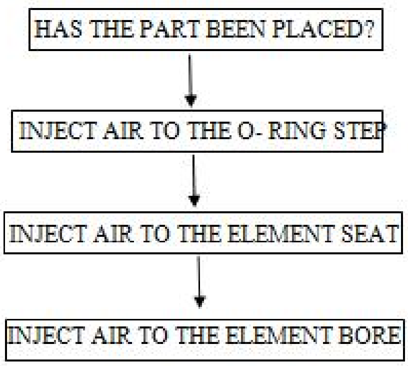


Fig.12 Balancing error

To rectify this error, a POKA-YOKE had to be designed so that the operator places the part in the exact orientation. After carefully studying the component, a simple POKA YOKE such as introducing a dowel pin will suffice. Due to the casting structure of the part, the casting has only one flat surface. Hence, a dowel pin just obstructed the part being placed in any other orientation except as specified.

This fixture must be equipped with an industrial PLC to be fully automated. This will follow the cycle and logic to function as shown below-



If any of the feedback results with an undesired or the reading is not within the specified bandwidth, it is a rejected part (the feedback is in counts with respect to the back pressure created).To get the accurate measurement and to calibrate the PLC to create a bandwidth, there is a requirement of a master. Hence, for every feature there are 2 masters manufactured. One with the lower and higher tolerances as per the component, respectively. The physical part cannot be used because, the accurate measurement of all the features in a single part is difficult to obtain. The abovementioned drawings are examples of a single lower tolerance gauge. Similar gauges are designed for higher tolerances also. The element seat height master comprises of 2 different parts i.e., the top plate and the cylinder. This is because it is easier to achieve surface finish if they are two different entities.

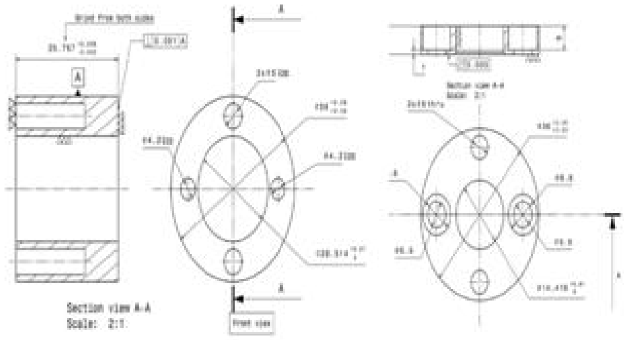


Fig 13. Element seat height master cylinder and top plate

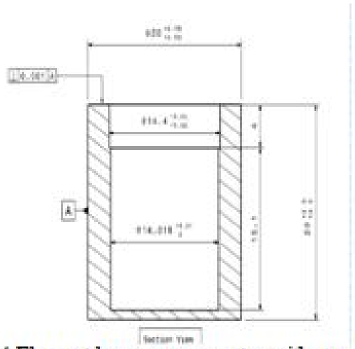


Fig.14 Element bore gauge master with counter bore

X. CNC 2 INSPECTION FIXTURE

Here we can observe that there are features machined both inside and outside of the part. For example, the hub diameter turning, and the RT bore Drilling. Hence, we needed a fixture that measures both the inside and the outside features in a single set-up. The inspiration for this fixture was taken from a fixture called the cammbox. A cammbox is a solid block which has a cavity of thecomponent machined. It is like a casting mold. This fixture would be very similar to the CNC1 fixture. However, the problem here is the element seat. The specified dimension of the Element seat height is from the flange face and not the top butting face. We still measured the element seat height from the butting face because the operation of facing the butting face or changing the drill length can be done right after the first set-up if it is not as per drawing. The conventional measuring of element seat height is done after the second set-up only even though the operation is performed in the first set-up. This usually results in facing operation of the flange, if it is not within tolerance (the part is rejected if it is higher than the tolerance limit, because it means that more material is removed. This posed a new problem. The entire inspection fixture had to be done in one single set-up. At this juncture, a brainstorming session was again conducted. The concept was that the cammbox and the inside mandrel similar to the CNC1 Fixture was designed. The inside mandrel measured the inside features and the outside the cammbox the outside ones. However, as seen in the earlier experiment, there must not be any contact to the element seat, since it caused dents thereby resulting in rejected parts. To overcome this obstacle, the element seat height was calculated from the RT bore surface rather than the flange face. The distances were calculated considering the minimum material condition. This resulted in the highest distance of the seat from the RT bore end. After this calculation, the inside mandrel was designed such that it exceeded the element seat by 0.3mm at Min material condition.

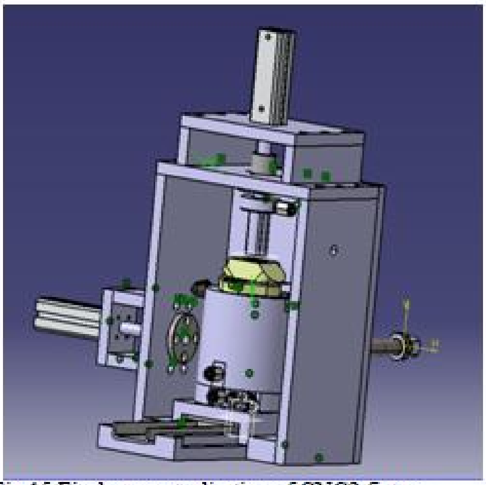


Fig.15 Final conceptualization of CNC2 fixture

Hence, the same concept was improved for the further development of the final design. The entire set up of the final concept is shown in the figure -

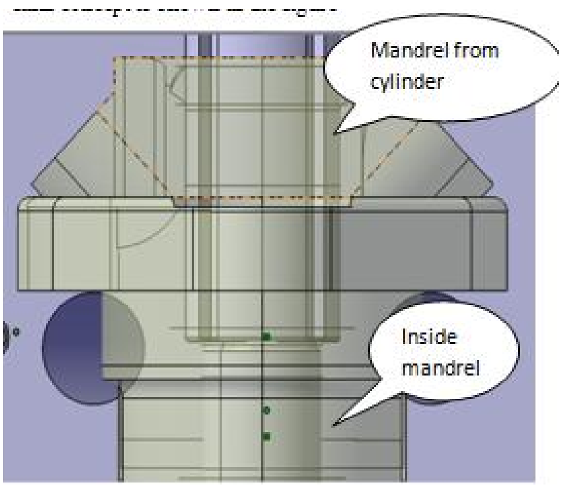


Fig.16 Gap between element seat and the cylinder mandrel

The final conceptualization consists of the following parts-

- Outer cammbox – The outer cammbox which was initially a square has been changed to a circular section to increase the manufacturability.the cammbox as mentioned earlier has a cavity of the outer dimension of the component. In the cammbox, the outer dimension of the part is added with gap of 70 to 80 microns. This is to create enough room for the air to be injected onto the surface of the component and there is enough back pressure created to obtain the counts. In the cammbox, there are two 1.5mm diameter holes provided on the top surface where the flange rests. This will give a feedback that the part is placed correctly. Further on, for the spigot diameter, the cavity provides as a GO gauge, i.e., the flange will not be in flush with the cammbox if the spigot height exceeds the dimension. This theory applies to all the lengths measurements of the part. The diameters are provided with 2 holes with a single air input fitting. At least 2 holes are provided for better results and higher accuracy. The part has a protrusion for the CR bore. Since this is a casting reference the cavity is on the higher side to accommodate any kind of casting variations. Furthermore, the outer diameter is provided with 2 pairs of air jet holes to compensate for the cylindrical run-out. There are slots milled with a dimension of 12mm x12mm to provide a flat surface for the Janatics coupler.

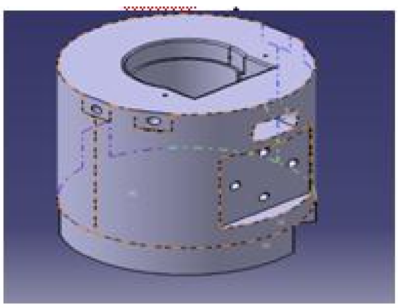


Fig.17Cammbox

- Inside Mandrell: - inside mandrel is like the CNC 1 fixture. It is mounted to the outer cambox using Allen bolts and dowel to maintain concentricity. the inside mandrel also works as a GO gauge with air inlets to measure diameters of RT bore and Pinion bore. Like the hub diameter, to measure RT bore diameter, there 2 pairs of holes provided. The mandrel also has slots to provide a free flow of air escape passage. The outer cammbox is not provided with air escape passage because the slots in the mandrel will accommodate for the air to flow out during the outer measurement cycle since there is a gap between the part and the cammbox.

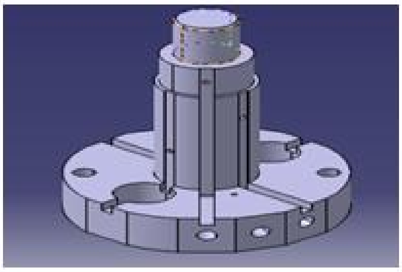


Fig.18Inside mandrel VMC

- Cylinder coupler - This mandrel is a coupler to the cylinder piston which consists of 2 holes on either sides and which meets the inside mandrel. The side hole is the entry of air through Janatics fitting. There are 2 holes of 0.8mm dia opening upto a 4.2mm(M5) thread hole with a 3.3mm step in between for the air inlet. Slots are provided for the air escape.

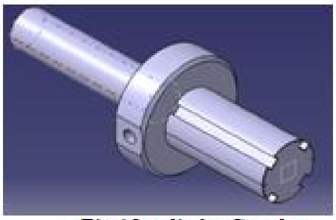


Fig.19-cylinder Coupler

- Base plate: - The base plate provides a platform for the inside mandrel and the outer cammbox.

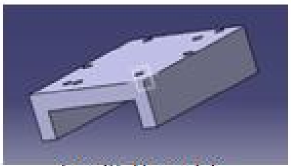


Fig 20. Base plate

- Channel Plate: a THK linear guide is employed. This takes care of linear moment without much deviation. In addition to the accurate movement, there is a channel provided for the base plate projection. Both have a sliding tolerance clearance in-between each other.

Working: -in this set-up, instead of the slider movement vertically, the slider is provided for horizontal movement. To reduce the the height of the fixture, the only way to measure all the features in a single step process is to ensure that the set-up moves in and out of another outerbox. Hence, the concept is that the entire set up moves inside and outside of this external box. This external box houses a another Janatics cylinder on top coupled with the cylinder coupler. The fixture is housed on the base plate, which further rests on the linear moment guide. This linear guide rests on the channel plate. The push and pull movement for the fixture is provided by another pneumatic cylinder, Janatics A52 magnetic series. Since, the positive stopper for the slider is not as per requirement, the stopper is provided in the channel base itself. There is another cylinder placed on the LHS of the set-up. This cylinder is coupled with a circular shaft which slides into the cammbox to an extent of 30mm. This shaft is also provided with an end chamfer to make up for the any variation. This is done to ensure that the fixture axis and the cylinder coupler axis are coincident.

The entire set up follows the cycle as illustrated below: -

Step1-

The cammbox is pushed outside the outer box.

Step2-

The part is placed inside the cammbox. Feedback is taken from the air holes with the flange flushed.

Step 3-

The part is pulled inside the outer box, along with the channel provided on which the base slides.

Step4-

The base is in flush with the air hole surface provided in the channel. (There are 2 holes provided in the channel base to ensure that the fixture is axially in place)

Step 5-

The piston is actuated radially to the inside of cammbox. This ensures that the part is radially inline, and axis are coincident.

Step6-

The inside mandrel starts injecting air and recording the feedback of each diameter.

Step7-

The outside Cammbox starts injecting air and taking the feedback after each air injection.

Step 8-

The top cylinder extends the coupler to the inside of the part.

Step 9-

Air is injected through the cylinder coupler and the element seat height is recorded.

Step 10-

The cycle is complete, and the all the cylinders retract except the cylinder which powers the linear guide. This cylinder pushes it outside again thereby declaring that the inspection is complete.

It is to be noted here that after any step if a negative feedback is obtained, the cycle is stopped, and the step 10 is initiated. This cycle is performed by programming an industrial PLC. There are different masters designed to calibratethe PLC to obtain the bandwidth. Initially the cylinder powering `the push and pull was coupled with a cylindrical shaft. This coupled to the cammbox at the other end. There was also bending moment analysis conducted as shown below: -

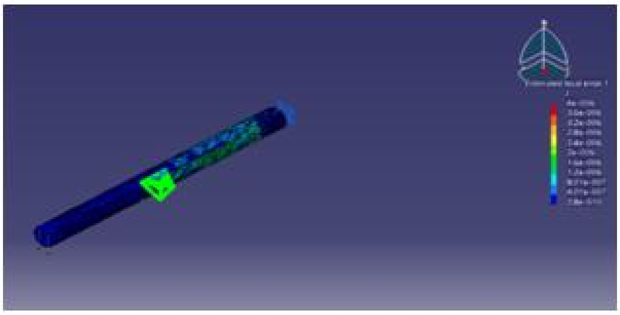


Fig.21 Bending moment of coupler.

This however increased the length of the entire set-up horizontally. Hence, the cylinder is coupled directly to the cammbox. For the movement of the couplers however linear bearings are provided to maintain axis accuracy. The set-up is also assembled with Allen bolts. To ensure perfect assembly, dowels are used wherever is necessary.

XI. VMC INSPECTION FIXTURE

In the VMC operation, most of the machining is performed are external features. These are done with keeping the internal features such as RT bore, pinion bore as the reference.

Keeping all the features in mind the following design was conceptualized as shown in the fig below:-

Fig.22X162 part, VMC features

VMC inspection fixture consist of the following sub assembly part: -

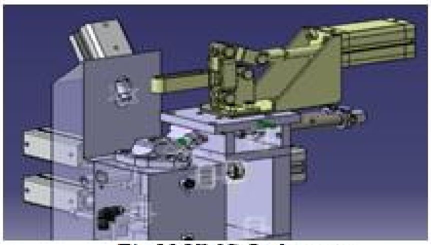


Fig.23 VMC final concept

- **Cammbox**- The external cammbox houses the part in place. It also has mounting pins as a sub-assembly part. The external features that are checked in this fixture are RT lock hole, element lock hole and CR bore. The inside mandrel is mounted on the rear side of the cammbox. To

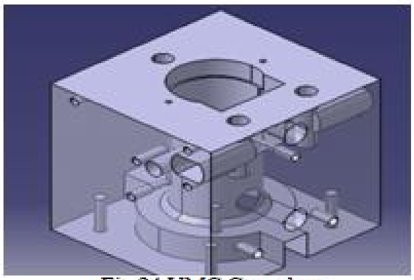


Fig.24 VMC Cammbox

maintain concentricity between the inside mandrel and the cammbox, there are dowel pins along with Allen bolts for mounting.There is a air inlet to measure the Boss mill of the CR bore.In the cammbox, two mutually opposite air inlet holes are provided which will be in flush with the part when it is placed. This is to make sure that the part is placed correctly.

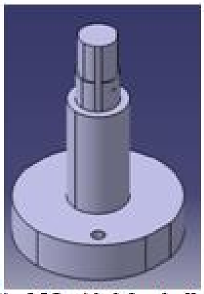


Fig.25 Inside Mandrell

- **Inside mandrel**- the inside mandrel used in this fixture is only to maintain the concentricity between the between the part and the cammbox. However, the other feature of the inside mandrel is to measure PED. PED is the distance of the center of the CR bore from the central axis of the part. So, an air hole is provided at a suitable distance to measure PED. The concept behind this will be explained in the working of the fixture.

- Inlet Hole side plate - the inlet hole side plate is designed in such a way that the material on the top surface of a rectangular block is removed at the exact angle as that of the component, i.e, 45 degrees. This side plate also housed two identical cylinders to identify the presence or absence of RTLH and ELH. This also takes care of the symmetry. To measure the inlet hole, the cylinder used is a rodless pneumatic cylinder and it is coupled with a rod end aligner. Since the entry of the coupler to measure the inlet hole is at an angle, there are more chances of inaccuracies. The movement of the cylinder piston will not maintain its linearity over a high frequency of usage.

This end aligner will take care of up to +-5 degrees of deviation. The side plate is also equipped with the cavity for the Janatics coupler.

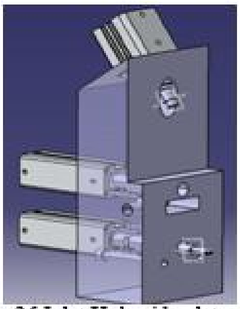


Fig.26 Inlet Hole side plate

- Coupler for CR bore – the CR bore coupler is designed to measure the straightness, diameter and roundness of the CR bore. Similar to the inlet hole, the cylinder to the coupler is coupled to has a rod end aligner sandwiched in between. This will take care of any kind of deviation in the straightness of the hole. But the end of the coupler is having a chamfer of 120 degrees. Chamfer will directly pass through the hole in the cammbox. This chamfer will not fit perfectly in the hole if the straightness is not achieved. And the feedback from the reed switch of the cylinder is not received if the piston does nor move the specified distance. furthermore, to measure the PED, the air injected from the inside mandrel should strike the CR bore coupler. To get better results, the air indentation should be on a flat surface. Hence the coupler is face milled. However, the coupler must also be guided so that the flat surface is exactly perpendicular to the air injection. Hence, a slot is provided where the projection of the guide is inserted. This projection and the slot are in sliding fit. The end of the coupler is threaded and coupled to the rod end aligner.

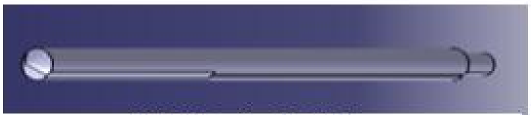


Fig.27 Coupler for CR bore

- Name plate hole position gauge - the name plate hole is the most critical feature of the part. The problem with this feature is that the holes are drilled at an angle on the casting surface. This means that there is no fixed reference that can be taken. To solve this problem, the solution is to make this a 2-step process. This will be placing the Name plate hole position gauge. The gauge was designed by taking the existing name plate hole gauge as a reference. But a few modifications of having 2 holes drilled on the face of the gauge are included. The name plate hole and the pins to measure the 2.2mm diameter hole are assembled, the pins are press fitted.

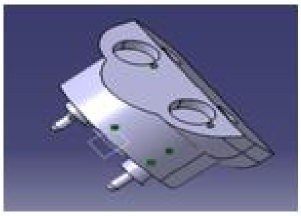


Fig.28 Name plate position gauge

- Couplers for RTLH, ELH and name plate hole- the couplers for the pneumatic cylinders are designed as stepped shafts or just straight shafts based on the requirement. All the couplers, however, are having end chamfer, this will enable smooth entry of the shaft inside the hole. The following figures represent the different couplers used in the design of the fixture; -

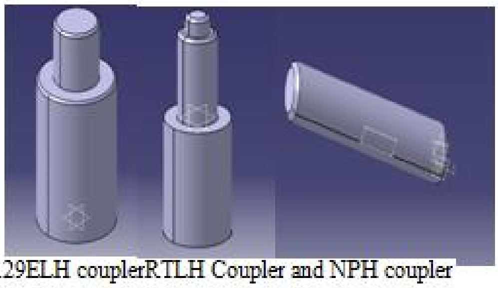


Fig.29ELH couplerRTLH Coupler and NPH coupler

- Mounting hole pin- The mounting hole pin measures the diameter of the mounting hole as well as the position of the hole w.r.t the center axis. The pins have through air hole, and they have a flat surface at the bottom end so that the position of the pin can be fixed using a grub screw.

Fig.30mounting hole pin

- Pneumatic toggle clamp – the pneumatic toggle clamp has been used in this fixture to make sure that the part is perfectly placed so that the features can be measured. The toggle clamp is accompanied with a swivel levelling pad. This pad makes sure that the force acting is always perpendicular even if there is a slight variation in the surface of the component.

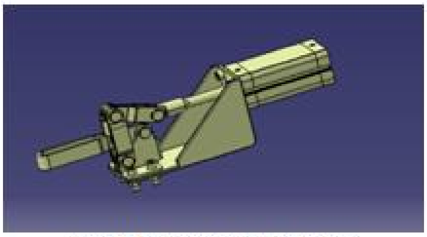


Fig.31 Pneumatic toggle clamp

- **Working of VMC fixture: -**

Fig.32 Pneumatic Circuit board

The working of the fixture takes place in the following steps.

Step 1- the part is placed with the name plate hole position gauge in the cammbox and the start button is pressed
Step2- the toggle clamp is actuated, and the levelling pad strikes the part. The part is held firmly.
Step 3 – air is suppled through the air holes to check whether the flange face is in flush with the cammbox.
Step 4- air is supplied through the mounting holes, to measure the diameter of the holes. The mounting pin undersized than the actual hole by 50 microns. This space is utilized in the air feedback or back compression.
Step 5- The cylinder with the coupler to measure the inlet hole is actuated. The feedback is received by the reed switch
Step 6 - ELH coupler is actuated, and feedback is received by the reed switch.
Step 7- the CR bore cylinder is actuated. The coupler enters the CR bore and the position of the coupler is determined again by the reed switch.
Step 8- Once the feedback is received by the reed switch, air is injected through the inside mandrel which strikes the flat surface CR bore coupler. This determines the PED.
Step 9- the name plate hole cylinders (A52 Magnetic Cylinders) are actuated, and the couplers strike the name plate hole position gauge. The couplers enter the hole in the position gauge thereby confirming that the name plate feature is present at the defined position.
Step 10 – All the cylinders are retracted, and the parts is ready to be removed from the cammbox.

Note- At any point of time if there is a negative feedback the above cycle ends and the cylinders which are actuated are retracted immediately. Alarm is switched on indicating that a rejected part is inserted.

XII. STRUCTURE AND CIRCUIT OF THE INSPECTION FIXTURE

Some of the components that are used in the pneumatic circuit are as follows: -.

1. **Pneumatic manifold**
2. **Solenoids Valves**
3. **Pneumatic Pressure Regulators-**.
4. **FRC Units**.
5. **Pneumatic Non-Return valve**
6. **Air Compressor**
7. **Pneumatic cylinder**
8. **Air line**

XIII. STRUCTURE OF A PLC

An industrial PLC consists of the following-

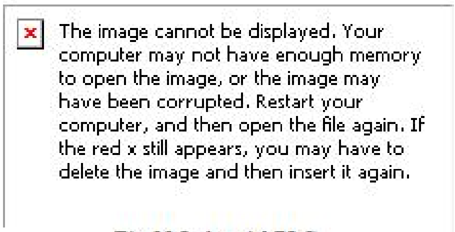


Fig.33 Industrial PLC

- **The Processor**
- **The PLC Input/Output (I/O)**
- **Power supply**

PLC Programming - In place of letters, ladder logic language usages graphical signs which display their proposed consequence.

A program in ladder language is like a diagram for a relay controller circuitry. It is a distinct language inscribed to mark it simplest for person who is used to with relay logic controller to program the Programmable Logic Controller.

XIV. INDUSTRIAL AUTOMATION USING PLC WORKING

The Electro–Pneumatic circuit consists of double acting cylinders, controlled by electrically actuated 5/2 way (i.e. 5 stroke 2 position) single solenoid spring return valve.

An output port of the valve supply compressed air to the pneumatic system. Flow control valves can also be used to control the speed of cylinders in both the direction. For example, its application can be used, in Industries, for clamping or in any other application. More details of the set-up can be had from the Regarding the electrical part of the circuit, the solenoid coils thus actuate the valve simultaneously, the two cylinder clamps the object and bending operation takes place. While pressing the start button from PC in the program or manually, the two Solenoids energizes & thus the respective cylinders move forward facing opposite to each other to clamp the object. There is a timer which delays timing between the cylinder 1 & 2 and cylinder 3 for example. After the time delay for, the Solenoid is energized, thus enabling the cylinder to perform the operation. After the execution of operation another timer executes delay to the operation for to ensure that operation is complete and then the cylinder retracts to its home position. Thus, after completion of operation timer executes and with another delay of both cylinders retracts thus completing the whole cycle. Further this cycle continues until the stop button is pressed remotely or manually. The movement of the cylinder takes place with the help of PLC interfacing. The start button gives signal to PLC, where it processes the signal and gives the output. The input to PLC is given by two components i.e., start button and stop button.

XV. CONCLUSION & FUTURE IMPROVEMENTS

Automation using PLC was studied successfully, and the CNC 1 inspection was manufactured and tested out with the soft material. All the design are based on 2 different casting families. However, on exception is the X242 part. This part has unique feature such as the mounting hole is larger in diameter, 2 inlet holes and locking pin hole. Using the same principle of design as done in this project, required modification can be done based on the features. It is also to be noted that the fixtures that are encountering the component must be heat treated. In this inspection fixture, the material that can be used in EN19 and should be heat treated up to 60-70 HRC. A slight modification of the VMC fixture, such as including a probe for CR bore which measures the Slitting operation can be employed and can be used in the Final Inspection Zone. In the CNC 1 fixture, the fuel chamber feature is not measured since it has a diameter larger than the entry hole. However, with the advancement of sensors, many laser beam sensors of inductive sensors can be used. However, they are to be trialed out first since they are highly affected by the reflecting surface.

REFERENCES

[1] REDUCTION OF REJECTION IN DIESEL FUEL INJECTION PUMPING ELEMENT Nithin.M.R1*, Dr.Divakar.H.N2 , Devaraju.G.R3 , Srinivas.C.N4 1* M Tech Scholar, Department of Industrial & Production Engineering, The National Institute of Engineering, Mysore 2Professor and HOD, Department of Industrial and Production Engineering, The National Institute of Engineering 3,4Senior manager, Department of Manufacturing of Element (BanP/MFE), Bosch Ltd AdugodiBangaluru – 560030 Correspondence Author: nithinmahendarkar@gmail.com

[2] INDUSTRIAL AUTOMATION WITH ELECTRO–PNEUMATIC SYSTEM USING PLC & WIRELESS/LAN ENVIRONMENT - A REMOTE EXPERIMENT 1 Nitin Sapre , 2 Dr. S Mohan Kumar 1 Drives & Control Academy, Bosch Rexroth India Limited, Bangalore, Karnataka, India dr.s.m.kumar@gmail.com.

[3] Investigative Report on First Pass Yield Improvement in PFR 1 k Pumps Vismay K G1 , Tejus D2 , Prathap Purushotham D.M3 , Upamanyu Deb 4 , Hemanth Kumar 5, Department of Mechanical Engineering, EPCET, Bengaluru, Karnataka, India2, 3, 4, 5

[4] Air Gaging Basics Willrich Precision Instr. Co Phone: 1-866-WILLRICH.

[5] Problems in Bosch Diesel Fuel Injection Pump and It's Effects – A Review UPADHYAY PINAK NITINBHAI RATHI VIVEK MANILAL MILAN J PANDYA B.E. Student, Final year, Mechanical Engineering Department, L J Institute of Engineering and Technology, Ahmedabad, Gujarat, India. B.E. Student, Final year, Mechanical Engineering Department, L J Institute of Engineering and Technology, Ahmedabad, Gujarat, India Asst. Professor, Mechanical Engineering Department, L J Institute of Engineering and Technology, Ahmedabad, Gujarat, India. KEYWORDS Fuel injection pump, efficiency, noise pollution, air pollution.