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CHAPTER 1: INTRODUCTION

This dissertation presents the results of the research in chronological sequence of the stages in the creation of the crankshaft inspection machine. It will begin with an overview of crankshaft designs, terminology, and other criteria, before moving on to the next section in depth on all steps of designing a system that can inspect the OEM-defined parameters crankshaft parameters in addition, the inspection machine's design and all of its components developed will be thoroughly discussed.

HISTORY OF CRANK SHAFT

The crank was first used in a machine in China during the Han Dynasty, in a crank-driven winnowing machine (202 BC - 220 AD) A water mill from late antiquity was the first to employ a crank mechanism. The non-manual crank occurs in numerous hydraulic machines documented by the Bane Musa brothers in their Book of Ingenious Devices in the ninth century. These automatically-operated cranks feature in a number of devices detailed in the book, two of which have a crankshaft-like motion. [1][2]

A crank handle with a rotary grindstone is seen in the early 9th century Carolingian text Utrecht Psalter. Scholars allude to a book by the Spanish Muslim physician Abu al-Qasim al-Zahrawi (936–1013) in the 10th century that mentions the use of crank handles in trepanation drills. [3][4]

Al-Jazari, an Arabic inventor, reported the oldest known crankshaft in 1206, which he used in his twin-cylinder pump along with a crank and connecting rod mechanism. The mechanism used by Al-Jazari consisted of a wheel that moved numerous crank pins. His water pump also used the first crank-slider system ever discovered. [5][6]

Later descriptions of crankshafts were written by Konrad Kyeser (d. 1405), Francesco di Giorgio (1439–1502), Leonardo da Vinci (1452–1519), and Taqi al-Din, who used one in a six-cylinder pump in 1551. Cornelis Corneliszoon van Uitgeest, a Dutch "farmer," described a crankshaft in 1592. His wind-powered sawmill relied on a crankshaft to transform the circular motion of a windmill into a back-and-forth motion that drove the saw. In 1597, Corneliszoon received a patent for the crankshaft. [7][8]

AUTOMOTIVE MANUFACTURING COMPANIES

automotive manufacturing companies create a huge number of engine parts and are always required to assure the quality of their goods. Most industries in Pakistan choose to import inspection equipment from outside the nation, paying thousands of dollars on a low-resolution inspection equipment. A locally built camshaft inspection machine will not only be less expensive, but it will also have a higher resolution than a machine imported 3 times the price of this equipment.

AUTOMOTIVE RESEARCH IN PAKISTAN

Due to a shortage of experiment equipment, Pakistan lags behind most other countries in engine research. A design parameter can only be studied by a crankshaft inspection machine, which is too expensive for institutions and academics to acquire. This technology enables engine researchers to make adjustments and assess the results. It also gives producers the opportunity to improve the overall efficiency of locally manufactured items.

PROBLEM STATEMENT

Develop a crankshaft inspection machine that measures crankshaft main bearing runouts precisely and accurately.

Engineering companies want to produce cheaper, more durable and highly efficient engine parts. Most nations in the world require certain international or national certifications for a product to be imported/exported. Testing equipment usually costs thousands of dollars and if you include shipping and importing tax cost, the total sum goes to millions. The only appropriate option is to design and manufacture such test rigs locally.

There are several crankshaft inspection machines on the world market, however none are accessible in Pakistan. Purchasing a high-resolution automated crankshaft inspection equipment costs hundreds of thousands of dollars. Constructing a Crankshaft Inspection Machine would not only increase the overall efficiency of locally made engines, but will also make them more reliable and exportable on an international scale

OBJECTIVE

Develop a crankshaft inspection machine in accordance with the needed resolution and requirements.

1. Use readily accessible components and produce locally.
2. Make the product competitive in the global market while keeping the cost reasonable.

CHAPTER 2: LITERATURE REVIEW

CRANKSHAFT

The crankshaft is a moving component of an internal combustion engine (ICE). Its primary function is to convert the piston's linear motion into rotational motion. The connecting rods, which are located within the engine block, link the pistons to the crankshaft.

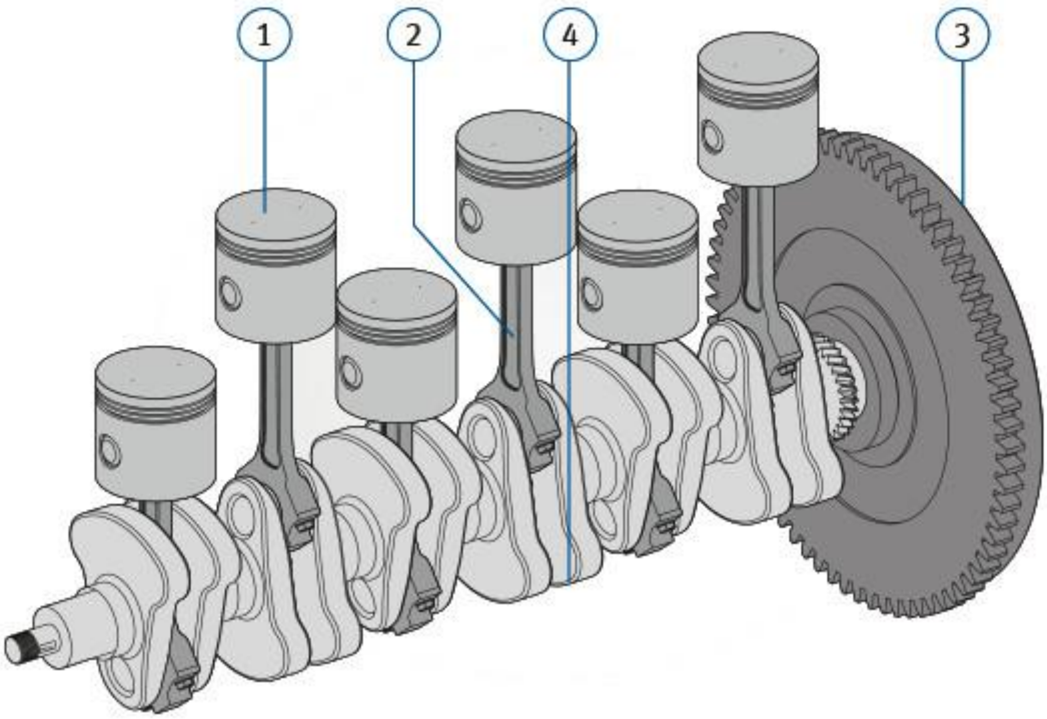


FIGURE 1 ENGINE CRANK MECHANISM

1. Pistons
2. Connecting rods
3. Flywheel
4. Crankshaft
5. The crank mechanism is made up of the pistons, connecting rods, and crankshaft.

The crankshaft's secondary role is to distribute power to other engine systems:

1. valve timing
2. oil pump
3. cooling (water) pump
4. air conditioning compressor
5. alternator, etc.

WORKING OF CRANKSHAFT

The crankshaft is attached to the engine block through its major journals. The connecting rods are secured to the crankshaft's conrod journals. The crankshaft features counterweights on opposing sides of the conrod journals that compensate for outside moments, minimize interior moments, and therefore lower vibration amplitudes and bearing loads. The flywheel is linked to one end of the crankshaft and the valve timing gearing is attached to the other.

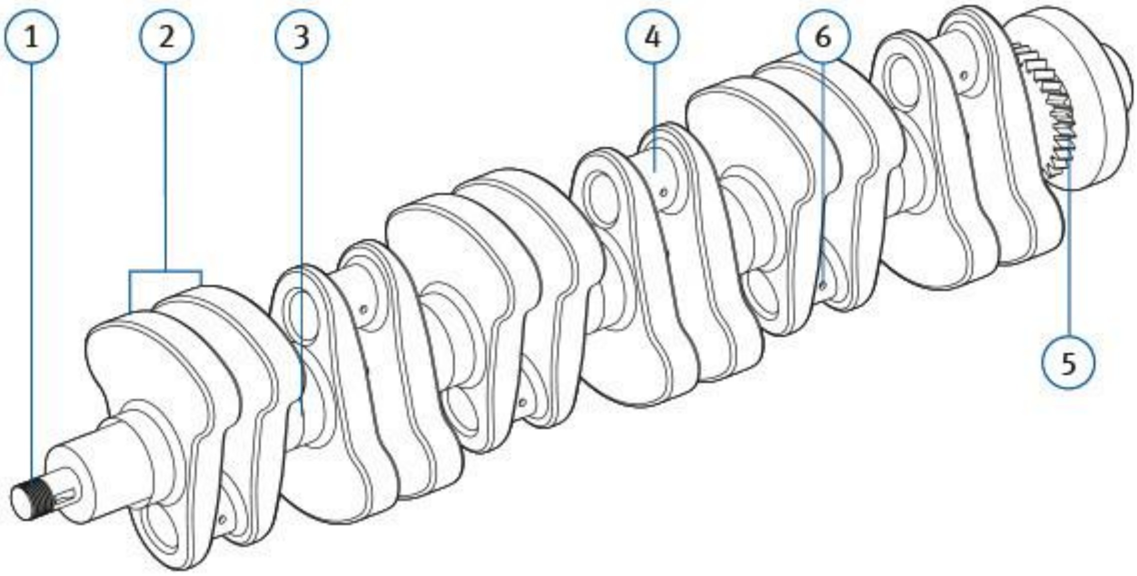


FIGURE 2 ENGINE CRANKSHAFT DESCRIPTION

1. Control side or drive end
2. Counterweights
3. Main bearing journal
4. Conrod journal
5. Flywheel side/force transfer

6. Oil bore

The number of main journals and conrod journals is determined by the number of cylinders and the engine type (V-type, straight, etc.) The crankshaft features lubricating orifices (oil bores) on both major journals through which oil flows when the engine is operating. The oil hole in the center of the crankcase allows oil to flow from one of the two journals into the other.

The length of a V6 engine is shorter than that of a straight 6 cylinders (L6) engine. A flywheel is mounted onto the crankshaft in order to smooth the engine torque and reduce vibrations. Because of this arrangement, a V-engine, for the same number of cylinder, is more compact than a straight engine. On V-type engine on the same journal, two connecting rods are mounted.

CRANKSHAFT MANUFACTURING

To decrease friction between the engine block and the crankcase, two types of crankshafts are manufactured: cast and forged. They can either be fastened on (using threaded bolts) or cast directly onto the crankshaft. The internal combustion engine's pistons all send their forces to the crankshaft. Mechanically, the crankshaft must endure strong torsional forces, bending forces, pressures, and vibrations.

In certain contemporary engines, the crankshaft is now made from a single billet of iron. Cnc machines are used to produce crankshafts with extremely precise finishing and specifications.

CRANKSHAFT INSPECTION MACHINES

A crankshaft inspection machine examines a crankshaft's parameters to evaluate the quality of the manufacturer's crankshaft. Without examination, the functioning of an engine becomes a guessing game, which is extremely unsatisfactory. There are several different types of machines that can be used to inspect crankshaft which are discussed in details below

V BLOCKS AND DIAL GAUGE INSPECTION MACHINE

It is one of the most basic devices for checking the runout of crankshaft main bearings. It consists of a table with two v blocks fixed on it. The crankshaft is held in place by these v blocks. A dial gauge is used to measure the runout of the main bearing. When the dial comes into contact with the main bearing, its value is reset to zero, and the crankshaft is turned 360 degrees by the operator. The data from the dial gauge is recorded and may be used to determine the runouts of the main bearings. This machine is not very precise and cannot provide many details.

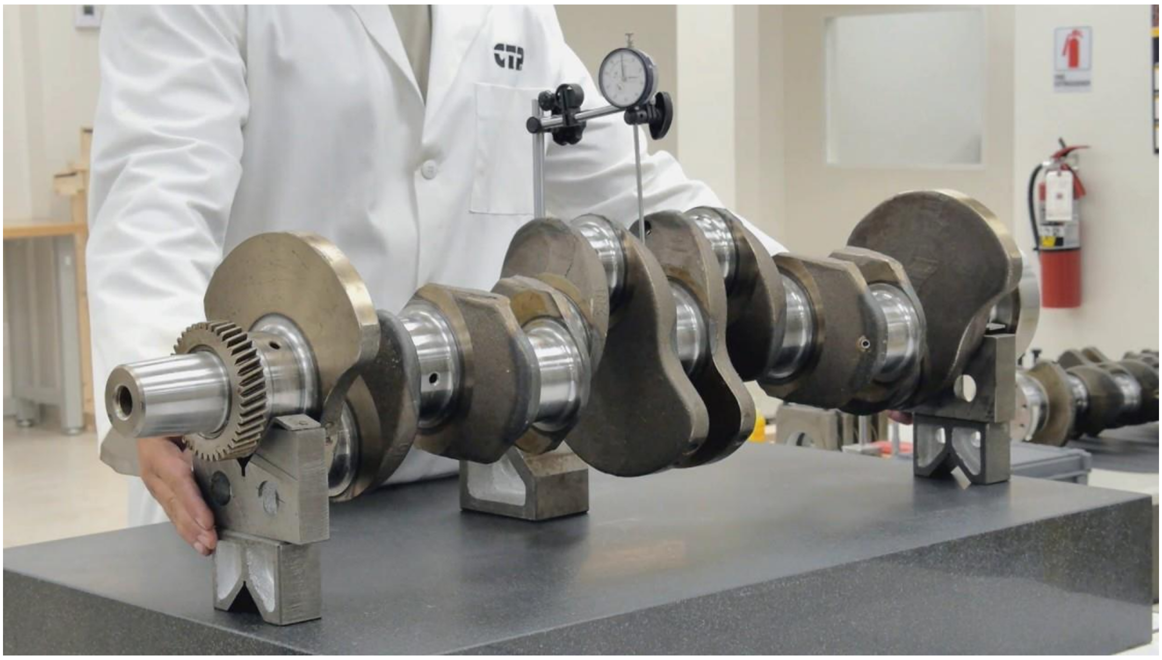


FIGURE 3 V BLOCK CRANK INSPECTION MACHINE

OPTICAL AUTOMATED CRANKSHAFT INSPECTION MACHINE

The gauge used to determine the runout of the main bearing of this kind is based on optics. At one end, the crankshaft is fixed on a tail stoke, and at the other end, a drive unit turns the crankshaft at a set rpm. The gauge travels from one bearing to another on an automated machine, and all readings are captured and stored in the computer. This sort of equipment is quite expensive and should only be used in a clean atmosphere; otherwise, its gauge may be compromised and data may be distorted if utilized in severe conditions.

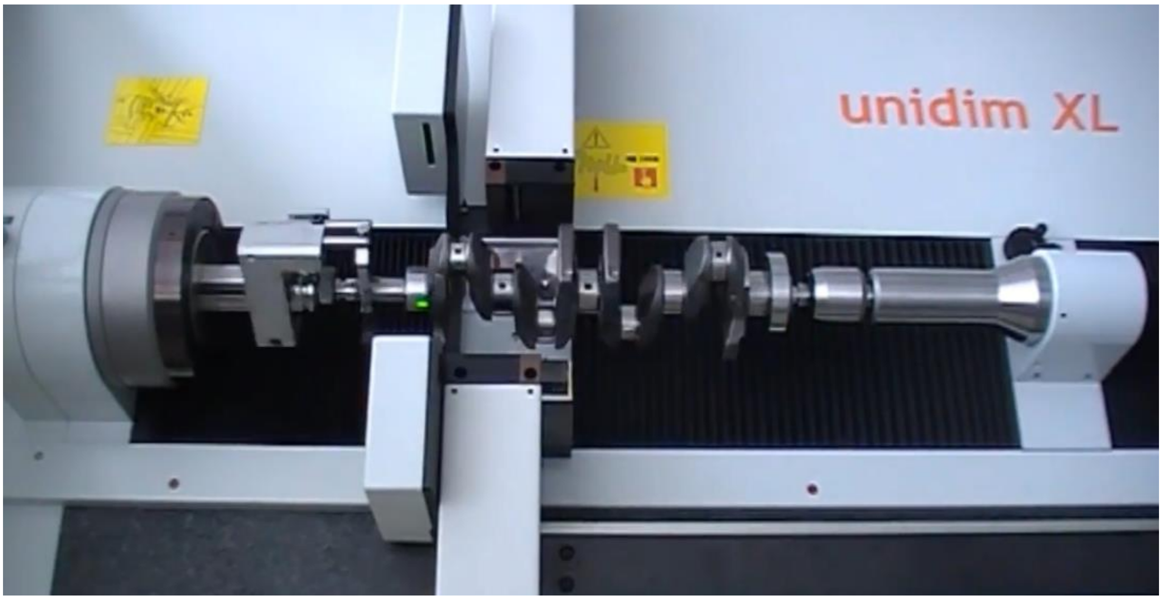


FIGURE 4 OPTICAL AUTOMATED CRANKSHAFT INSPECTION MACHINE

CO ORDINATE MEASURING MACHINE

This equipment is extremely precise and efficient, yet it is prohibitively expensive. Crankshaft machines can be mounted vertically or horizontally. A single probe is utilized to locate main bearing runouts, and data is logged in a computer. The probe, like optical machines, travels from one bearing to another using an automated mechanism. CMMs are complex machines that cannot be utilized in hostile environments because the findings would be affected.

FIGURE 5 OPTICAL AUTOMATED CRANKSHAFT INSPECTION MACHINE

FULLY AUTOMATED CRANKSHAFT MACHINES

In this sort of machine, the entire process is automated, from choosing the crankshaft to gauging it and testing it. After testing, the machine determines if the crank is within specification or not based on data. The gauge used in this sort of equipment is known as a snap gauge, and each major bearing has its own gauge, allowing each bearing to be measured at the same time. This machine saves time and can be utilized in hard and tough circumstances due to the snap gauge.

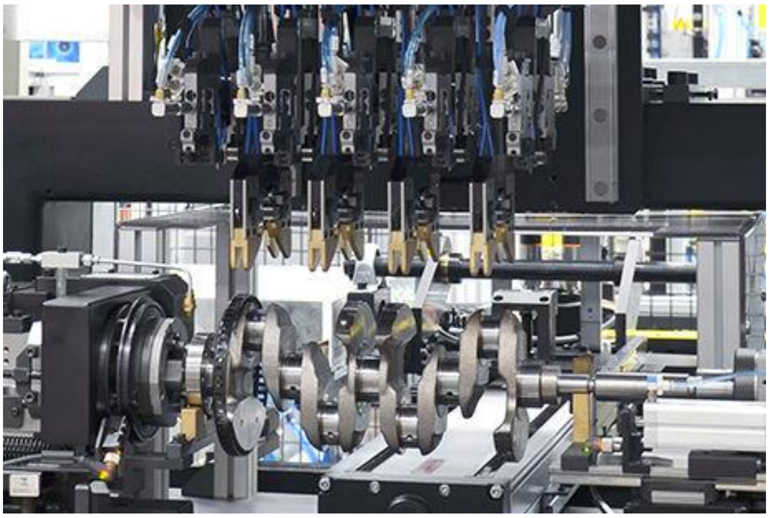


FIGURE 6 FULLY AUTOMATED CRANKSHAFT MACHINESFULLY AUTOMATED CRANKSHAFT MACHINES

LVDT

A linear variable differential transducer is an electrical transducer or device that transforms an object's linear location into an electrical signal. This signal may then be analyzed and calibrated to provide a precise distance measurement. It is made up of three solenoid coils that are encircled by a cylindrical tube. The central main coil receives an alternating current, which produces a voltage between the two secondary coils. The frequency range is generally between 1 and 10 kHz. Because the core is connected to both the main and secondary coils, it alters the induced voltage across both secondary coils when it moves. This difference is measured, and the resulting value is calibrated to the relevant location. The voltage differential between the coils is zero when the cylindrical metal tube is placed between the centers of both secondary coils. The residual voltage present due to phase shift causes a tiny quadrature error, which may be reduced by utilizing accurate full bridge rectifiers. Linear variable differential transducers operate with high reliability and theoretically unlimited cycles. It can provide high precision in a wide range of systems, including satellites, ship engines, aviation turbines, automobiles, and basic lab measuring equipment. Figure 11 depicts the fundamental design of a lvdt.

FIGURE 7 DIFFERENT TYPE AND SIZE OF LVDT

ROTARY ENCODERS

A rotary encoder is an electromechanical device that transforms an axel's or shaft's angular position into a digital or analogue output signal. Optical encoders are frequently utilized in industry. They have a metal disc with slits all the way around it. On one side of the disc is a light source, while on the other is a light detector. When light hits the detector, a signal is created, and when light is obstructed by the slits on the metal disc, a signal is stopped. The slots are designed to allow the shaft to couple with the metal disc in an angle orientation. Figure 12 depicts this.
Rotary encoders are further classified into two types based on the information they provide about the angular position of the rotating assembly to which they are attached.
• Absolute rotary encoders • Incremental rotary encoders

The absolute position of the rotating device coupled to incremental rotary encoders is not known. They are durable because they send out a signal as soon as a change in location is detected. As a result, they can assess positioning precision at even high speeds. The resolution of incremental rotary encoders is not as limited as that of absolute rotary encoders, and incremental rotary encoders with resolutions of 10,000 or more are readily available. It produces two square-form waves, A and B, which represent movement and direction. A takes the lead, while B follows in a clockwise fashion. B takes the lead while A follows in the anti-clockwise direction. In addition, there is generally a Z signal that indicates a full rotation and serves as an index. Figure 8 illustrates this.

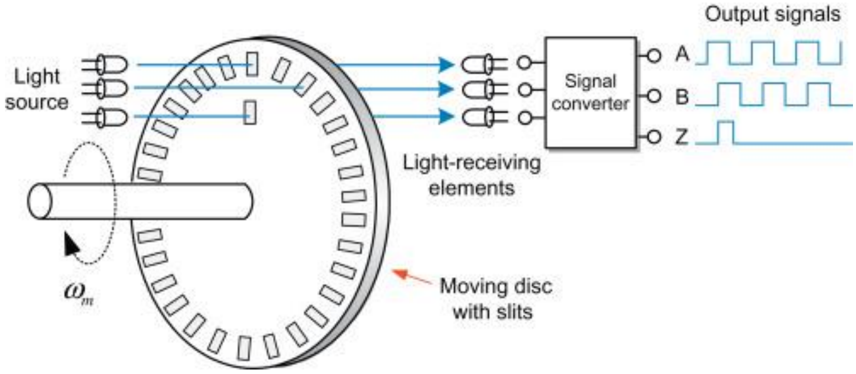


FIGURE 8 INCREMENTAL ROTARY ENCODER MECHANISM

Even when the power is switched off, absolute encoders retain information about the rotating device's position. Because the rotary encoder's metal disc has many rows of slots, each position is distinct. Absolute encoders may operate at high rates; however, they are often used in circumstances where positional data is important. Windmills and robotic arms are two examples. Gray code is a binary coding variation used by these encoders. Only one line on the disc changes since only one "bit" is utilized.

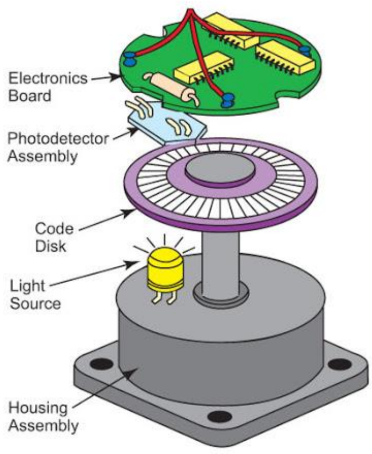


FIGURE 9 CONSTRUCTION OF ROTARY ENCODER

STEPPER MOTOR

A stepper motor is a brushless DC motor that spins in steps. It may be precisely positioned. Stepper motors are tiny in size, yet they create a lot of torque. Ideal for quick acceleration and response. A stepper motor is a form of direct current motor that may be activated by delivering excitation pulses to the phase windings.

There are three types of stepper motor

1. Permanent magnet stepper motor
2. Variable reluctance stepper motor
3. Hybrid stepper motor

PERMANENT STEPPER MOTOR

This stepper motor features a permanent magnet rotor and is similar to a traditional 2- or 3-phase induction motor. The motor's direction is exactly proportional to the direction of current flow in the windings. The magnetic poles of this motor are reversed by altering the direction of the current flowing through it.

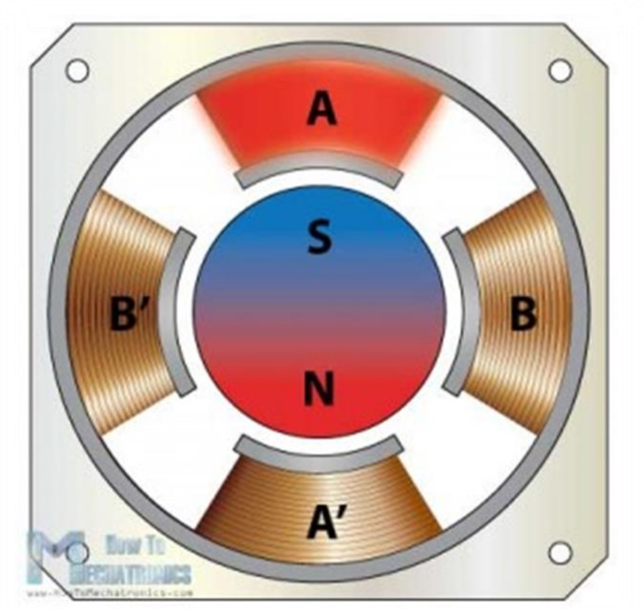


FIGURE 10 PERMANENT STEPPER MOTOR

VARIABLE RELUCTANCE STEPPER MOTOR

This stepper motor features an electromagnetic stator and a rotor made of magnetically soft iron with teeth. VR motors necessitate at least three stages. The rotor teeth are offset from the stator, and the rotor rotates when we activate the windings in a certain order. The motor's direction is independent of the direction of current flow in the windings.

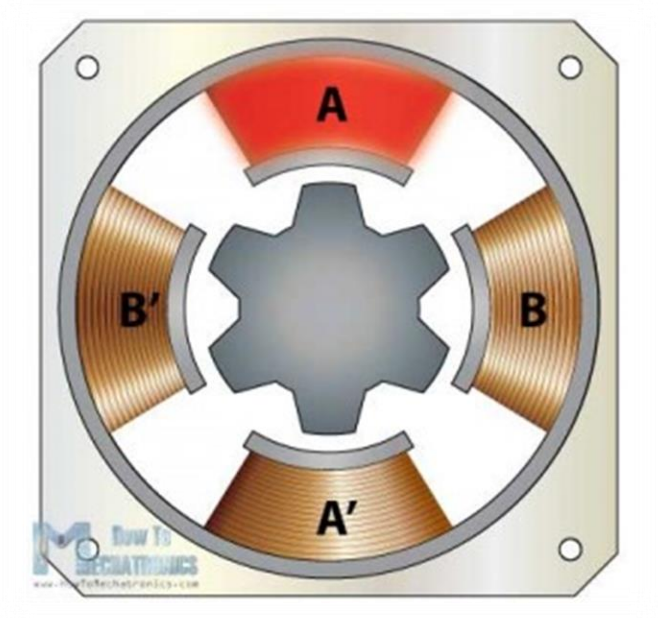


FIGURE 11 VARIABLE STEPPER MOTOR

HYBRID STEPPER MOTOR

This motor has a mix of a permanent magnet and a variable reluctance construction. It has a toothed rotor made of permanent magnets as well as a toothed stator. The rotor is divided into two parts with opposing polarities and offset teeth.

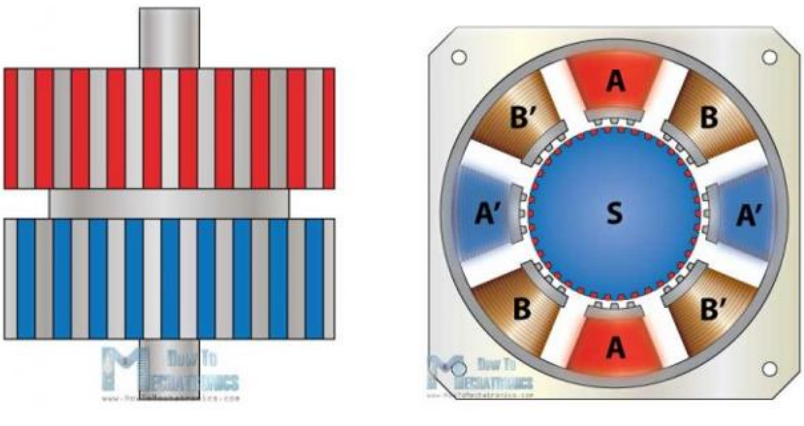


FIGURE 12 HYBRID STEPPER MOTOR

We can also classify the stepper motors as **unipolar and bipolar** based on the type of stator winding

Bipolar stepper motor

- The stator coils on this type of motor will not have a common wire
- The driving of this type of stepper motor is different and complex
- Driving circuit cannot be easily designed without a microcontroller.

Unipolar stepper motor

- In this type of stepper motor we can take the center tapping of both the phase windings for a common ground or for a common power
- This makes it easy to drive the motors, there are many types in unipolar stepper motor as well

WORKING OF STEPPER MOTOR

The stepper motor is made up of a rotor that is usually a permanent magnet and is surrounded by stator windings. We engage the windings in a specific order and allow electricity to flow through them. They will magnetize the stator and create electromagnetic poles, which will propel the motor. This is the fundamental operation of stepper motors. The electric pulse is generated by the stepper motor's driver and controller.

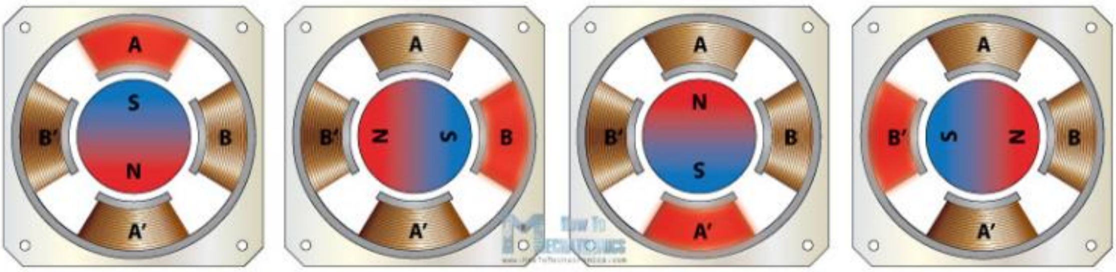


FIGURE 13 WORKING OF STEPPER MOTOR

CONCLUSION

After thoroughly researching the design and operation of different machines and accessories, we decided that employing tailstocks with dead centers is the ideal approach to build a crankshaft inspection machine that can be built locally. This machine’s measurement component includes a high resolution incremental rotary encoder and a linear variable differential transducer. A robust and precise electric slider will be utilized to move a linear variable differential transducer throughout the length of the crankshaft in between two dead centers. The rotary encoder will be connected in such a way that the shaft of the rotary encoder moves with or in synchronization with the crankshaft. Stepper motors will be utilized to revolve the crankshaft via a pulley linked to the machine's crankshaft turning mechanism. Further design adjustments will be required throughout the project development, but the core design concept will remain the same. Some parts will be fabricated, but our aim will be to employ the majority of the components that are currently on the market. A single LVDT is used to determine the runout of the main bearing.

CHAPTER NO 3: METHODOLOGY

This chapter will go through every detail of the entire system's design. It will go through the individual component utilized in depth as well as the reasons behind its selection. The finished product will be exhibited in the end.

DESIGN REQUIREMENTS

The automotive company provided the exact dimensions and specs for the crankshafts. It has diameter of 79.81 ± 0.01 mm and 63.704 ± 0.01 mm, concentricity of one bearing with respect to another is given as 0.1mm and the cylindricity of each bearing is given as 0.008 mm. The necessary runout data for the crankshafts' main bearings should be no more than 8 microns.

Other design considerations include using readily accessible components and keeping costs within budget while maintaining accuracy and quality.

COMPONENT CHOSEN AND SPECIFICATIONS

Some components used in this machine were already available in market. The selection of these components was based on machine requirement. Following are the names of these components and each of them will be discussed in detail too

1. metal bed plus table
2. heavy duty tail stokes
3. SMC pneumatic slider
4. Solartron feather touch LVDT
5. NEMA 32 stepper motor
6. Electric slider
7. Higwin linear slider
8. SMC pneumatic actuator
9. Hollow shaft encoder

METAL BED AND TABLE

The bed is composed of mild steel and is 1300 mm in length and 500 mm in width. The thickness of the bed is 15 mm. A table made of 50 mm square tubing is used to support the bed. The whole surface of the bed is machined to be consistent and have no influence on the findings. Another advantage of a consistent surface is that the machine will be repeatable. It has four sets of holes:

	Description	Designation	Qty.
1	Drive mechanism and tailstock mounting holes	M8x1.25 thru	**4**
2	Pneumatic tailstock mounting holes	M8x1.25 thru	**4**
3	Electric slider mounting holes	Φ6.0mm thru	**8**
4	Slider rail mounting holes	M8x1.25 thru	**4**

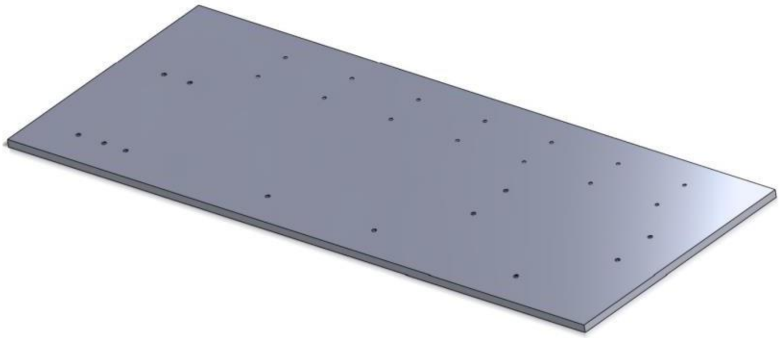


FIGURE 14 METAL BED OF CRANKSHAFT INSPECTION MACHINE

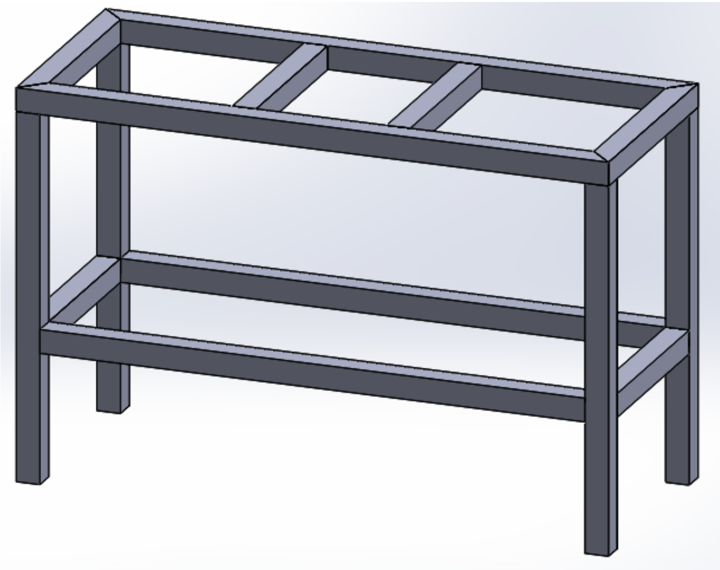


FIGURE 15 TABLE

TAILSTOCK

A heavy-duty pneumatic tailstock is utilized to support the crankshaft at one end. The pneumatic system engages and disengages the tailstock. This tailstock features a dead center and some mores taper 4 size. The dead center quill travel is 45mm. The center height of the tailstock is 125mm, however it may be increased to 180mm using a metal block, as detailed in the next section. The net weight of the tailstock is around 20kg.

FIGURE 16 PNEUMATIC TAILSTOCK

SMC PNEUMATIC LINEAR SLIDER

This slider is utilized to create indirect contact between the LVDT and the main bearing. The model utilized is the MXQ-8, with a stroke of 75mm. It had a pneumatic mechanism, but it was removed so that it could glide down by weight. At the tip, a carbide rod is connected, which makes tangential contact with the bearing. SMC manufactures a high precision slider table. Despite having a parallelism of 10-20µm, it has a rattling of less than 0µm, making it perfect for high precision operations. This component's table and tube enable several mounting places for desired assemblies or multiple assemblies.

FIGURE 17 SMC MXQ8-75 LINEAR SLIDER

SOLARTRON FEATHER TOUCH LVDT

It's the key measuring component that converts linear SMC slider movement into an electrical signal for the data collecting system. Solartron at/5/p is the model number. This LVDT probe has a resolution of greater than 1μm and a repeatability of 0.05μm. It's made of high-strength stainless steel, which means it'll last a long time. It features a spherical tip that may be removed. It comes with an IP50-rated wire that provides good electrical noise isolation. Pneumatic action or spring loading can be used to operate it.

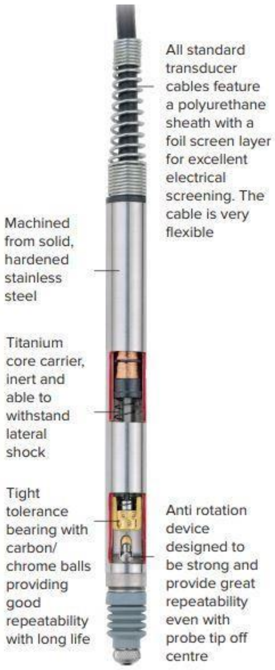


FIGURE 18 CROSS SECTION OF SOLARTRON LVDT

NEMA 32 STEPPER MOTOR

The crankshaft weighs around 35kg, and the minimum torque necessary to operate it smoothly was 4Nm. At 6-7 rpm, Nema 32 was utilized to drive the crankshaft. It has a 12Nm torque. To make the crankshaft drive more smoothly, a micro step driver and signal generator were utilized.

FIGURE 19 NEMA 32 HYBRID STEPPER MOTOR

ELECTRIC SLIDER

In the automation, packing, precision manufacturing, and logistics sectors, electric sliders are frequently utilized. This machine's electric slider is a high-precision slider with 12mm diameter ball screws with a 5mm pitch and a positional accuracy of 20-30 microns. The vertical parallelism of this component is about 3-microns over an 800mm stroke length when tested against a granite surface plate. It has a vertical weight capacity of 30kg and a horizontal load capacity of 50kg. The ball screw has C7 accuracy and have a maximum speed of 500mm/s

FIGURE 20 800 MM STROKE ELECTRIC SLIDER

SMC PNEUMATIC ACTUATOR

The entire run out assembly is lifted by a pneumatic actuator, which means that after one major bearing's reading is complete, it must move on to the next bearing. This actuator is utilized to avoid contact with the crankshaft webs. The CDJ-10-75 is the model that was utilized. It features a 10mm bore diameter and a 75mm stroke. It has a working pressure of 0.1 to 0.2 MPa. Spring return, double acting, single acting, and spring extended are all options for this type of actuator. In this case, the single acting type is employed.

FIGURE 21 CDJ 10-75 SMC PNEUMATIC SINGLE ACTING ACTUATOR

HOLLOW SHAFT ENCODER

A rotary encoder is a type of electromechanical device that detects the angular motion and position of the shaft of a rotating component. They come in a number of shapes and sizes, as well as a wide range of ppr and r.p.m values. In this situation, the most often used rotary encoders are incremental encoders. It also features a hollow shaft. It has a 14400 ppr and a 4000 rpm rating. It is designed to accommodate a shaft with a diameter of 38mm and a tolerance of h7. It is powered by an 8-30-volt DC source and produces a 5-volt digital signal.

FIGURE 22 K-100 HOLLOW SHAFT ROTARY ENCODER

HIGWIN LINEAR SLIDER

This slider is used to assist the electric slider. one tower is mounted on the electric slider while another is mounted on the Higwin linear slider. Theses towers are connected through a vertical plate on which the whole runout assembly is mounted on one side and on other side assembly is mounted which is part of research on journal bearing. Higwin slider has total stroke of 900mm. it is quiet precise and accurate and has a parallelism of 2 microns.

FIGURE 23 HIGWIN LINEAR SLIDER

PARTS AND ASSEMBLIES DESIGNED AND MANUFACTURED

Despite the time-consuming process of selecting components for the crankshaft inspection machine, many parts and assemblies had to be precisely developed and built. The following are the manufactured components and assemblies.

1. base main bearing runout assembly
2. runout measurement lift attachment and carbide rod mounting
3. drive pin and mounting
4. drive unit assembly
5. towers and horizontal plate
6. tailstock block
7. base plate

BASE MAIN BEARING RUNOUT ASSEMBLY

The base plate, which is 285mm long, 131mm wide, and 10mm thick, is the most important component of this arrangement. It features six holes on the top that are used to fasten it to the vertical plate. Brackets are used to install the lvdt in the bottom left corner. The smc slider is positioned next to the lvdt, and the pneumatic actuator is mounted with a bracket on the bottom left. Both designed and manufactured base main bearing runout assembly is shown below.

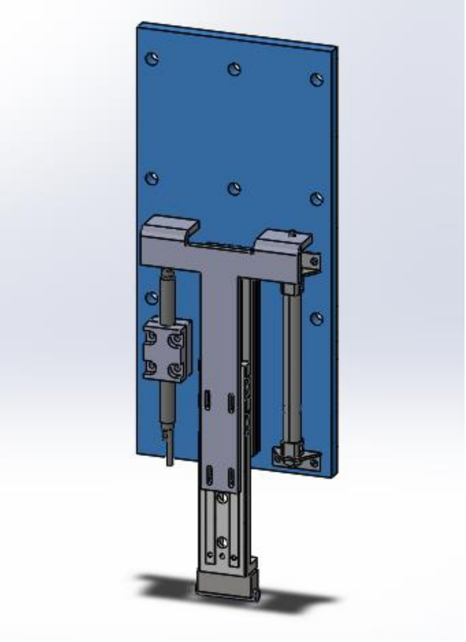


FIGURE 24 CAD MODEL OF MAIN BEARING RUNOUT ASSEMBLY

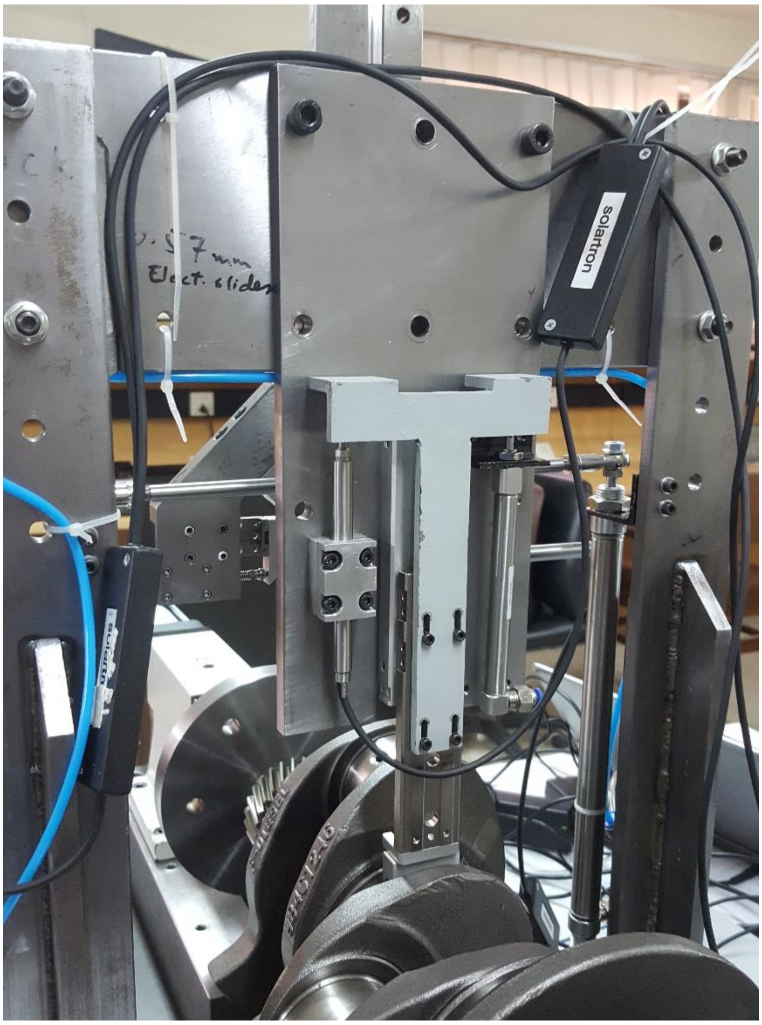


FIGURE 25 MANUFACTURED RUNOUT ASSEMBLY

RUNOUT MEASUREMENT LIFT ATTACHMENT AND CARBIDE ROD MOUNTING

The lift attachment is composed of mild steel and is 170mm in length with an overall thickness of 5mm. It resembles the letter "T" in shape. The upper side is bent to make contact with the lvdt and the pneumatic actuator. When data is captured, it just comes into touch with the lvdt, and when the assembly advances to the next bearing, the pneumatic actuator comes into contact with it and lifts the whole assembly clear of the crankshaft webs. This attachment connects to the Smc slider and transfers deflection from the main bearing to the lvdt. It includes slots on the bottom side so that it may be adjusted as needed. This component allows us to collect readings without touching the probe, allowing the probe to be put in a safer location so that it is not harmed in the event of a machine malfunction. The component that was developed and fabricated is shown below.

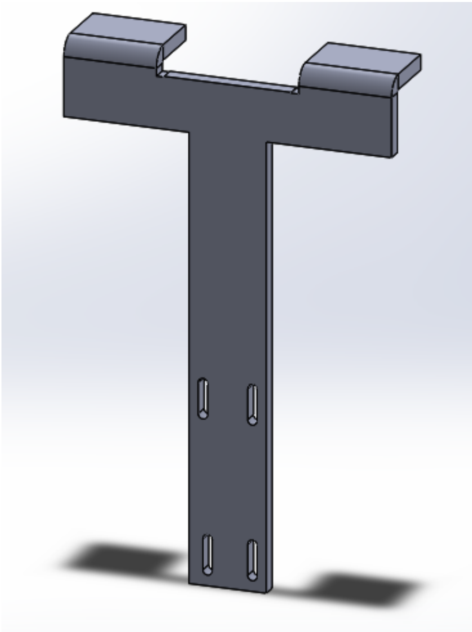


FIGURE 26 CAD MODEL OF LIFT ATTACHMENT

A carbide mounting is made of aluminum and attached to the smc slide on the front side, and a carbide rod with a diameter of 8mm and a length of 36mm is inserted in it. The major bearing comes into contact with the carbide rod.

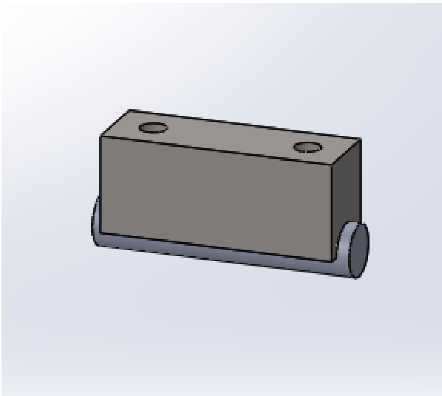


FIGURE 27 CAD MODEL OF CARBIDE HOLDER

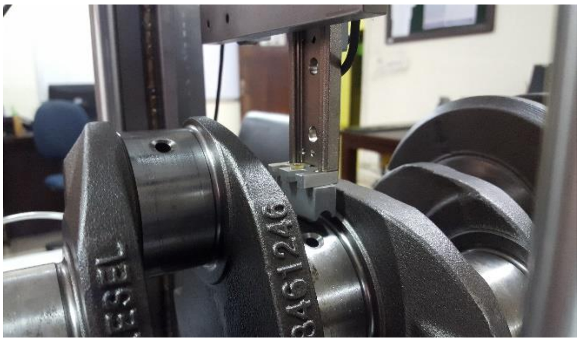


FIGURE 28 CARBIDE PIN AND HOLDER INSTALLED IN MACHINE

DRIVE PIN AND MOUNTING

This small assembly consist of 2 parts, pin and the pin mounting. The crankshaft that was under test has a flange at one end. this flange has 7 threaded holes and among these 7 hole 2 of them are unique. So the pin mounting was designed in such a way that it is always mounted on those two unique holes. The pin mounting is 10mm thick and has length and width of 60mm and 25mm respectively.

The pin is mounted in center of pin mounting and has diameter of 10.7mm and has a length of 60mm. this pin transfer the motion from the drive unit to the crankshaft.

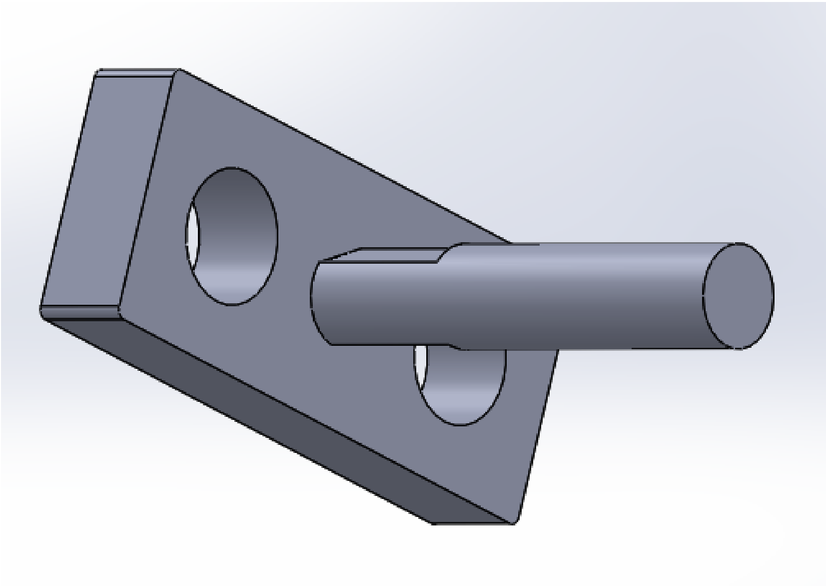


FIGURE 29 DRIVE PIN AND MOUNTING

DRIVE UNIT ASSEMBLY

This machine's driving unit was designed and built particularly for it. It's a one-of-a-kind design that serves as a dead center for the crankshaft and drive unit. The driving mechanism's components are listed below.

1 metal block
2 shaft holder
3 dead center shaft
4 hollow shaft encoder and encoder sleeve
5 pulley
6 stepper motor and its bracket
7 6806 bearings

The metal block is needed to provide the drive unit strength and height, as the dead center should be at 180mm. The SK-30 shaft holder is used to keep the dead center in place. On the dead center shaft, 6806 bearings are installed, and a pulley is placed on these bearings. The timing pulley utilized had 72 teeth and a pitch of 5mm, with a diameter of around 114mm and a thickness of 25mm. The encoder is mounted to the encoder sleeve, which is bolted to the side of the pulley. On the opposite side of the block, Nema 32 is placed on an L-shaped bracket. The pulley of the Nema 32 has 14 teeth and is 25mm wide. HTD-450-M5 is the belt that transfers motion from the stepper motor to the larger pulley. Both manufactured and designed drive unit is given below as well as a cross section is given as well.

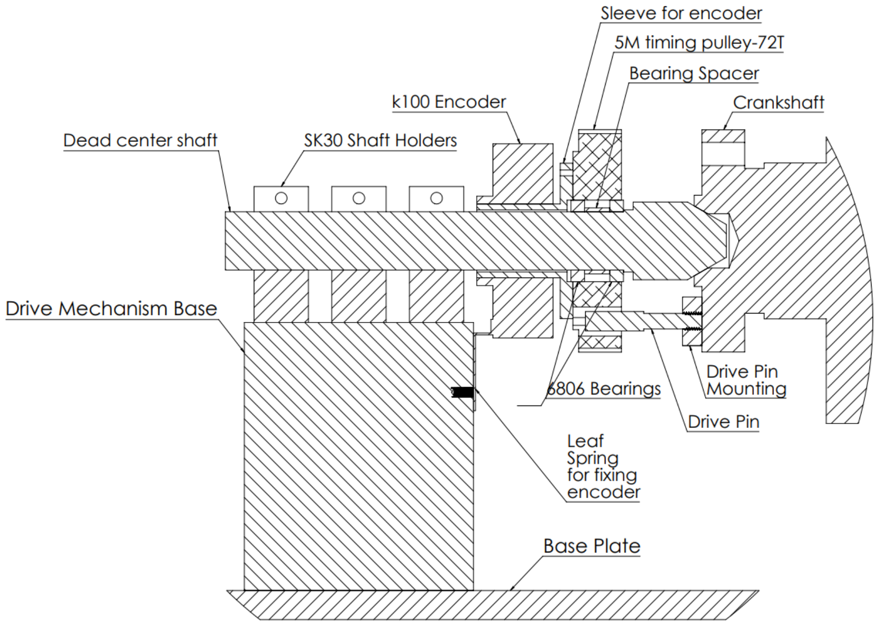


FIGURE 31 CROSS SECTION OF DRIVE UNIT

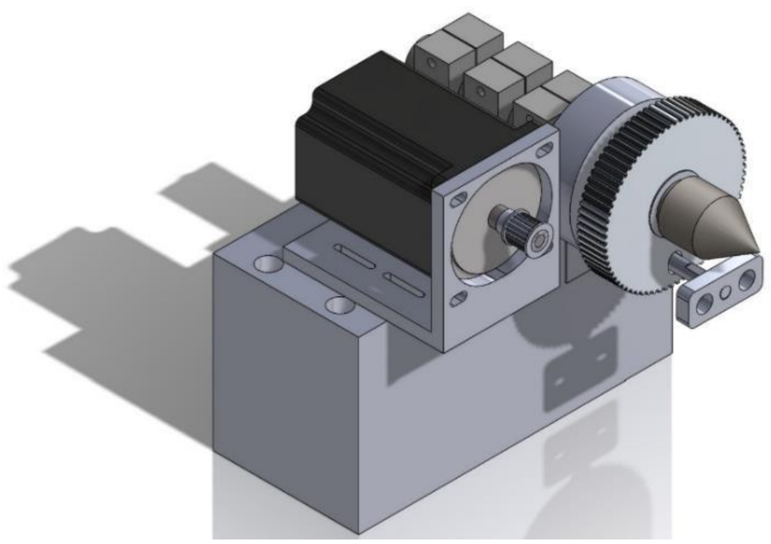


FIGURE 30 CAD MODEL DRIVE UNIT

FIGURE 32 MANUFACTURED DRIVE UNIT

TOWERS AND VERTICAL PLATE

In this machine, there are two towers that hold the vertical plate to which the runout assembly is attached. The electric slider is used for one tower, while the Higwin linear slider is used for the other. The height of the tower installed on a Higwin slider is 547mm, whereas the height of the tower mounted on an electric slider is 513mm. The vertical plate is 393mm in length and 120mm in breadth and is 10mm thick.

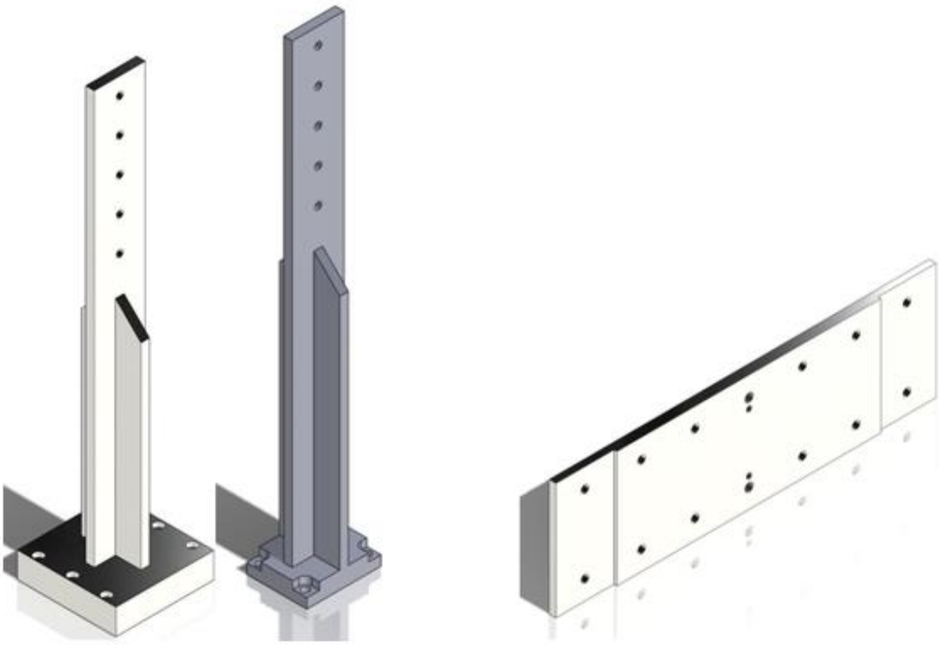


FIGURE 33 TOWERS AND VERTICAL PLATE

TAILSTOCK BLOCK

This block serves two purposes: it raises the center height of the tail stoke from 125mm to 180mm, and it features a slot that allows the tail stoke to be changed for both 3 and 4 cylinder crankshafts. This block has a height of 70 mm, a length of 365 mm, and a width of 125 mm.

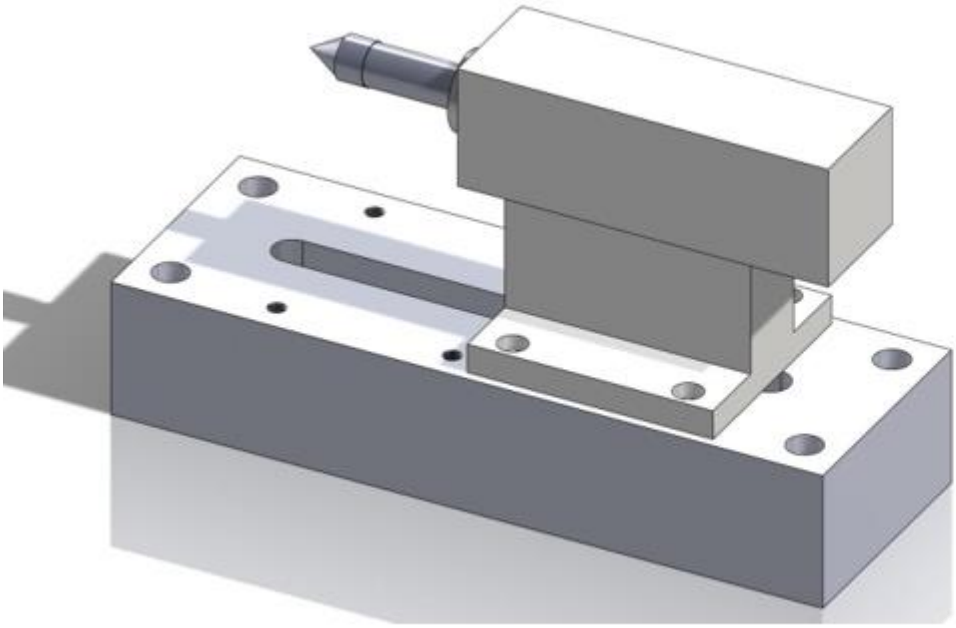


FIGURE 34 CAD MODEL TAILSTOCK AND ITS BLOCK

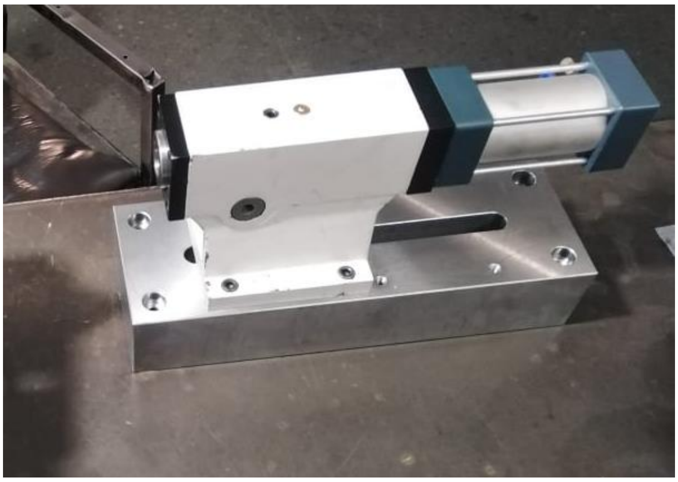


FIGURE 35 MANUFACTURED TAILSTOCK AND ITS BLOCK

FINAL DESIGN OF CAMSHAFT INSPECTION MACHINE

In actuality, after numerous design iterations and tests, all of the pieces were chosen and built. After that, the design was authorized, and the purchase of the selected components began. Meanwhile, the components and assemblies were developed and fabricated in accordance with the anticipated operation. Here you can see the finished CAD model as well as the real machine.

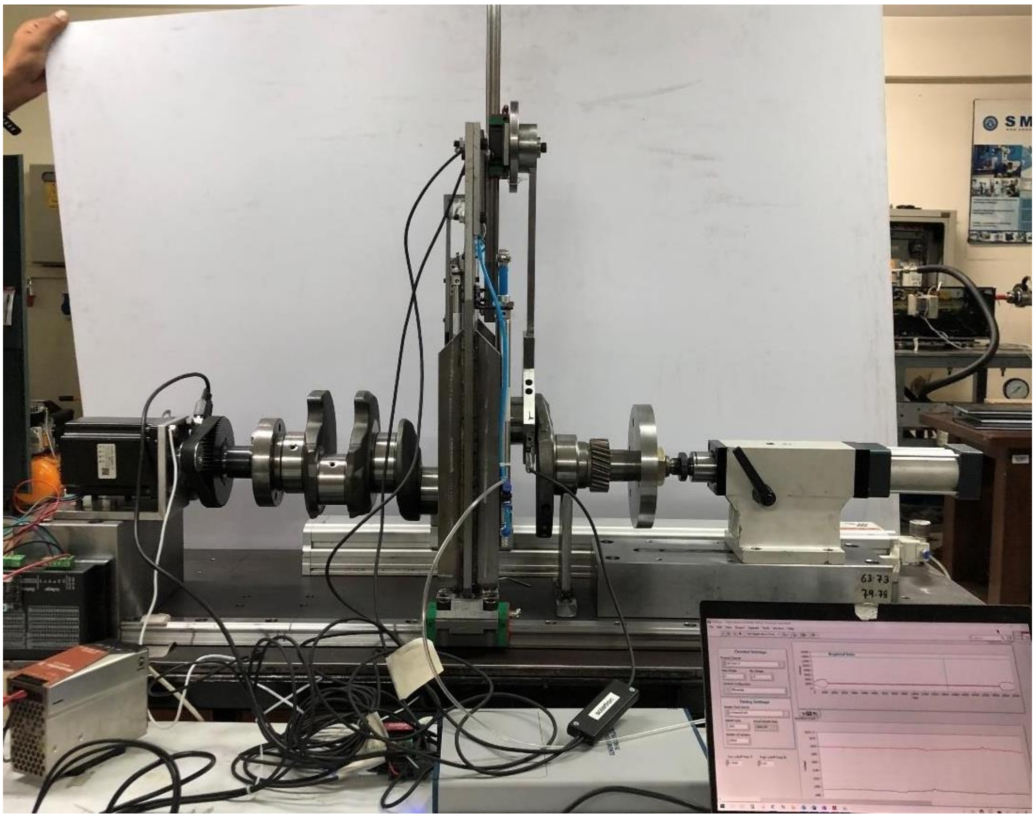


FIGURE 36 MANUFACTURED AND ASSEMBLED COMPLETE CRANKSHAFT MAIN BEARING RUNOUT MACHINE

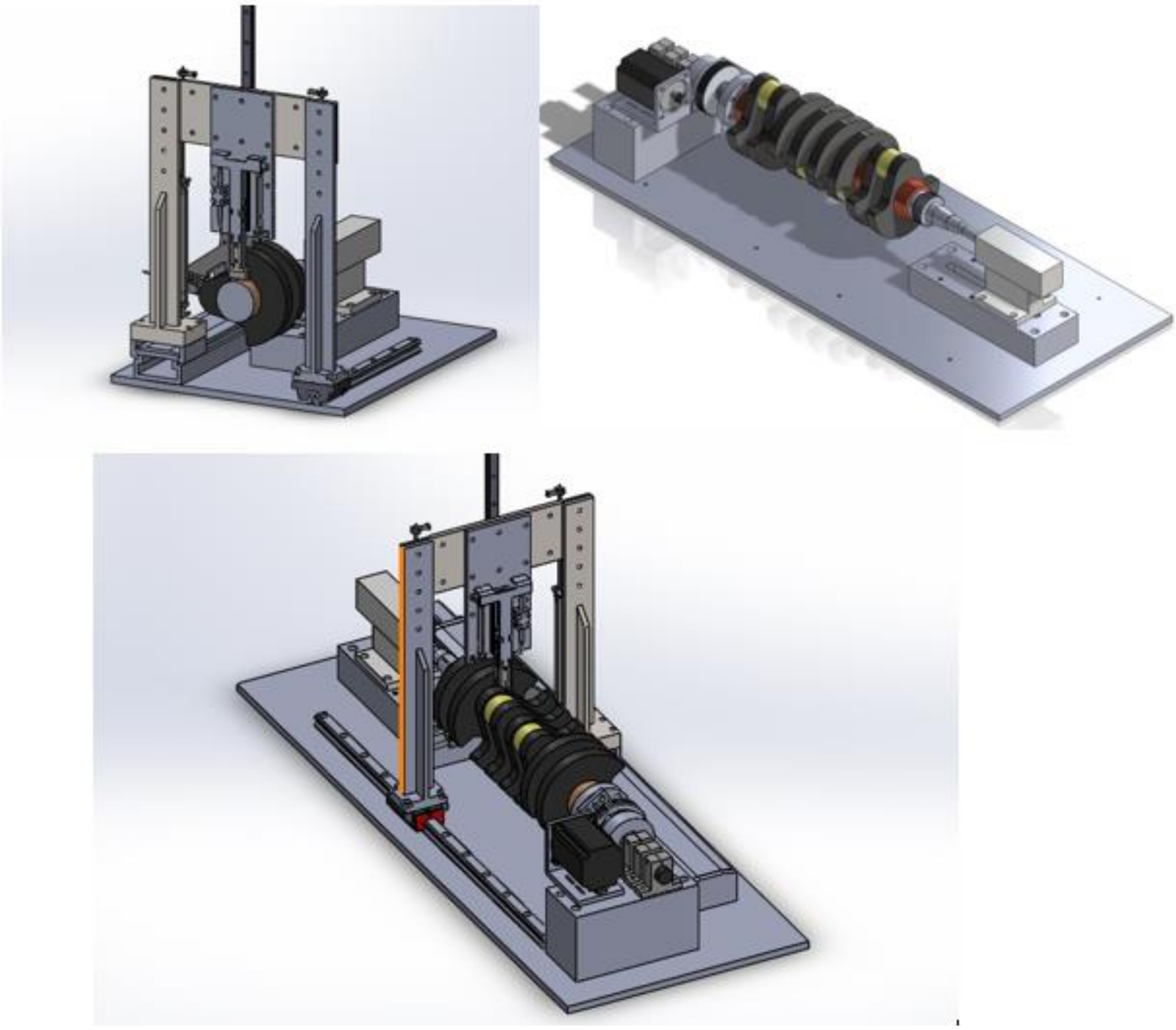


FIGURE 37 DIFFERENT VIEWS OF FINAL DESIGN OF CAD MODEL

CHAPTER NO 4: DATA ACQUISITION AND ELECTRONICS

Crankshaft inspection equipment uses very sensitive electronic measurements to determine the crankshaft. These gadgets provide signals that a data collecting system can analyses to produce useful output data. This chapter will go over the data acquisition system that was employed in this system.

DATA ACQUISITION

DAQ systems (data acquisition systems) are devices or procedures that collect data in order to document or evaluate a phenomenon. A sensor detects a physical amount and sends a signal to a device that amplifies or cleans the signal for electrical interference before feeding it to another device that transforms the analogue signal to a digital signal. After that, the digital signal is transmitted to a computer software for processing and reporting back to the user.

Electronic equipment has simplified and made this sort of procedure more precise, flexible, and dependable as technology has developed. Simple data loggers, complex computer systems, and even smart phones transformed into portable data collection daq. devices are all available.

Data acquisition systems serve as the system's focal point, connecting a wide range of goods such as temperature, flow, level, and pressure sensors.

DATA ACQUISITION SYSTEM

The following are the components of a data acquisition system:

1. Sensors
2. conditioning unit
3. Data acquisition card/module
4. LabVIEW

SENSOR

A sensor is a device that detects physical quality and converts it into an electrical signal. A transducer is another name for a sensor. We have a linear variable differential transducer (LVDT) in our situation, which translates physical changes in length into electrical voltage variations. The length gauge is another name for LVDT. The main sensor of our crankshaft inspection equipment was a Solartron LVDT type at/5/p. It provides a 0.5m resolution and a repeatability of just under 0.05m.

FIGURE 38 SOLARTRON FEATHER TOUCH LVDT WITH CONDITIONING UNIT

CONDITIONING UNIT

A data collection system's conditioning unit's goal is to clean, enhance, or suppress the noisy signal originating from the sensor put in the system. Because of electrical, optical, or mechanical interference, the signal emitted by the sensor after performing a physical quantity measurement is usually highly noisy. Sometimes, as in our instance, the signal from the sensor is insignificant in comparison to the physical quantity. As a result, a conditioning unit is utilized to alleviate both problems through amplification and signal cleaning. Our sensor's conditioning unit is a boxed in-line conditioning module (BICM), which operates on a bipolar DC supply of 15 volts. With an LVDT sensor, the BICM is ready to use.

DAQ CARD

Data acquisition card is used to converts analogue signal from conditioning unit to digital signal that is readable by the computer. For that purpose, it has a built-in analogue to digital (ADC). For prototyping purposes, NI X-series USB card has been used. It has:

1. Analogue inputs: 16
2. Digital I/O: 24
3. Analogue outputs: 2
4. DIO max clock rate: 1MHz

FIGURE 39 NI INSTRUMENTS DAQ CARD

LABVIEW

National Instruments created LabVIEW, which is an abbreviation for Laboratory Virtual Instrument Engineering Workbench, a graphical or visual programming language. It's utilized to create and construct data acquisition, instrument control, and automation systems. Because of its ease of use and visible data flow depiction, this platform was chosen for the operation of the crankshaft inspection machine. There are two windows on the platform: a block diagram window and a front panel window. The majority of the programming is done in the block diagram window, while the controls and graphs of the readings are displayed on the front panel. Below picture show the basic layout of LabVIEW software

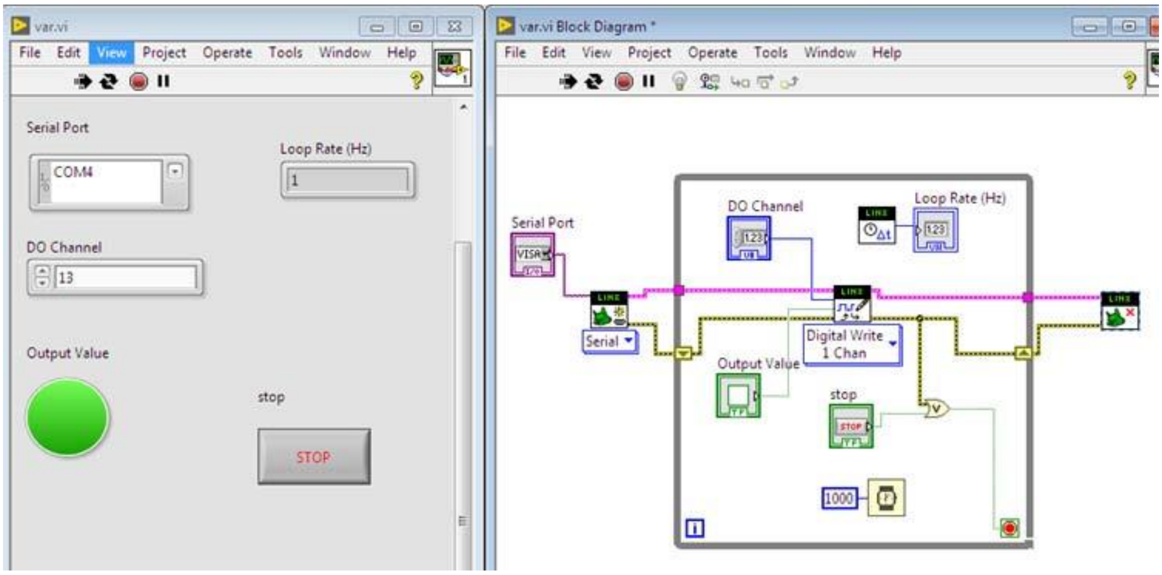


FIGURE 40 LABVIEW INTERFACE

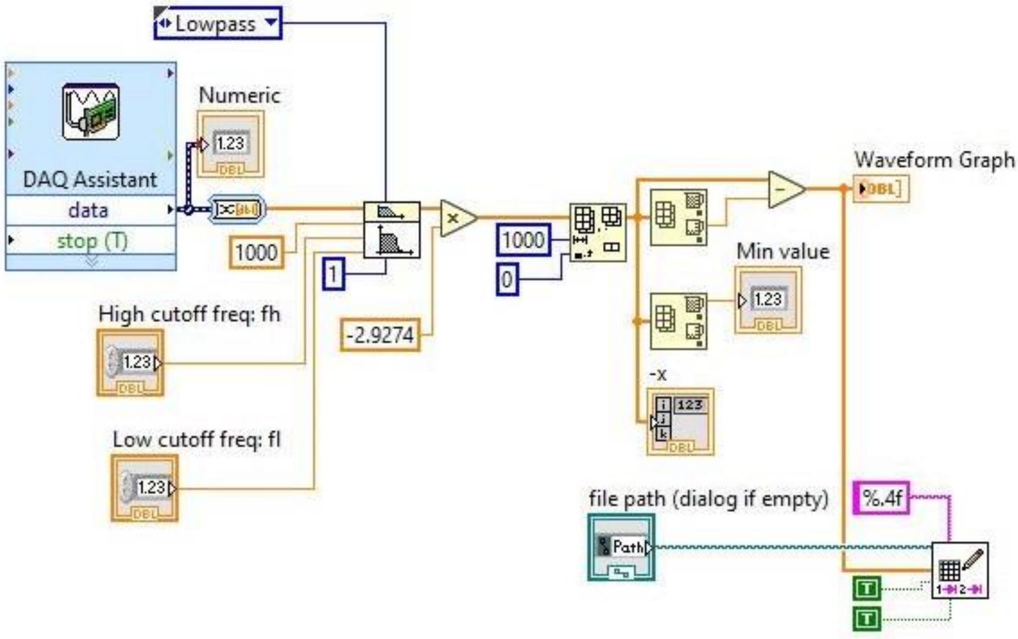
DATA ACQUISITION SYSTEM CIRCUIT DIAGRAM

The data acquisition system created for the crankshaft inspection machine's circuit is depicted in the diagram below.

FIGURE 41 DATA ACQUISITION CIRCUIT DIAGRAM

LABVIEW DATA ACQUISITION SYSTEM BLOCK DIAGRAM

The data acquisition system is depicted in this block diagram as the programmer that reads digital data from the DAQ module and represents the reading in the form of crankshaft main bearing runout using virtual instruments provided in LabVIEW.



CHAPTER #5: RESULTS AND CONCLUSIONS

This chapter gives an overview of the testing process as well as the outcomes of the tests. The machine's measurements are compared to the OEM-specified specifications and their tolerances. The machine's results and performance are discussed.

TESTING

The test design has a significant impact on the test outcome. It's crucial to make sure that the design purpose and the user demands are in sync. The steps in this procedure are as follows:

DESIGN VERIFICATION

The term "design verification" refers to ensuring that the product works as planned by the designer. The inspection machine, for example, is intended to measure the runout and its fluctuation at intervals of less than 0.5°. The present configuration has a maximum reading rate of 48000 readings per rotation. As a result, the reading interval might be as low as 0. 0075°.The test arrangement, on the other hand, takes 1000 samples every rotation. This results in a 0.36-degree interval. The repeatability and accuracy should be less than or equal to 0.001mm.

The design process is iterated until the design is confirmed if the findings cannot be verified.

DESIGN VALIDATION

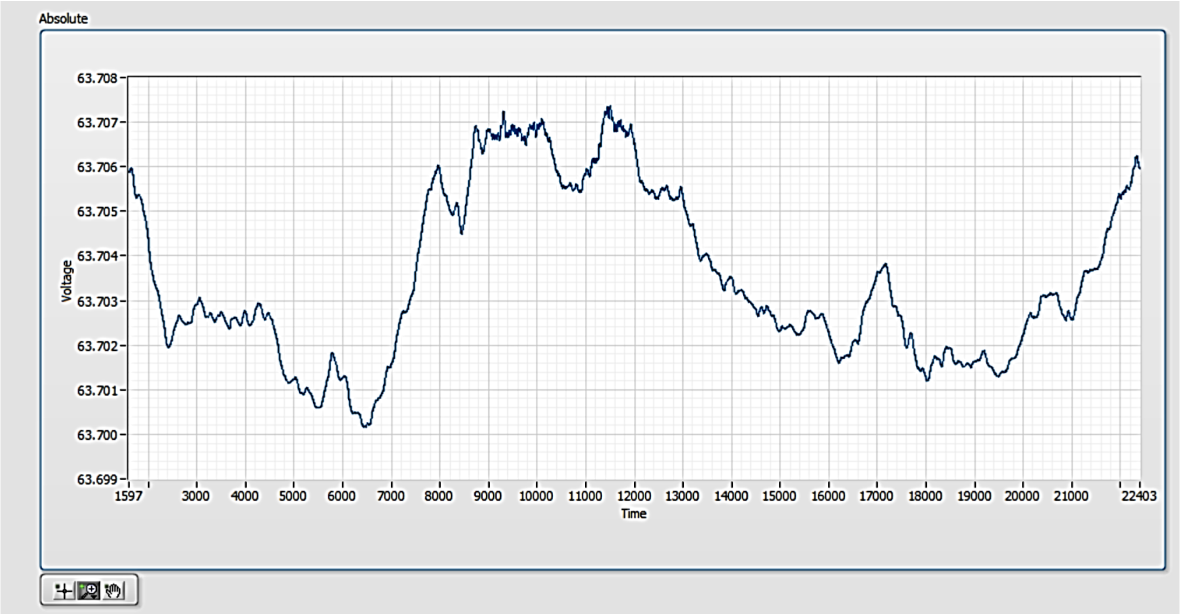
Design validation comes after a successful design verification. Design validation is the process of evaluating the outcomes that have already been validated. It guarantees that the customer's requirements are satisfied. If the design cannot be validated, the test controls are changed until validation and verification agree. If the design cannot be confirmed, the design process is repeated until the verification and validation are completed successfully.

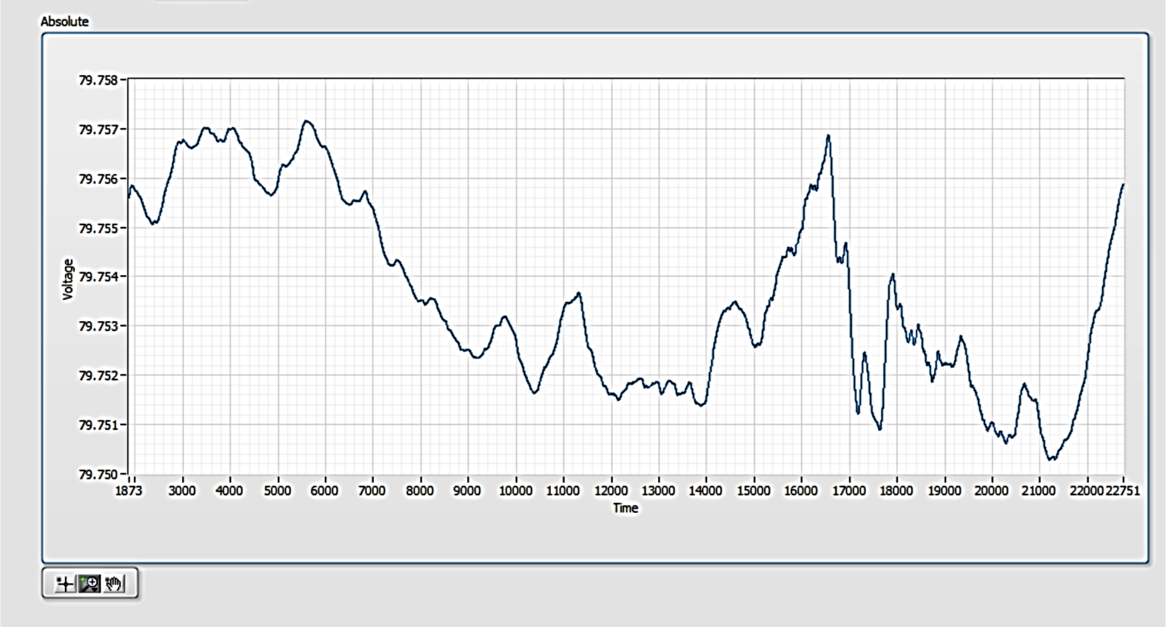
DESIGN OF THE TEST

The most important factors in the design of a test for a crankshaft inspection machine are accuracy and repeatability. The test should be done several times with the same results each time. The runout assembly is dropped onto the main journals and the crankshaft is spun at least 360° twice for current testing. The runout values are taken in two cycles of crankshaft rotation, one in the first cycle and the other in the second cycle. This makes comparing the runout variation values for two cycles much easier.

DATA AND GRAPH

The below graph shows the runout of main journal bearings using the above LabVIEW program which was mentioned in details.





Both the designer's and the user's planned functions are met by the equipment. It inspects both 3- and 4-cylinder engines and can accurately quantify main journal runout. This machine can give runout having accuracy of one micron.

CONCLUSION AND RECOMENDATION

This chapter includes a thorough conclusion based on the findings. There will also be suggestions for future projects of a similar kind and improvements that may be made to this machine.

CONCLUSION

A functional crankshaft inspection machine was designed and constructed after several design revisions and testing. The crankshaft inspection machine's parts were carefully chosen and produced, and they functioned well. The data collecting system was difficult to create, but it produced a clean output signal and performed well. Multiple readings of key journals were taken under various settings, and the same results were achieved. The data was taken on several days with varied settings, yet the output remained consistent, demonstrating the machine's industrial grade durability and reproducibility. There were no inconsistencies in the machine's output when it was tested. Overall, the project was a success, but like with any other project, there is always space for improvement.

RECOMMENDATIONS

FUNCTIONAL RECOMMENDATION

The following enhancements are suggested for future prototype iterations:

1. This prototype lays the basis for a variety of automobile OEM goods. Multiple characteristics, such as diameter and phase angle measurements (relative locations of pin journals) and cylindricity, can be added to make it a full-scale commercial product.
2. The modular design makes retrofitting for the above specified dimensions more easy.
3. The machine may be mechanized for industrial usage, allowing for greater production.

DESIGN RECOMMENDATION

The driving mechanism as well as the pneumatic base are both large and hefty. These blocks can be fashioned shell-like for a final industrial product to save weight.

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