A Report

on

Laboratory Experiments and Studies

Conducted at

Thermal Engineering Lab

Department of Mechanical Engineering,

National Institute of Technology Kurukshetra

Kurukshetra Haryana, INDIA

Submitted By

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Abstract

In my quest to learn more about machines and engineering, I had been visiting manufacturing plants and factories during my breaks.

The Thermal Engineering Lab is a key part of hands -on curriculum for mechanical engineering and has an array of machines, engines, simulators and models that can be studied, under supervision.

I performed the following experiments at the lab under the supervision of Professor Rajneesh and Mr. Rahul Sharma, Lab In-charge. These experiments showed me how machines/ engines behave under different load factors. The most interesting part of the study was creating a heat balance sheet which I learnt about for the first time. I've also enclosed the heat balance sheet along with this report

Study a single cylinder 4 stroke petrol engine through a model

- Perform a trial run on a 4-stroke high speed diesel engine to draw its heat balance sheet.
- Conducted Morse Test to calculate the IHP of a multi cylinder petrol engine and determine its mechanical efficiency.
- Studied Braking system in automobiles through a model.

NIT Kurukshetra

During the summer break of 2024, I visited NIT Kurukshetra, which is one of the premier engineering institutes and is usually ranked amongst the top 50 engineering colleges in the country. This institute is classified as an Institute of National Importance and boasts of a very accomplished alumnus. There are very successful technocrats, business and industry leaders, civil servants, start-up founders and academicians, who have graduated from this institute. It is spread across 300 acres and offers several disciplines of engineering under its 4 years B.Tech program. Mechanical Engineering is amongst the most sought-after stream at this institute.

The Thermal Engineering Laboratory is a part of the Mechanical Engineering Department and is almost as large as the academic block.

Experiment 1

Objective: Study of a four stroke Internal Combustion Engine (ICE) and understand the role of each of its components, through a cross-section model.

Picture 1.1 *Cross section model of an internal combustion engine*

In the age of Electrical Vehicles (EVs) which are essentially electric motors I have attempted to understand the conventional Internal Combustion engine, also known as ICE, these days. These engines are also called Spark Ignition or SI engines. The ignition is started through a spark which is generated by the spark plug, when we turn on the ignition. At that stage the battery of the vehicle is used to ignite the spark.

The other type of fossil fuel-based engine is the dienes engine, which uses compressed air-fuel mixture and self-ignites, due to high temperature in the combustion chamber. Diesel engines are also called CI engines.

The various parts of the engine, their role and abbreviations are detailed below.

Top-Dead-Center (TDC): Position of the piston when it stops at the furthest point away from the crankshaft. Top because this position is at the top of most engines (not always), and dead because the piston stops at this point. Because in some engines top-dead-center is not at the top of the engine (e.g., horizontally opposed engines, radial engines, etc.), some sources call **Inner Dead Center** at this position.

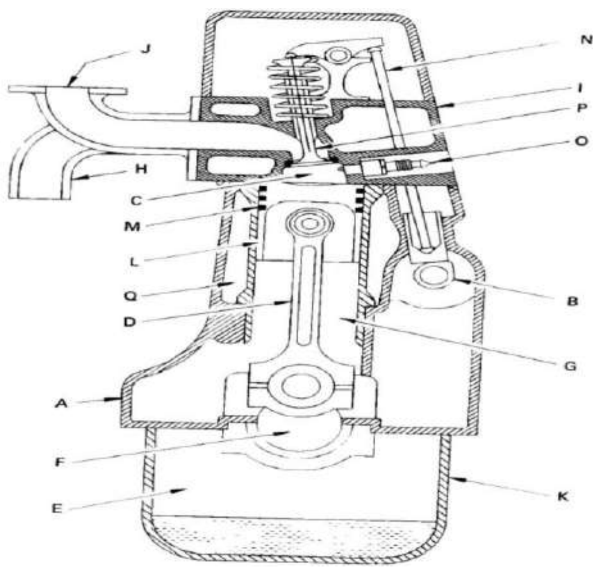
Bottom-Dead-Center (BDC): Position of the piston when it stops at the point closest to the crankshaft. Some sources call this **Crank-End-Dead-Center** (CEDC) because it is not always at the bottom of the engine.

Clearance Volume: When the piston is at TDC, the volume in the cylinder is a minimum called the clearance volume.

Direct Injection (DI): Fuel is injected into the main combustion chamber of an engine. Engines have either one main combustion chamber (open chamber) or a divided combustion chamber made up of a main chamber and a smaller connected secondary chamber.

Indirect Injection (IDI): Fuel injection into the secondary chamber of an engine with a divided combustion chamber.
Bore: Diameter of the cylinder or diameter of the piston face, which is the same minus a very small clearance.
Stroke: Movement distance of the piston from one extreme position to the other: TDC to BDC or BDC to TDC.
Displacement or Displacement Volume: The volume displaced by the piston as it travels through one stroke. Displacement can be given for one cylinder or for the entire engine (one cylinder times number of cylinders). Some literature calls this swept volume.
Air-Fuel Ratio (AF): Ratio of mass of air to mass of fuel input into engine.
Fuel-Air Ratio (FA): Ratio of mass of fuel to mass of air input into engine.

ENGINE COMPONENTS: The following is a list of major components found in most reciprocating internal combustion engines.
Block: Body of engine containing the cylinders, made of cast iron or aluminum. Many older engines, the valves and valve ports were contained in the block. The block of water-cooled engines includes a water jacket cast around the cylinders. On air-cooled engines, the exterior surface of the block has cooling fins.



Picture 1.2 *Cross-section of four-stroke cycle S1 engine showing engine components; (A) block, (B) camshaft, (C) combustion chamber, (D) connecting rod, (E) crankcase, (F) crankshaft, (G) cylinder, (H) exhaust manifold, (I) head, (J) intake manifold, (K) oil pan, (L) piston, (M) piston rings, (N) push rod, (0) spark plug, (P) valve, (Q) water jacket.*

Camshaft: Rotating shaft used to push open valves at the proper time in the engine cycle, either directly or through mechanical or hydraulic linkage (push rods, rocker arms, tappets). Most modern automobile engines have one or more camshafts mounted in the engine head (overhead cam). Older engines had camshafts in the crankcase. Camshafts are generally made of forged steel or cast iron and are driven off the crankshaft by means of a belt or chain (timing chain). To reduce weight, some cams are made from a hollow shaft with the cam lobes press-fit on. In four-stroke cycle engines, the camshaft rotates at half engine speed.

Carburetor: A flow device which meters the proper amount of fuel into the air flow by means of a pressure differential. For many decades it was the basic fuel metering system on all automobile (and other) engines. It is still used on low-cost small engines like lawn mowers, but is uncommon on new automobiles.

Combustion chamber: The end of the cylinder between the head and the piston face where combustion occurs. The size of the combustion chamber continuously changes from a minimum volume when the piston is at TDC to a maximum when the piston is at BDC. The term "cylinder" is sometimes synonymous with "combustion chamber" (e.g., "the engine was firing on all cylinders"). Some engines have open combustion chambers which consist of one chamber for each cylinder. Other engines have divided chambers which consist of dual chambers on each cylinder connected by an orifice.

Connecting rod: Rod connecting the piston with the rotating crankshaft, usually made of steel or alloy forging in most engines but may be aluminum in some small engines.

Crankcase: Part of the engine block surrounding the rotating crankshaft. In many engines, the oil pan makes up part of the crankcase housing.

Crankshaft: Rotating shaft through which engine work output is supplied to external systems. The crankshaft is connected to the engine block with the main bearings. It is rotated by the reciprocating pistons through connecting rods connected to the crankshaft, offset from the axis of rotation. This offset is sometimes called crank throw or crank radius. Most crankshafts are made of forged steel, while some are made of cast iron.

Cylinders: The circular cylinders in the engine block in which the pistons reciprocate back and forth. The walls of the cylinder have highly polished hard surfaces. Cylinders may be machined directly in the engine block, or a hard metal (drawn steel) sleeve may be pressed into the softer metal block. Sleeves may be dry sleeves, which do not contact the liquid in the water jacket, or wet sleeves, which form part of the water jacket. In a few engines, the cylinder walls are given a knurled surface to help hold a lubricant film on the walls. In some very rare cases, the cross section of the cylinder is not round.

Exhaust manifold: Piping system which carries exhaust gases away from the engine cylinders, usually made of cast iron.

Exhaust: Flow system for removing exhaust gases from the cylinders, treating them, and exhausting them to the surroundings. It consists of an exhaust manifold which carries the exhaust gases away from the engine, a thermal or catalytic converter to reduce emissions, a muffler to reduce engine noise, and a tailpipe to carry the exhaust gases away from the passenger compartment.

Fan: Most engines have an engine-driven fan to increase air flow through the radiator and through the engine compartment, which increases waste heat removal from the engine. Fans can be driven mechanically or electrically, and can run continuously or be used only when needed.

Flywheel: Rotating mass with a large moment of inertia connected to the crankshaft of the engine. The purpose of the flywheel is to store energy and furnish a large angular momentum that keeps the engine rotating between power strokes and smoothen out engine operation. On some aircraft engines the propeller serves as the flywheel, as does the rotating blade on many lawn mowers.

Head: The piece which closes the end of the cylinders, usually containing part of the clearance volume of the combustion chamber. The head is usually cast iron or aluminum, and bolts to the engine block. In some less common engines, the head is one piece with the block. The head contains the spark plugs in SI engines and the fuel injectors in CI engines and some SI engines. Most modern engines have the valves in the head, and many have the camshaft(s) positioned there also (overhead valves and overhead cam).

Head gasket: Gasket which serves as a sealant between the engine block and head where they bolt together. They are usually made in sandwich construction of metal and composite materials. Some engines use liquid head gaskets.

Intake manifold: Piping system which delivers incoming air to the cylinders, usually made of cast metal, plastic, or composite material. In most SI engines, fuel is added to the air in the intake manifold system either by fuel injectors or with a carburetor. Some intake manifolds are heated to enhance fuel evaporation. The individual pipe to a single cylinder is called a runner.

Main bearing: The bearings connected to the engine block in which the crankshaft rotates. The maximum number of main bearings would be equal to the number of pistons plus one, or one between each set of pistons plus the two ends. On some less powerful engines, the number of main bearings is less than this maximum.

Oil pan: Oil reservoir usually bolted to the bottom of the engine block, making up part of the crankcase. Acts as the oil sump for most engines.

Oil pump: Pump used to distribute oil from the oil sump to required lubrication points. The oil pump can be electrically driven, but is most commonly mechanically driven by the engine. Some small engines do not have an oil pump and are lubricated by splash distribution.

Oil sump: Reservoir for the oil system of the engine, commonly part of the crankcase. Some engines (aircraft) have a separate closed reservoir called a dry sump.

Piston: The cylindrical-shaped mass that reciprocates back and forth in the cylinder, transmitting the pressure forces in the combustion chamber to the rotating crankshaft. The top of the piston is called the crown and the sides are called the skirt. The face on the crown makes up one wall of the combustion chamber and may be a flat or highly contoured surface. Some pistons contain an indented bowl in the crown, which makes up a large percent of the clearance volume. Pistons are made of cast iron, steel, or aluminum. Iron and steel pistons can have sharper corners because of their higher strength. They also have lower thermal expansion, which allows for tighter tolerances and less crevice volume. Aluminum pistons are lighter and have less mass inertia. Sometimes synthetic or composite materials are used for the body of the piston, with only the crown made of metal. Some pistons have a ceramic coating on the face.

Piston rings: Metal rings that fit into circumferential grooves around the piston and form a sliding surface against the cylinder walls. Near the top of the piston are usually two or more compression rings made of highly polished hard chrome steel. The purpose of these is to form a seal between the piston and cylinder walls and to restrict the high-pressure gases in the combustion chamber from leaking past the piston into the crankcase (blow-by). Below the compression rings on the piston is at least one oil ring, which assists in lubricating the cylinder walls and scrapes away excess oil to reduce oil consumption.

Push rods: Mechanical linkage between the camshaft and valves on overhead valve engines with the camshaft in the crankcase. Many push rods have oil passages through their length as part of a pressurized lubrication system.

Radiator: Liquid-to-air heat exchanger of honeycomb construction used to remove heat from the engine coolant after the engine has been cooled. The radiator is usually mounted in front of the engine in the flow of air as the automobile moves forward. An engine-driven fan is often used to increase air flow through the radiator.

Spark plug: Electrical device used to initiate combustion in an SI engine by creating a high-voltage discharge across an electrode gap. Spark plugs are usually made of metal surrounded with ceramic insulation. Some modern spark plugs have built-in pressure sensors which supply one of the inputs into engine control.

Water jacket: System of liquid flow passages surrounding the cylinders, usually constructed as part of the engine block and head. Engine coolant flows through the water jacket and keeps the cylinder walls from overheating. The coolant is usually a water-ethylene glycol mixture.

Water pump: Pump used to circulate engine coolant through the engine and radiator. It is usually mechanically run off of the engine.

Experiment 2

Objective: To perform a trial on an actual high speed diesel engine and make a heat balance sheet.

Specifications of Engine:
Type TVL, series: 1 BHP = 5, Speed = 1500 RPM
Bore = 80 MM. Stroke = 110 MM, Swept Volume = 558 CC

Picture 2.1: Testing bay for high-speed diesel engine

Hypothesis to be tested: Of the total heat energy supplied to the engine due to combustion of the fuel, a small proportion is converted into useful work such as movement or lifting of weights, etc. The useful energy is transferred by the engine to the crankshaft from where it gets converted into other forms of mechanical energy. All engineers work towards minimizing these heat losses so that more useful work can be done by the heat produced. The heat balance sheet accounts for energy supplied, useful energy output and energy losses.

Procedure performed:

1. Started the engine through manual cranking.
2. I used a stopwatch to note the time taken for consumption of 20 cc of fuel at no load.
3. I noted the RPM of the engine with a tachometer.
4. Noted the rise of water level in the tank for a particular time.
5. Noted the inlet temperature of water to the engine, outlet temperature of water from the engine cylinder jacket, exhaust gas temperature and ambient air temperature.
6. Increased the load in steps of 3 Amp with the help of Electrical Dynamometer and made observations as in Step 2 by keeping the speed (RPM) of the engine constant. While changing the load, the speed of the engine fluctuates and the readings can be taken only when the speed is steady at the desired load.
7. Observed how the calculations for BHP, heat input, Heat carried away by water, Heat carried away by exhaust gases were made and generated the heat balance sheet.

The heat balance sheet generated by the application for this experiment, based on the readings is as follows:

Test Performed Date	22/07/2024 10:20:31	**Test Performed By**	Ms. Aarna Chugh
Engine Type	4-Stroke, Single Cylinder, VCRE MF Water Cooled	**Test Approved By**	Dr. Rajneesh
Engine Make & Model	ATE VCRE_MF	**End User**	NIT Kurukshetra
Specifications of Engine			
Bore(mm)	87.50	**Test Rig Manufacturer**	M/S. Accurate Test Equipments & Engineers, Plot No. C-49, M.I.D.C. Shiroli Area, Kolhapur - 416122
Stroke(mm)	110.00		
C.R.	17.50		
Com. Rod Length(mm)	232.00	**Fuel Used**	Diesel
Swept Volume (C.C.)	662.00	**Remark**	

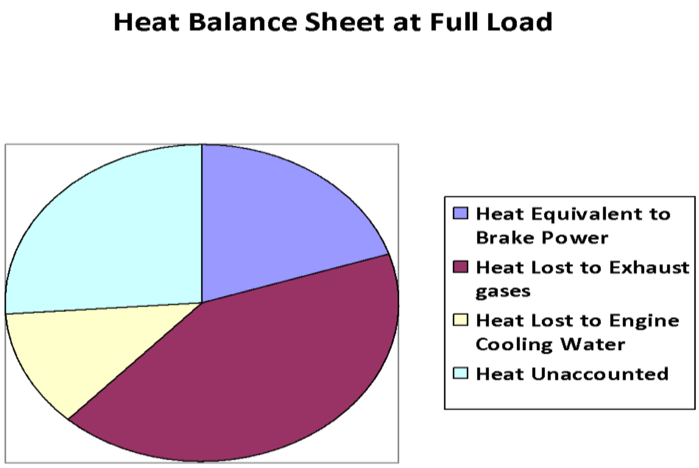
Observations Table

Sr. No.	Section	Parameter	Symbol	Unit	Load 1	Load 2	Load 3	Load 4	Load 5
1.	**Dynamometer**	Torque	T	N-m	4.20	7.60	10.70	13.20	17.00
2.		Speed	N	RPM	1561.60	1559.39	1548.87	1538.57	1528.79
3.	**Fuel Consumption**	Calorific Value of Fuel	Cf	KJ/Kg	44800.00	44800.00	44800.0	44800.0	44800.0
4.		Fuel Sample Quantity	Wf	C.C.	12.00	13.00	14.00	16.00	18.00
5.		Time for Fuel Consumption	Tf	Sec	60.00	60.00	60.00	60.00	60.00
6.	**Exhaust Gas**	Water Inlet Temp. to Calorimeter	Twic	Deg.C	18.90	19.20	19.50	19.70	19.80
7.	**Calorimeter**	Water Outler Temp. from Calorimeter	Twoc	Deg.C	24.80	26.40	27.70	28.70	30.40
8.	**Section**	Exhaust Gas Outler Temp. from Engine	Tgoe	Deg.C	323.70	365.80	399.20	442.70	504.80
9.		Exhaust Gas Inlet Temp. to Calorimeter	Tgic	Deg.C	227.20	250.50	274.80	296.30	332.90
10.		Exhaust Gas Outlet Temp. from Calorimeter	Tgoc	Deg.C	105.70	116.90	127.80	138.50	155.60
11.		Water Flow Rate - Calorimeter	Mw	LPH	167.60	166.60	166.20	166.50	168.60
12.	**Engine Cooling**	Water Inlet Temp. to Engine	Twie	Deg.C	24.80	26.40	27.70	28.70	30.40
13.		Water Flow Rate - Engine	Mw	LPH	167.60	166.60	166.20	166.50	168.60
14.	**Orifice Meter**	Pr. Difference on Manometer	Hw	mm	31.40	33.80	36.00	32.40	31.30
15.	**Section**	Size of Orifice	Do	mm	25.40	25.40	25.40	25.40	25.40
16.		Atmospheric Temperature	Tair	Deg. C	25.00	25.00	25.00	25.00	25.00

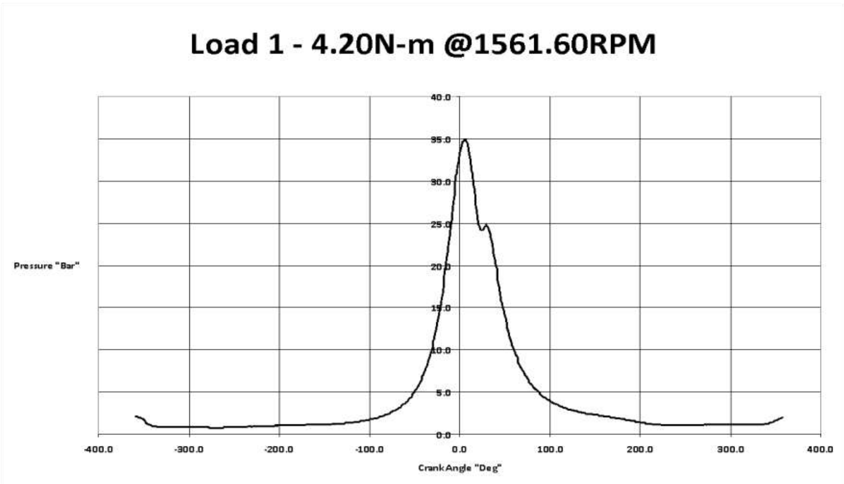
Sr. No.	Section	Parameter	Symbol	Unit	Load 1	Load 2	Load 3	Load 4	Load 5
17.		Atmospheric Pressure	p1	Kg/Cu.m	1.00	1.00	1.00	1.00	1.00
18.		Coeff. Of Discharge	Cd		0.60	0.60	0.60	0.60	0.60
19.		Indicated Mean Effective Pressure	Pi	Bar	5.00	5.68	6.14	6.59	7.25
20.		Indicated Power	Pi	Kw	4.31	4.88	5.25	5.58	6.09
21.	**Compression Ratio**	Micrometer Reading	MR	mm	4.95	4.95	4.95	4.95	4.95
22.		Compression Ratio	CR		11.82	11.82	11.82	11.82	11.82
23.		Spark Advance	SA			0.	0.	0.	0.
24.	**Power & Heat**	Brake Power	Pbrk	Kw	0.69	1.24	1.74	2.13	2.72
25.		Indicated Power	Pi	Kw	4.31	4.88	5.25	5.58	6.09
26.		Mechanical Efficiency	ŋmec h	%	15.94	25.43	33.07	38.11	44.69
27.		Brake Specific Fuel Consumption	BSFC	gm/Kw-hr	1048.30	628.49	484.01	451.39	396.82
28.		Brake Terminal Efficiency	ŋb	%	7.67	12.79	16.60	17.80	20.25
29.		Indicated Terminal Efficiency	ŋi	%	48.08	50.28	50.20	46.71	45.32
30.		Heat Supplied by Fuel/min	Hf	KJ/min	537.60	582.40	627.20	716.80	806.40
31.		Heat Equivalent of brake Power	Hbrk	KJ/min	41.21	74.46	104.13	127.61	163.30
32.		Heat Equivalent of Indicated Power	Hip	KJ/min	258.46	292.82	314.88	334.80	365.42

Sr. No.	Section	Parameter	Symbol	Unit	Load 1	Load 2	Load 3	Load 4	Load 5
33.		Mg x Cpg Value		KJ/Deg C	0.57	0.62	0.64	0.66	0.70
34.		Heat Lost to Exhaust gases	HLEG	KJ/min	168.90	212.59	241.03	275.58	336.01
35.		Heat Lost to Engine Cooling Water	HLCW	KJ/min	61.71	64.82	76.21	86.76	99.57
36.		Heat Unaccounted	HU	KJ/mi n	265.78	230.53	205.83	226.85	207.53
37.	**Heat Balance**	Heat Supplied by Fuel		%	100.00	100.00	100.00	100.00	100.00
38.		Heat Equivalent to Brake Power		%	7.67	12.79	16.60	17.80	20.25
39.		Heat Lost to Exhaust gases		%	31.42	36.50	38.43	38.45	41.67
40.		Heat Lost to Engine Cooling Water		%	11.48	11.13	12.15	12.10	12.35
41.		Heat Unaccounted		%	49.44	39.58	32.82	31.65	25.73
42.	**Air Flow Calculations**	Mass of Air per Cubic meter	m_air	Kg/Cu.m	1.15	1.15	1.15	1.15	1.15
43.		Head of Air Equivalent to manometer Diff	H_air	m	27.39	29.48	31.40	28.26	27.30
44.		Volume of Air intake per minute	Qair	Cu.m/ min	0.46	0.43	0.42	0.43	0.44
45.		Weight of Air per minute	Wair	gm/min	0.53	0.49	0.48	0.49	0.50
46.		Air / Flow Ratio	AFR		43.85	37.76	34.18	30.68	28.03
47.		Volume Displaced/min by Piston	Ve	Cu.m/min	0.52	0.52	0.51	0.51	0.51
48.		Volumetric Efficiency	ŋv	%	88.84	83.00	81.46	84.12	86.99

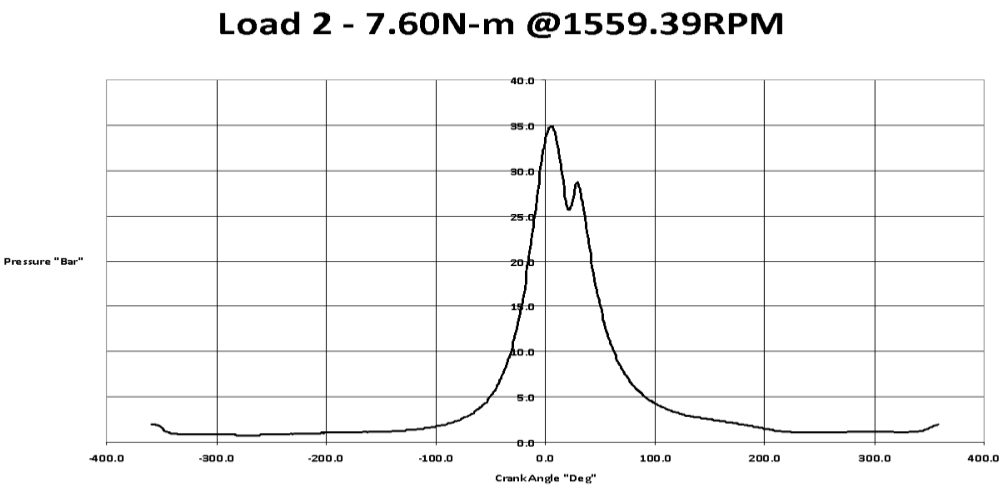
Heat Balance Sheet



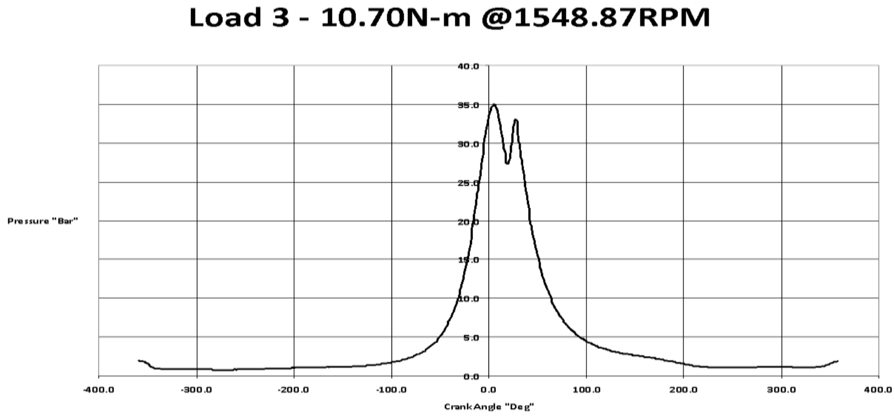
Pressure Vs Crank Angle: Load 1



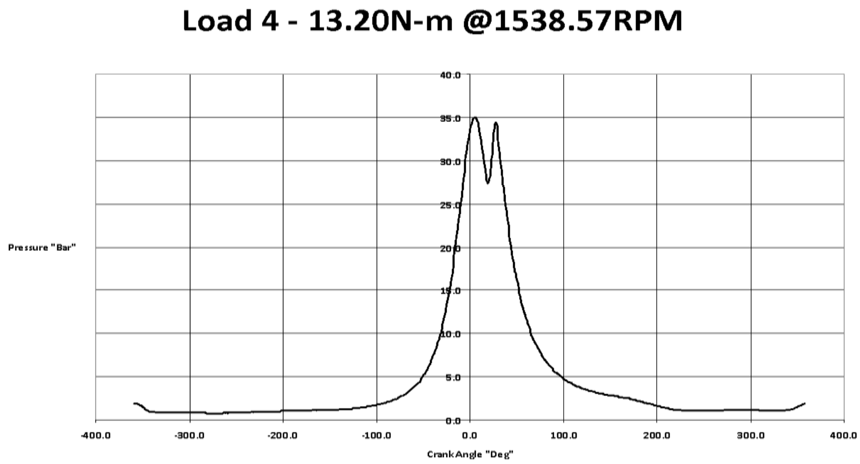
Pressure Vs Crank Angle: Load 2



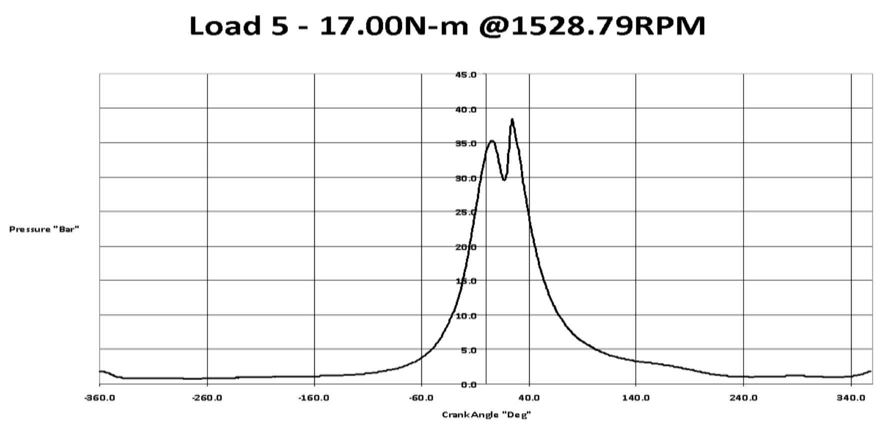
Pressure Vs Crank Angle: Load 3



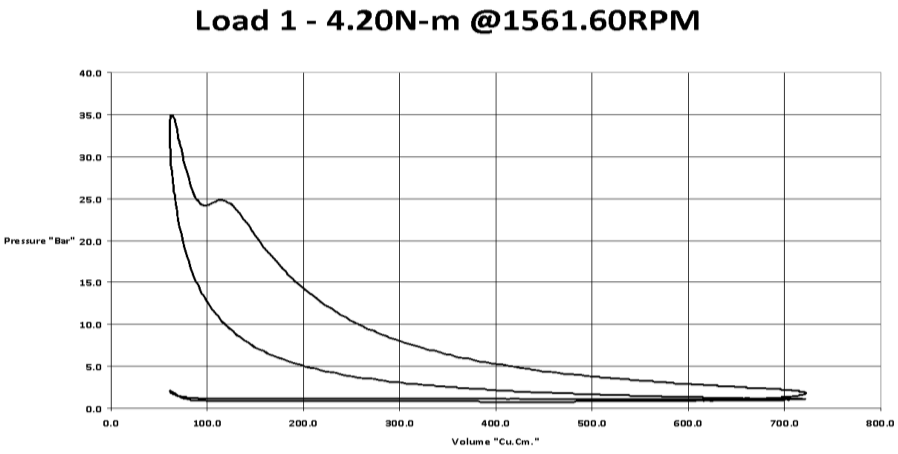
Pressure Vs Crank Angle: Load 4



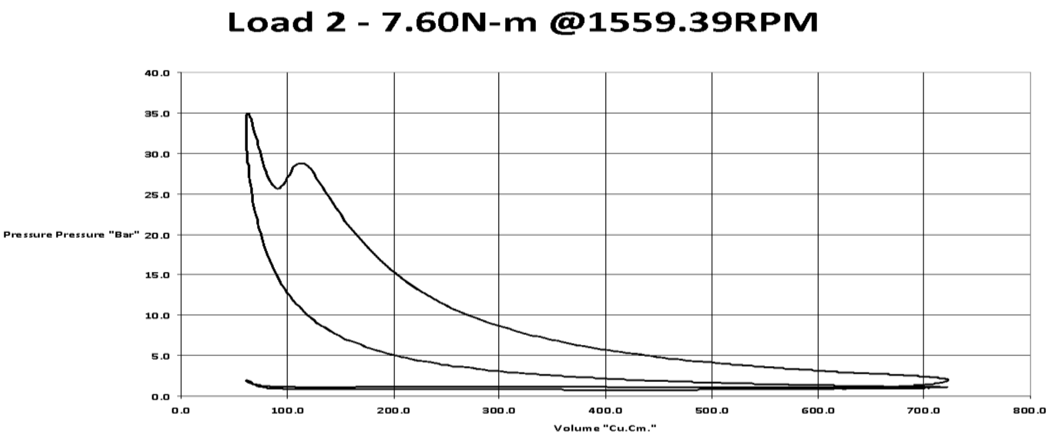
Pressure Vs Crank Angle: Load 5



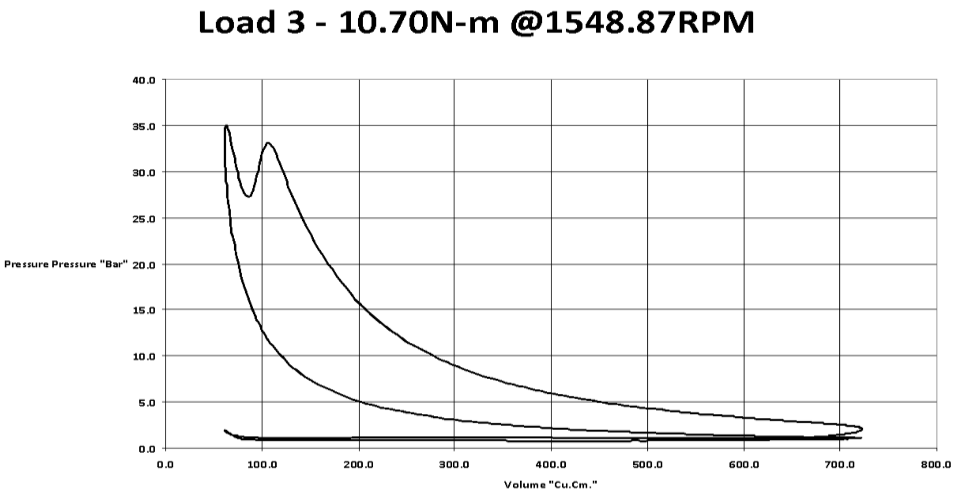
Pressure Vs Volume: Load 1



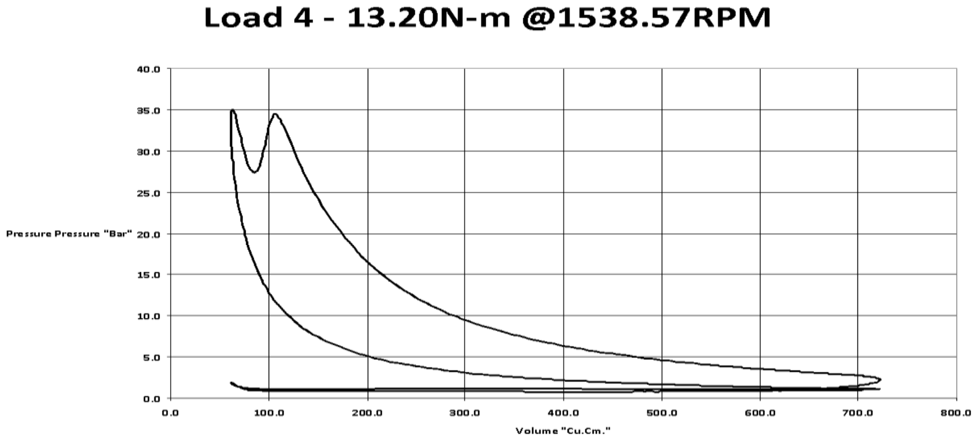
Pressure Vs Volume: Load 2



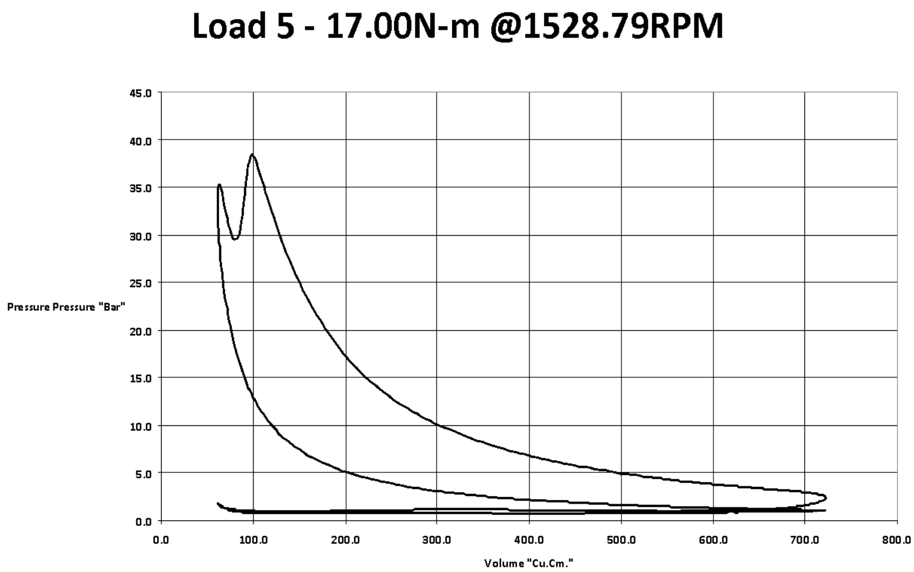
Pressure Vs Volume: Load 3



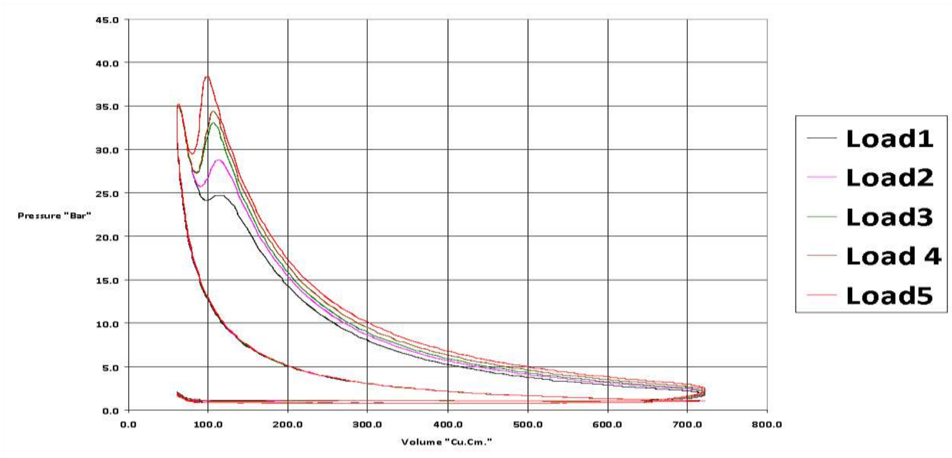
Pressure Vs Volume: Load 4



Pressure Vs Volume: Load 5



Pressure Vs Volume All Loads



Experiment 3

Objective: To perform Morse Test to calculate the IHP of a multi-cylinder petrol engine and determine mechanical efficiency.

Engine Type:

Make: Maruti MPFI
No. of cylinders: 3

Morse test is a standard test to determine the Indicative Horse Power (IHP) of a multi-cylinder engine. The test is performed at constant speed and throttle settings.

The experiment starts with all cylinders working and then gradually cutting out one cylinder at a time, while adjusting the load to keep the speed constant. The BHP readings are taken at each setting. In petrol multi cylinder engines, individual cylinders are cut off by shorting the spark plug. While in diesel engines, this is done by cutting off the fuel supply to individual cylinders.

Picture 3: Testing bay of 4 stroke 3-cylinder petrol engine

Hypothesis to be tested: The main assumption in this method of finding the IHP is that the Friction Horse Power (FHP) remains the same after shorting, as it was when all the cylinders were functional. The theoretical equation for determining IHP is as follows:

BHP = IHP + FHP

Everytime, a cylinder is cut off, the IHP changes and the FHP is moderated through changing the load and BHP is measured.

The mechanical efficiency is BHP/IHP and should remain the same in all scenarios. Procedure followed

1. Started the multi cylinder petrol engine with throttle füılly open.
2. With all cylinders working took brake dynamometer readings and noted the engine speed
3. Keeping the throttle opening fixed cut out the first cylinder by shorting its spark plug.
4. Brought the engine speed back to original value by adjusting the brake dynamometer load and noted down the new brake or dynamometer reading.
5. Rendered the first cylinder operative but cut out the second and third cylinder in turn.
6. Repeated the procedure taking care that speed remained constant and throttle opening was undisturbed while the test was being conducted

Observations:

Cut off cylinder number	Speed (RPM)	Load (Kg)	Brake power (Kw)	Indicated power (Kw)
1	2000	12.5	5.39	3.24
2	2000	12.1	5.22	3.41
3	2000	12.8	5.52	3.11
All working	2000	20	8.63	9.75
Friction power (Kw)		1.12		
Mechanical efficiency%		88.5		

Experiment 4

Objective: To study the drum braking systems in automobiles through a model and understand the theory through diagrams.

Picture. 4.1: Model of braking system with 4 wheels and a brake pedal

Functions of Brake

There are two distinct functions of the brake:

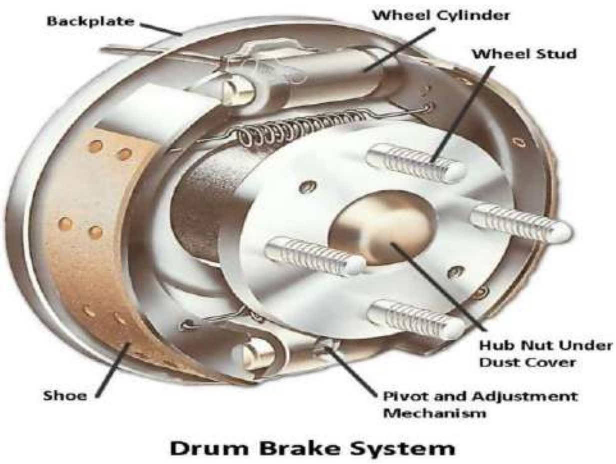
1. To stop or slow down the vehicle in the shortest possible distances in emergencies.
2. To control the vehicle to be retained when descending or ascending a slope.

Classification of brakes:

1. There are two types of brakes from a construction point of view
   (a) Drum brakes (b) Disc brakes
2. By method of actuation, there are several types of brakes even though they could be one of the previous two types. (a) Mechanical brakes (b) Hydraulic brakes (c) Electric brakes (d) Vacuum brakes (e) Air brake

Drum Brakes

In this type of brakes, a brake drum is anchored concentric to the axle hub whereas on the axle casing is mounted a back plate. In the case of the front axle, the back plate is bolted to the steering knuckle. The back plate is made of pressed steel sheet and is ribbed to increase rigidity and to provide support for the expander, anchor and brake shoes. It also protects the drum and shoe assembly from mud and dust. Moreover, it absorbs the complete torque reaction of the shoes due to which it is sometimes also called 'torque plate'. Two brake shoes are anchored on the back plate. Friction linings are mounted on the brake shoes. One or two retractor springs are used which serve to keep the brake shoes away from the drum when the brakes are not applied. The brake shoes are anchored at one end, whereas on the other ends Force F is applied by means of some brake actuating mechanism, which forces the brake shoe against the revolving drum, thereby applying the brakes. An adjuster is also provided to compensate for wear of friction lining with use. The relative braking torque obtained at the shoes for the same force applied at the pedal varies depending upon whether the expander (cam or toggle lever) is fixed to the back plate or it is floating; whether the anchor is fixed or floating and whether the shoes are leading or trailing.

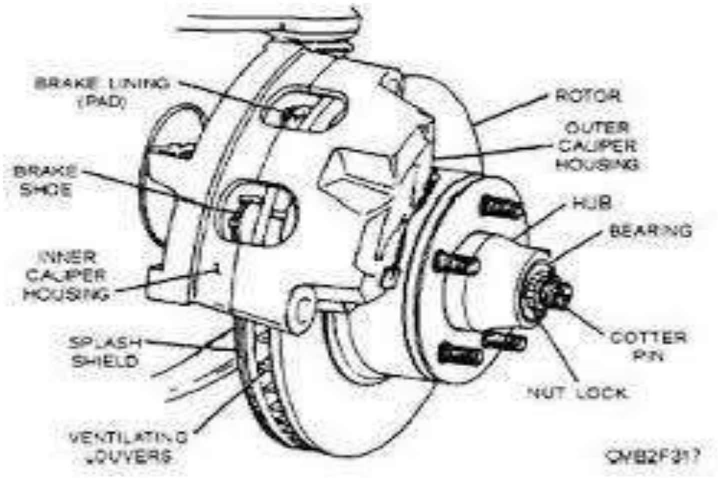


Picture 4.3: Graphical representation of a drum brake cross section

Disc Brakes

The disc brake has a metal disc instead of a drum. It has a flat shoe, or pad, located on each side of the disc. To slow or stop the car, these two flat shoes are forced tightly against the rotating disc or rotor. The shoes grip the disc. Fluid pressure from the master cylinder forces the pistons to move in.

This action pushes the friction pads of the brake shoes tightly against the disc. The friction between the shoes and the disc slows and stops the disc.



Picture 4.4: Diagram of a disc brake

Hydraulic Brake System:

These types of brakes consist of master cylinder, which contains hydraulic brake fluid.

Master cylinder is operated by the brake pedal and is further connected to the wheel cylinder in each wheel through pipelines, unions and flexible lines. The system is so designed that even when the brakes are in the released position, a small pressure of about 50kpa is maintained in the pipelines to ensure that the cups of the wheel cylinder are kept expanded. This prevents the air entering the wheel cylinders when the brakes are released. Besides this pressure also serves the following purposes:

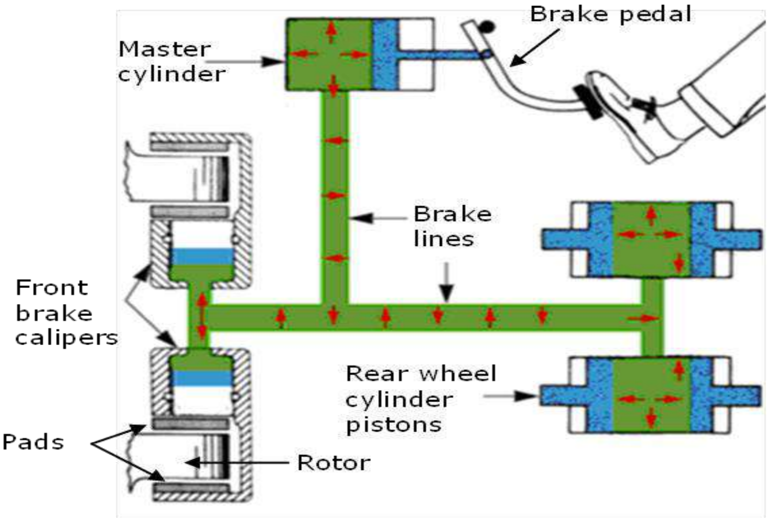
- It keeps the free travel of the pedal minimum by opposing the brake shoe retraction springs.
- During bleeding, it does not allow the fluid pumped into the line to return, thus quickly purging air from the system

Master Cylinder:
It consists of fluid reservoir and compression chamber in which piston operates. The fluid in the reservoir compensates for any change in the fluid volume in the pipelines due to temperature variations and to some extent due to leakage. To prevent leakage there are rubber seals on both sides of the piston in the compression chamber. The fluid always surrounds the reduced diameter region of the piston. A rubber boot covers the push rod and of the master cylinder to prevent the dirt entering inside.

Towards the brake lines side of the compression chamber, there is fluid check valve with a rubber cup inside. It serves to retain the residual pressure in the brake lines even when the brakes released.

There are a number of holes in the piston head on the primary (high pressure) seal side.
Two holes connect the reservoir to the compression chamber. The smaller one out of these is about 0.7 mm diameter and is called the bypass or compression port. The second hole is called the intake or recuperation port. Besides, there is a vent in the cap, to keep the brake fluid always at atmospheric pressure. The push rod is operated with the foot brake pedal through the linkage.

As the pedal is pressed, the push rod moves to the left against the force of the spring, till it covers the bypass port. Further movement of the push rod causes building up of pressure in the compression chamber. Finally, when sufficient pressure has built up, the inner rubber cup of the fluid check valve is deflected, forcing the fluid under pressure in the lines. This fluid enters the wheel cylinder or the calliper and moves the pistons, thereby applying the brakes.



Picture 4.5: Diagram representing functioning of hydraulic brakes

When the brakes are released, the spring pressure in the master cylinder moves the piston to the right extreme position. This same force of the spring keeps the fluid check valve pressed on its seat for some time and thereby delays the return of fluid from the lines into the compression chamber again.

Conclusion and reflections

Some of the other areas I learnt about automobiles, while at the lab, were: ignition systems, a model of carburetor, difference between a petrol and diesel engine and four stroke petrol engine through a model. At the end, I was very clear about how automobiles work. Doing these experiments and studies first hand in a real engineering school laboratory, also made me very confident. While these experiments are meant for semester 4 and 5 mechanical engineering students, from my point of view it was a very good correlation of the theory that I had studied, to practical science.

Spending time in an institution like NIT Kurukshetra, amidst some of the best engineering minds, was immensely inspiring.

Picture 5: Main entrance to the administrative and academic blocks of NIT Kurukshetra

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