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Design and development of bumping clearance measuring gauge

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ABSTRACT
In this paper bumping clearance measuring gauge for four stroke internal combustion engine, is been developed which intern measures the very accurate set of shims to be required. Earlier the required set of shims to be inserted is calculated by trial and error method. Now this is done with the introduction of proximity sensor and programmed processing unit which measures the oversized piston height with reference to the cylinder block. The contactless measuring technique with the help of proximity sensor will give readings with very high accuracy and which completely eliminates the operator involvement. The reading from sensor will be served as an input to the PCB and microcontroller 8051. The required set of shims to be inserted on to the cylinder block is calculated to get exact set of shims. The operator gets the required thickness of shims set in thou.
By implementation of such measuring gauge has reduces cycle time of this operation almost to the half, results in increase the production rate as well. Results here in the paper are tabulated experimentally for set combustion engines. It is expected that the methodology used and the results presented will be useful in the optimal performance of internal combustion engine.
Keywords: Measuring gauge, Microcontroller 805, PCB

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I. INTRODUCTION

The adjustment of Bumping Clearance is a very critical adjustment of the clearance volume. If more the clearance volume, then volumetric efficiency of the four stroke diesel engine suffers and if less the unloaded piston may hit the cylinder head and damage both.

1.1 Bumping Clearance

Bumping clearance as the name signifies is a clearance given so that the piston of the diesel engine would not bump into its cylinder head. In new diesel engine this clearance is adjusted by the manufacturers and the workers who are going to assemble an engine are blissfully unaware of its importance.

Bumping is a process in which T.D.C. of engine cylinder or clearance between piston and cylinder head is set by placing shims between liner and cylinder head. Bumping is used to provide proper clearance between Piston and cylinder head. Generally, piston comes above or below the T.D.C. of engine while rotation of crank shaft during assembly and when this happens it means it will result in head noise. In order to avoid this shims according to need, have desired thickness are introduced between liner and cylinder head. By this process all cylinders of engine have the same clearance value.

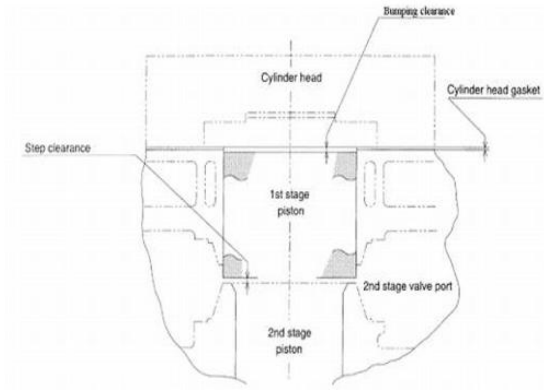


Fig 1.1 Bumping Clearance

Significance and Effects of Bumping Clearance:-

In an engine, when the discharge valve closes in the end of the compression cycle, a small amount of high pressure air-fuel mixture is trapped in the clearance volume. Before again taking suction, the air trapped in the clearance volume must expand below the suction pressure i.e. below the atmospheric pressure. The expansion of this trapped air-fuel mixture in the clearance volume causes effective loss of stroke due to which the volumetric efficiency of engine drops. Therefore, the clearance volume (bumping clearance) has a significant effect on the efficiency of the engine.

Adjustment of Bumping Clearance:-

The adjustment of bumping clearance is done by inserting shims below the cylinder block which having certain thickness. The amount of thickness of shims required depends on how much piston is oversized over the top surface of cylinder block. There are different shims are available with different thicknesses, so multiple combinations of shims can be used to adjust the bumping clearance if how much piston is oversized over the top surface of cylinder block is known.

Fig 1.2 Shims

Flow Chart

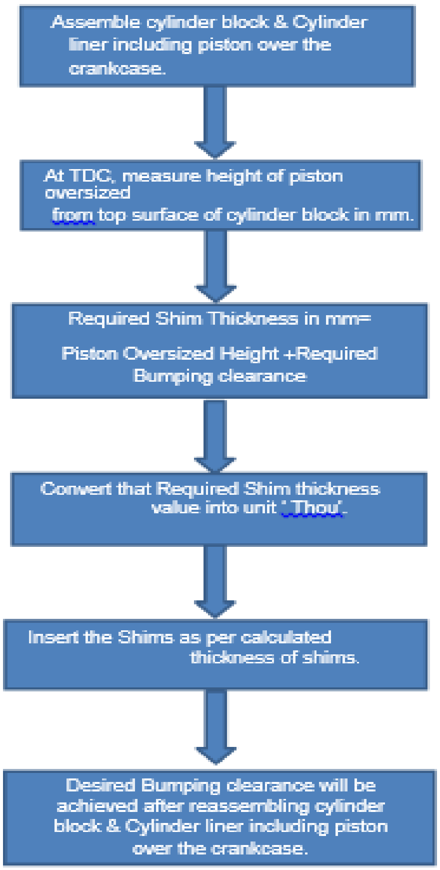


Fig 1.3: Adjustment of Bumping Clearance

Hence measuring the height oversized by the piston from top surface of cylinder block is essential for adjusting the desired bumping clearance in that engine.

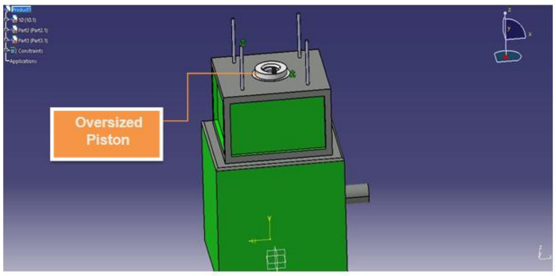


Fig 1.4 Oversized Piston.

1.1 Various Tools and Techniques used for Measure Oversized Piston Height:-

1.1.1 Dial Gauge with Bridge Stand

Fig 1.5 Dial Gauge with Bridge Stand

In that dial gauge is mounted on bridge type stand and it is fixed in that bridge stand tightly. The dial gauge is fixed in that bridge stand in such a way that the bottoms of bridge stand and end of plunger of dial gauge are in-line as shown in fig.

After assembling of cylinder block, the bridge stand with dial gauge is places on the well finished cylinder block. Initially the dial gauge set to zero position; it cannot show any deflection until piston oversize over the top of cylinder block. After placing this instrument over cylinder block of engine, piston is brought at its TDC by rotating crankshaft manually. At that time the dial shows the height of piston" top surface from the top of cylinder block. Then worker adds required bumping clearance in the dial gauge reading and calculates required thickness of shims. Then worker choose multiple shims whose total thickness is equal to required shim thickness. Then worker will add that much of shims below of cylinder block and reassembles the cylinder block again and required bumping clearance will be achieved.

Another kind of instrument which exists till in the LOEPL is shown below.

Fig 1.6 Instrument used in LOEPL

1.1.1 Vernier Height Gauge with Dial: -

Fig 1.7 Vernier Height Gauge with Dial

It is conventional Vernier height gauge only the dial is mounted over it. The dial is interlinked with plunger of height gauge as shown in fig.

In that the worker has to only place this height gauge over the cylinder liner vertically. Initially the dial shows zero reading. Whenever piston is at its TDC then the dial will show the height oversized by the piston from top of cylinder block.

Then worker will do further calculation as same as above method of bridge stand and adjusts the bumping clearance of that particular diesel engine.

II. PROBLEM STATEMENT

Laxmi Oil Engine Pvt. Ltd (LOEPL) is the company where our project problem was found. How the worker in LOEPL adjusts the bumping clearance of an engine is described in flow chart given below:

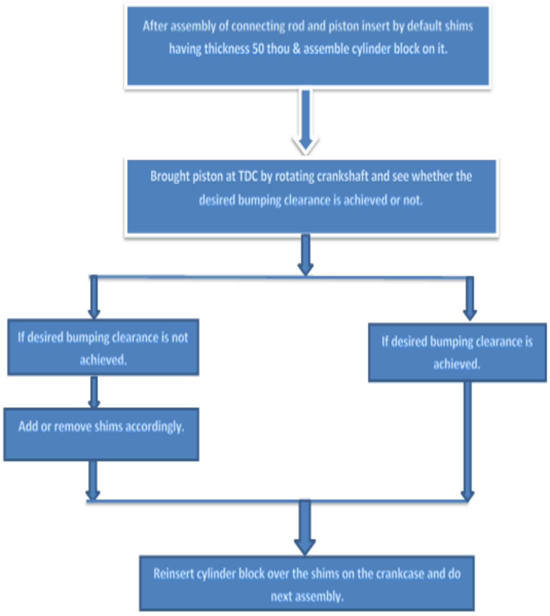


Fig 2.1 Flow chart for adjustment of bumping clearance

The procedure followed by the worker in the LOEPL is shown in above flow chart.

This procedure has some disadvantages are as follows.

1. They could not to be using any kind of measuring instrument to oversized piston height. Only by using thumb rule they approximately predict the oversized piston height which will definitely create an error in adjustment in bumping clearance.
2. After inserting shims they will assume, if the piston is at TDC and it reaches lower edge of chamfer which is provided at top of cylinder liner then desired bumping clearance (0.91 mm – 1.1 mm) will be achieved. The chamfer provided during machining is shown in fig. below.
3. If the piston is at TDC and it not reach lower edge of chamfer which is provided at top of cylinder liner then they will again disassemble the cylinder block. After that by trial and error they add/remove shims and again assemble the cylinder block and repeat the procedure till maintaining desired bumping clearance (0.91 mm – 1.1 mm).

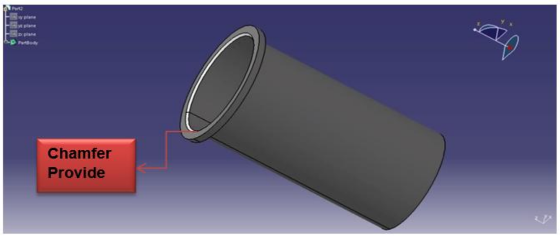


Fig 2.2 Cylinder Liner

4. Hence this current procedure used in LOEPL takes more time to adjust the bumping clearance which will lowers the productivity of the LOEPL.
5. Also this procedure not a reliable, there is always 2-3 engines from the lot of 100 engines have the bumping clearance out of desired limit which are unable to start at the time of testing.

III. EXPERIMENTAL WORK

The experimental work of our project is distinguished in three parts are as follows:

1. PART A (Measurement of oversized piston height)
2. PART B (Calculation for required shim thickness)
3. PART C (Fabrication for experimental set-up)

3.1 PART A: Measurement of Oversized Piston Height

3.1.1 Advantage of non-contact type measurement over contact type measurement

- Superior resolution.
- Excellent Non-Linearity.
- Enhanced thermal and long term stability.
- High sensitivity
- Lower power consumption.
- Small package size.
- High repeatability.

3.1.2 The commonly used displacement sensors are listed below:

1. Potentiometer sensors
2. Strain gauged element
3. Linear Variable Differential Transformer “LVDT”:
4. Eddy current proximity sensors
5. Optical position encoders
6. Pneumatic sensors
7. Proximity switches
8. Inductive proximity sensor

3.1.3 Selection of Sensor

For measuring height of oversized piston we select **Inductive Proximity Sensor** and which is sponsored by **IFM Electronics, India**, Kolhapur. Reasons of Selecting the Inductive Proximity Sensor are as follows:

1. Detecting distances are small, typically one inch or less.
2. Circuitry is protected by a rugged, epoxy-full housing.
3. Inductive proximity sensors will detect metals.
4. They have shortened sensing distances for conductive metals.
5. Inductive proximity sensors are known to be repeatable to 0.0001 inch.
6. Inductive sensors have a wide range of input voltages, 10 to 30 V DC and beyond are typical.
7. They are relatively strong against temperature extremes from –40 C to 85 C.

This PART A (Measurement of oversized piston height) consists three main components are as follows:

1. Inductive Proximity Sensor
2. LC Display
3. 24 Volt Power Source

3.1.4 Inductive Proximity Sensor

Principles of Operation for Inductive Proximity Sensors

Inductive proximity sensors are noncontact proximity devices that set up a radio frequency field with an oscillator and a coil. The presence of an object alters this field and the sensor is able to detect this alteration. An inductive proximity sensor comprises an LC oscillating circuit, a signal evaluator, and a switching amplifier. The coil of this oscillating circuit generates a high-frequency electromagnetic alternating field. This field is emitted at the sensing face of the sensor. If a metallic object (switching trigger) nears the sensing face, eddy currents are generated. The resultant losses draw energy from the oscillating circuit and reduce the oscillations.

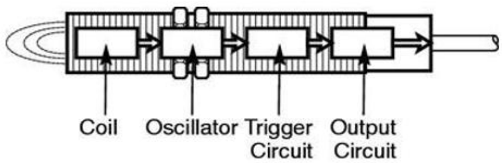


Fig 3.1 Parts of inductive sensor

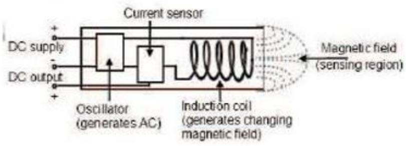


Fig 3.2 Internal Circuit of Inductive Sensor

The signal evaluator behind the LC oscillating circuit converts this information into a clear signal by effective impedance. Figure 3.18 shows its construction and Figure 3.19 shows its operation. The sensor reduction circuit monitors the oscillatory strength and triggers an output signal from the output circuitry proportional to the sensed gap between probe and target. Inductive proximity sensors are designed to operate by generating an electromagnetic field and detecting the eddy current losses generated when ferrous and nonferrous metal target objects enter the field. The sensor consists of a coil on a ferrite core, an oscillator, a trigger-signal level detector and an output circuit. As a metal object advances into the field, eddy currents are induced in the target. The result is a loss of energy and smaller amplitude of oscillation. The detector circuit then recognizes a specific change in amplitude and generates a signal which will turn the solid-state output "ON" or "OFF".

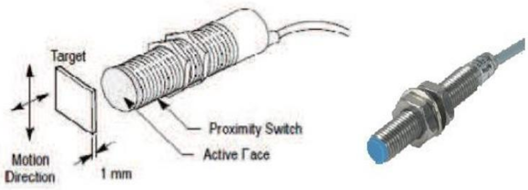


Fig 3.3 Proximity Sensor and its Detection

The active face of an inductive proximity switch is the surface where a high frequency electro-magnetic field emerges. A standard target is a mild steel square, one mm thick, with side lengths equal to the diameter of the active face or three times the nominal switching distance, whichever is greater. For every rotation a pulse is produced and time interval also sensed.

We used this inductive type of proximity sensor to measure the oversized height of piston from the top of cylinder surface which is sponsored by **IFM Electronics India** as shown in fig. below.

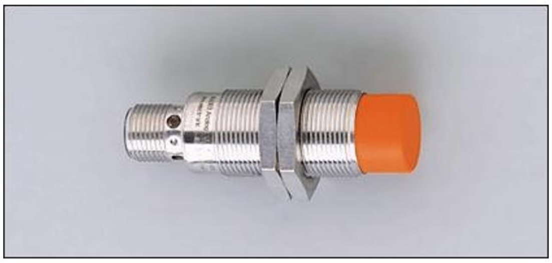


Fig 3.4 IFM Inductive Proximity Sensor (IG6083)

Connection Diagram of components in PART A is schematically represented as follows:

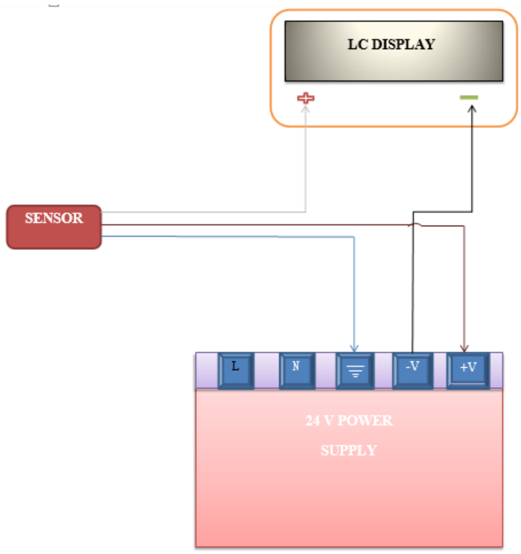


Fig 3.5 Connection Diagram of Inductive Proximity Sensor

3.1.5 LC Display

This LC display has also sponsored us by the **IFM Electronics India**. It takes input analog signal from sensor and displays the corresponding readings.

Function and features:-

The display indicates analog output values of pulse evaluation systems, pressure sensors, flow sensors and suchlike. It is directly switched into the current loop of the output which supplies the display with voltage.

- Current range: 4...20 mA or 10...50 mA.
- Display with free scaling: -1999...1999 (zero point) / 0...2000 (maximum value).

Installation:-

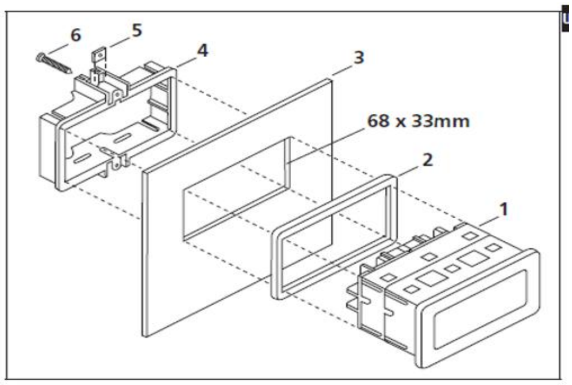


Fig 3.6 Installation of LC Display

1: Unit 2: Washer 3: Control panel
4: Clamping frame 5: Square nuts 6: Mounting screws

- **Adjustment:-**

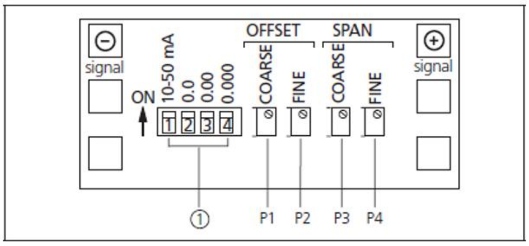


Fig 3.7 Adjustment of LC Display

1: DIP switch
P1: Coarse setting min. value P2: Fine setting min. value P3: Coarse setting max. Value P4: Fine setting max. Value

Adaptation to the current range
The standard setting of the unit is 4...20 mA.
Set the DIP switch 1 to ON to select the range of 10...50 mA.

Setting the decimal point
The basic setting is a display without decimal places. Set the DIP switch 2 (or 3 or 4) to ON if one (or 2 or 3) decimal places are to be indicated.

Scaling the displayed range
Apply the lowest signal; set approximately the requested minimum value of the display by means of potentiometer P1.Apply the highest signal; set approximately the requested maximum value of the display by means of potentiometer P3.Repeat steps 1 and 2 until the requested values are indicated approximately.
24 Volt DC Power Supply
As the operating DC voltage range of inductive proximity sensor is in between
15 V- 30 V there is need of step down transformer which converts the analog 230 V voltage into 24 V.

Working of PART A

Hence PART A in experimental set up is for the measurement purpose. After successfully making the connections of sensor, display, 24 v power supply and extension board of 230 v output as shown in fig this PART A set up is ready to measure. The actual set photo of PART A on experimental set up is shown below:

Fig 3.8 Photograph of PART A

Whatever be the position detected by the sensor is converted into height of display from certain reference and it is indicated on display in mm. In our project we require two reading of piston positions that are as follows:
Initial reading „a"
This reading is taken when the piston of an engine is at in line with top of cylinder liner and block. This is nothing but zero position reading of piston with respect to certain reference and it is denoted by letter „a".
Final reading „b"
This reading is taken at when piston is at TDC. That is the maximum reading value indicated in display whenever the crankshaft is rotated simultaneously one or two cycles manually.
PART B (Calculation for required shim thickness)
After finding the oversized piston height from the top surface of cylinder block when piston is at TDC then next step in adjusting the bumping clearance of an engine is, calculate the required shim thickness.
Formula for calculation of required shim thickness:-

Required Shim Thickness (mm) = 0.96 + Oversized Piston Height (mm)… (a)

As bumping clearance value which we are going to adjust is in between 0.91 mm to
1.1 mm in LOEPL. Hence the mean value of this clearance range i.e. 0.96 is used in equation (a)
Also the shims available in LOEPL are having thickness of 5, 10, 15 thou. Thus, after calculating the required shim thickness in mm, that thickness must convert into the unit thou. The relation between mm and thou is,
1 mm = 39.76 thou.

Hence the equation (a) can be modified as,

Required Shim Thickness (thou) = [0.96 + Oversized Piston Height (mm)] * (39.76) (b)
Equation (b) is the final formula to get the required thickness of shim in thou.

Experimental work of PART B:-

To do the calculation of required shim thickness we use the PCB circuit having microcontroller 8051 as well as the display (16*2) with numeric keypad (4*4). The overall unit of PART B contains three main parts,
PCB circuit with microcontroller 8051
Display (16*2)
Numeric Keyboard (4*4)

3.2.3 Microcontroller 8051

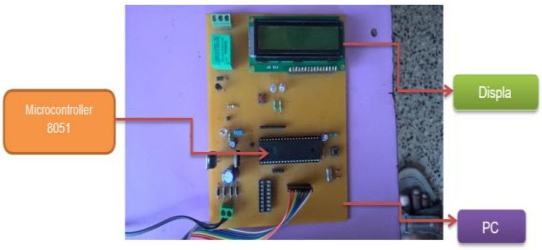


Fig 3.9 PCB with Microcontroller 8051 and display

A microcontroller unit is a small computer on a single integrated circuit consisting of a relatively simple CPU combined with support functions such as a crystal oscillator, timers, watchdog, serial and analog I/O etc. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a, typically small, read/write memory.

The 8051 architecture provides many functions central processing unit (CPU), random access memory(RAM), read-only memory (ROM), input/output (I/O), interrupt logic, timer, etc.) in one package:

8-bit arithmetic logic unit (ALU) and accumulator, 8-bit registers (one 16-bit register with special move instructions), 8-bit data bus and 2×16-bit address bus/program counter/data pointer and related 8/11/16-bit operations; hence it is mainly an 8-bit microcontroller
Boolean processor with 17 instructions, 1-bit accumulator, 32 registers (4 bit- addressable 8-bit) and up to 144 special 1 bit-addressable RAM variables (18 bit- addressable 8-bit)[3]
Multiply, divide and compare instructions

4 fast switchable register banks with 8 registers each (memory mapped)
Fast interrupt with optional register bank switching
Interrupts and threads with selectable priority[4]
Dual 16-bit address bus – It can access 2 x 216 memory locations – 64 KB (65,536 locations) each of RAM and ROM
128 bytes of on-chip RAM (IRAM)
4 KB of on-chip ROM, with a 16-bit (64 KB) address space (PMEM). Not included on 803X variants
Four 8-bit bi-directional input/output port, bit addressable
UART (serial port)
Two 16-bit Counter/timers
Power saving mode (on some derivatives)

One feature of the 8051 core is the inclusion of a boolean processing engine which allows bit-level boolean logic operations to be carried out directly and efficiently on select internal registers, ports and select RAM locations. This feature helped cement the 8051's popularity in industrial control applications because it reduced code size by as much as 30%.[citation needed] Another feature is the inclusion of four bank selectable working register sets which greatly reduce the amount of time required to complete an interrupt service routine. With one instruction, the 8051 can switch register banks versus the timeconsuming task of transferring the critical registers to the stack, or designated RAM locations. These registers also allowed the 8051 to quickly perform a context switch.

The graphical representation of microcontroller 8051 is as shown fig. below.

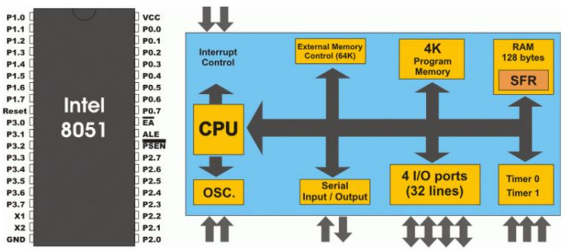


Fig 3.10 Microcontroller 8051

In our project we use this microcontroller 8051 which is mounted on PCB (Printed Circuit Board). In that microcontroller we feed on program which gives output as a thickness of shim in „thou‟ which is desired. For that we have to give two readings input that are nothing but initial reading „a‟ and final reading „b‟. These two readings a and b can be brought by the sensor and LC display unit by rotating crankshaft of an engine. Also we input these two reading by the keyboard which is also one of the component of PCB unit. The keyboard is shown in fig below.

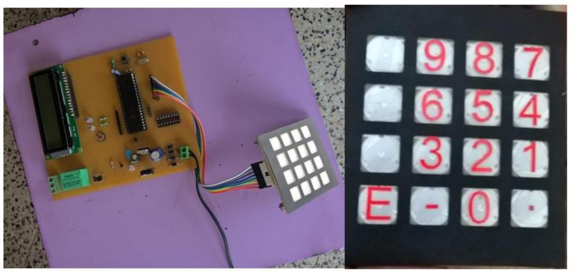


Fig 3.11 Keyboard with PCB

Programming

There are various high-level programming language compilers for the 8051.

Several C compilers are available for the 8051, most of which allow the programmer to specify where each variable should be stored in its six types of memory, and provide access to 8051 specific hardware features such as the multiple register banks and bit manipulation instructions. There are many commercial C compilers. Small Device C Compiler (SDCC) is a popular open source C compiler. Other high level languages such as C++, Forth,

BASIC, Object Pascal, Pascal, PL/M and Modula-2 are available for the 8051, but they are less widely used than C and assembly.

Because IRAM, XRAM, and PMEM (read only) all have an address 0, C compilers for the 8051 architecture provide compiler-specific pragmas or other extensions to indicate where a particular piece of data should be stored (i.e. constants in PMEM or variables needing fast access in IRAM). Since data could be in one of three memory spaces, a mechanism is usually provided to allow determining to which memory a pointer refers, either by constraining the pointer type to include the memory space, or by storing metadata with the pointer.

Also the program which we feed into the microcontroller is in C language. Similar program we were done in C++ language is as follows:

```
#include<iostream.h>
#include<conio.h>

class bumping
{
float a,b,c ;
public:
void getdata();
void cal();
void display();

};
void bumping::getdata()
{
cout<<"Enter initial
reading"<<endl;
cin>>a;
cout<<"Enter final reading"<<endl;
cin>>b;
} void bumping::cal()
{
c={[0.96+a+(-1*b)]*39.76};
}
void bumping::display()
{
cout<<"Thickness of shiemes
="<<c<<endl;
}
void main ()
{
clrscr();
bumping s;
s.getdata();
s.cal();
s.display();
getch();
}
```

This PART B contains Printed Circuit Board (PCB) with display (16*2) and keyboard (4*4) which is housed into wooden box to assure the safety of these parts as well as safety of worker who is going to work on it. Also the 24 volt DC power source is also mounted on this wooden box and this whole box can be invoked as **PCB Unit**.

Fig 3.12 PCB Unit

3.3 PART C (Fabrication for Experimental Set up)

The image of that rough design is given below.

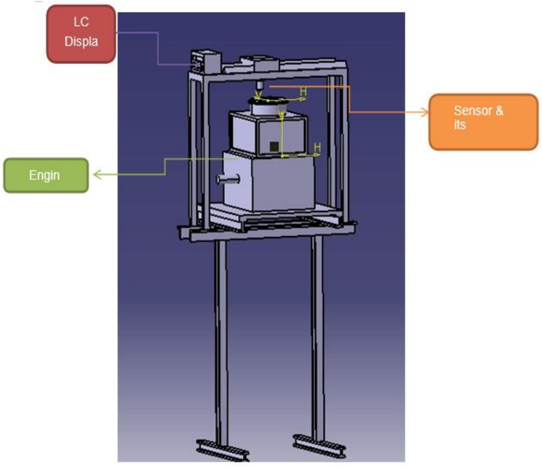


Fig 3.13 Rough Design of Fabrication

3.3.1 Initial measurement-

After making rough design we decided to make a separate station for our set up. For that we have to fabricate a table with flat surface plate which must be compatible with the existing assembly line table. Thus, the work measuring table we are going to fabricate is according to the assembly line of Laxmi Oil Engines Pvt. Ltd.

So before fabrication we have to take some measurements on existing assembly line in LOEPL, which are as follows.

Table 3.2 Initial Measurements

Sr. No.	Specification	Size (mm)
1.	Height upto the surface plate	787.4
2.	M.S. flat Plate	457.2x381x5
3.	Range of height of engines	310 to 422

As per our measurements and all the accessories we are going to mounted is conceptualized model as shown.

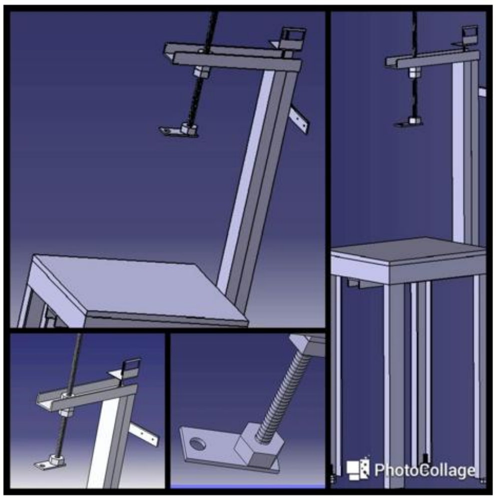


Fig 3.14 CATIA Design

Table 3.3 Material list for Fabrication

Sr. No.	Specification	Size	Quantity
1.	„C" Channel	70x35 mm (30 feet)	1
2.	M.S. Flat Plate	457.2x381x17 mm	1
4.	Lead Screw	M16 (1.70 feet)	1
5.	Lead Screw Nut		3
6.	Nut & Bolt		4
7.	Nut & Bolt		1
8.	Sensor Plate	100x35x4 mm	1

3.3.1 Fabrication Work

The fabrication part in our project is distinguished in three parts are as follows.

- Table with surface plate
- Mounting for sensor and LC display
- Mounting for PCB unit.

1. Table with surface plate

As per measurements taken in the LOEPL, the table is fabricated with mounting of surface plate. As we are going to take measurements on this table it is essential to maintain perfect level and flatness of surface plate and table. For that there is leveling screws were attached at the bottom of table as shown in fig.

Fig 3.15 Table with Surface Plate

1. Mounting for sensor and LC display

After fabricating the table and surface plate next is to make mounting for sensor and LC display unit. For that one L shaped structure is joined over the surface plate.

- **Mounting for sensor**

In LOEPL three different types of engine assembly is going on. So heights of that three types of engines are 312 mm, 360mm and 410 mm with having capacities 3 H.P., 5 H.P. and 7 H.P. respectively. Hence to accommodate the sensor height as per height of engine whose assembly is going on, the threaded screw with locking nuts were used. After that one plate (100x35x4 mm) is welded at end of screw on which the sensor is going to mounted further as shown in fig.

Fig3.16 Sensor Mounting

- **Mounting for LC Display**

As this set up installed within the assembly line of LOEPL the worker might be work from any side of the assembly line. So the LC display should be rotate in 360 degree manually. At the top of this L shaped structure the arrangement for the LC display were made as shown in fig.

Fig 3.17 Mounting for Sensor and Display

1. Mounting for PCB unit.

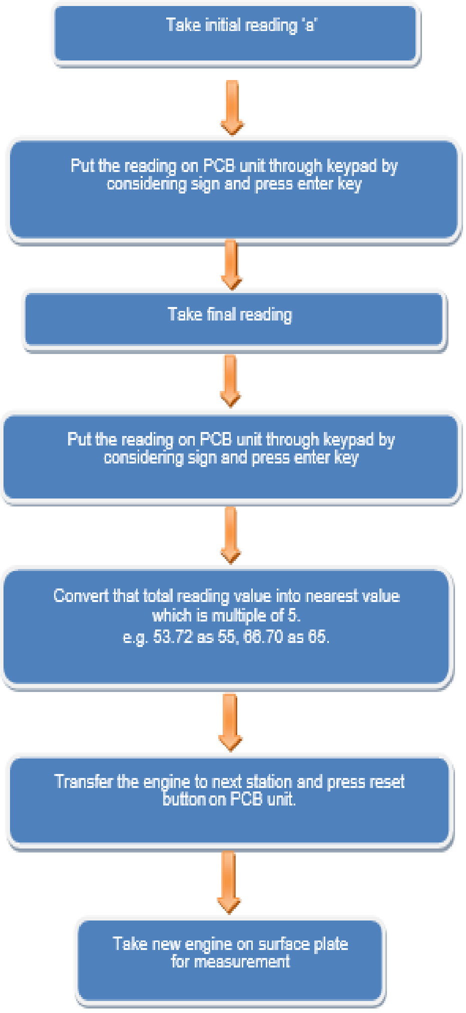
The PCB unit which we were already fabricated it should be mounted on this set up. For that on horizontal L angle was welded to vertical square channel of L shaped structure and the PCB unit joined it by nut and bolts as shown in fig.

Fig 3.18 Mounting for PCB Unit

Finally the whole fabricated set up is painted with navy blue color to avoid corrosion and improve aesthetics of set up. The overall fabricated set up with all mountings is shown below.

IV. TESTING AND RESULT

In testing, we were taken 10 readings of engines for adjusting bumping clearance. The testing procedure is shown in flow chart as follows.



Testing readings are tabulated as follows:

Table 4.1 Testing Readings

Sr. No.	Initial reading 'a' in mm	Final reading 'b' in mm	Shim thickness in 'thou'	Actual shim thickness in 'thou'
1.	-1.32	-2.04	66.79	65
2.	-1.40	-2.26	72.36	70
3.	-1.23	-1.82	60.83	60
4.	-1.53	-2.02	57.65	60
5.	-1.72	-2.39	64.80	65
6.	-1.59	-2.32	67.19	70
7.	-1.78	-2.36	61.23	60
8.	-1.98	-2.54	60.43	60
9.	-1.38	-2.23	71.96	70
10.	-1.76	-1.78	38.96	40

The bumping clearance maintained by inserting shims having thickness shown in above table can be calculated by using mathematical formula given below:

Bumping Clearance Maintained =
{(Actual shim thickness in mm – Initial reading 'a' in mm)+(Final reading 'b' in mm)}

Sample Calculation:-
For first reading,
Bumping clearance achieved by first engine =
(65/39.76) - (-1.32) + (-2.04) = **0.914**

The Bumping engine of all tested engine is calculated by the formula mentioned above. Those values are tabulated and shown below:

Table 4.2 Results of Testing

Sr. No.	Shim thickness in 'thou'	Actual shim thickness in 'thou'	Actual shim thickness in mm	Bumping Clearance in mm
1.	66.79	65	1.634	0.914
2.	72.36	70	1.761	0.91
3.	60.83	60	1.509	0.919
4.	57.65	60	1.509	1.019
5.	64.80	65	1.634	0.964
6.	67.19	70	1.761	1.031
7.	61.23	60	1.509	0.929
8.	60.43	60	1.509	0.949
9.	71.96	70	1.761	0.911
10.	38.96	40	1.006	0.986

Hence all the calculated values of bumping clearance are within the limits 0.91 mm to 1.1 mm.

V. PROJECT EXPENDITURE

1. Fabrication Cost

Sr. No.	Description	Cost (Rs.)
1.	„C" Channel 70x35 mm (30 feet)	1500.00
2.	M.S. Flat Plate 457.2x381x17 mm	1750.00
3.	Lead Screw M16 (1.70 feet)	150.00
4.	Lead Screw Nut (3 Nos.)	100.00
5.	Nut & Bolt (5 Nos.)	50.00
6.	Fabrication Work Cost	2280.00

2. PCB Unit Cost & Measurement Unit Cost

Sr. No.	Description	Cost (Rs.)
1.	Microcontroller 8051	1750.00
2.	Display (16*2)	550.00
3.	Keypad (4*4)	350.00
4.	Programming on microcontroller	550.00
5.	Fabrication of PCB Unit	130.00
6.	Sensor	7000.00
7.	LC Display	10000.00
8.	24 Volt DC Power Source	850.00
9.	Single Stand Wire (10 m)	105.00

3. Total Cost

Sr. No.	Description	Cost (Rs.)
1.	Fabrication Cost	5760.00
2.	PCB Unit Cost	3435.00
3.	Measurement Unit Cost	17850.00
	Total Cost	**27065.00**

VI. CONCLUSION

The practical study on measurement of bumping clearance gauge has been carried out. The results are obtained from analysis of practical observation with PRINTED CIRCUIT BOARD (PCB) unit. Effects of various parameters affect on performance of diesel engine have been investigated. From all the practical observations and data analysis results following conclusion can be drawn.

I. Bumping clearance achieved by measurement from bumping clearance gauge is in the range of 0.91mm to 1.1mm is acceptable for diesel engine in LOEPL.

II. Time required for adjusting bumping clearance of diesel engine is upto 35 to 40 sec which is much less than conventional technique used in LOEPL.

III. As less time required for measurement and adjustment of bumping clearance, assembly time required for engine is less, therefore increase in production rate.

6.1 Future Scope of Project

In our project, the operators has to insert two readings „a" and „b" on PCB unit through numeric keyboard on it. This is a manual operation, where some sort of scope of improvement.

In that instead of using keypad one ADC is placed in between sensor and microcontroller (PIC) and make

program accordingly. So by this the operator must not require to enter any reading that both values automatically entered in PIC microcontroller and directly expresses result on display as a "Total Reading =_______________
So, this method reduces operation time as well as human effort. It would be efficient but it requires more cost to install. The block diagram of this particular system is shown below.

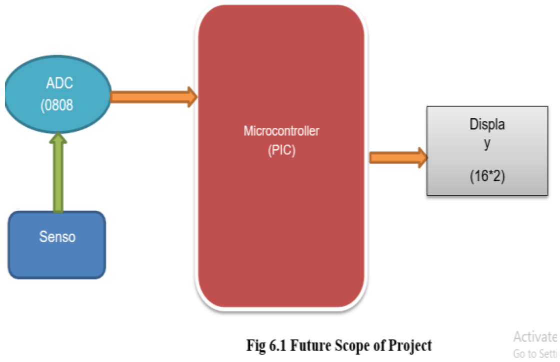


Fig 6.1 Future Scope of Project

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