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Project On:

GOVERNING SYSTEM BETWEEN ENGINE & COMPRESSOR ON AIR BRAKE SYSTEM FOR COMMERCIAL VEHICLE

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Certification

This is to certify that the Project titled **"Governing System Between Engine & Compressor on Air Brake System for Commercial Vehicle"** was carried out by **Mutasim Billah Khan, Deloar Hossain, Azmain Mahtab, Md. Reaj Ahmad, Abdullah Al Mamun** and submitted to the Department of Mechanical Engineering, Sonargaon University as a partial fulfilment of the requirement for the award of Bachelor of Science Degree in Mechanical Engineering.

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

The safe operation of vehicles on roads depends, among other things, on a properly functioning brake system. An 'Air Braking System' has been designed to use in commercial heavy vehicles with heavier braking capacity and greater efficiency than conventional braking system. Air brake systems are widely used in commercial vehicles such as trucks, tractor-trailers and buses. In these brake systems, compressed air is used as the energy transmitting medium to actuate the foundation brakes mounted on the axles. Normally compressed air is produced by an Air Compressor which is directly driven by the Engine of vehicle. No governing system given between Engine & Air Compressor. Governing system provided after Air Compressor which act as Pressure Relief Valve where the valve will be opened on a certain pressure and release the air to atmosphere. Compressed air then dried through an Air Drier to ensure moisture free air to the system to protect all rubber components. Then the air stored to a Reservoir Tank from where compressed air travel to actuators as per driver pedal pressing. On foot pedal, Dual Brake Valve is given to regulate the air pressures to actuator. Air Pressure Gauge tapped from the Reservoir Tank to show the actual pressure into the system. Actuators convert the pneumatic pressures to linear motion. This linear motion makes the useful torque through Slack Adjuster where worm gear arrangement given. Slack Adjuster gives a rotary motion to S-Cam which directly press the brake liner to drum and applied the brake on wheels.

In this project, we are implementing governing system between Engine & Air Compressor. When maximum designed pressure will be developed to the system, Air Compressor will be disengaged from Engine. Hence power loss of engine will be reduced. Also, Air Compressor life will be extended. As per theoretical calculation, 0.35 % of engine power loss can be prevented by this governing system. Also approximate 450-liter fuel cost can be minimized in a single year.

LIST OF ABRREVIATIONS

DDU	Drying and Distribution Unit
HCV	Heavy Commercial Vehicle
GVW	Gross Vehicle Weight
KM	Kilometer
HP	Metric Horse Power
EMC	Electro Magnetic Clutch
kWh	Kilo Watt Hour
Hrs.	Hours
KMPL	Kilometer per Liter
Tk	Taka
Kg/cm2	Kg per square Centimeter
Cfm	Cubic Feet per Minute
Cm	Centimeter
DC	Direct Current
V	Volt
Vac	Alternating Current Voltage
W	Wattage

Chapter 1
INTRODUCTION

One of the most important systems in a vehicle that is critical for its safe operation is the brake system. A brake system must ensure the safe control of a vehicle during its normal operation and must bring the vehicle to a smooth stop within the shortest possible distance under emergency conditions [1]. Based on these functions, brake systems are usually classified as service brakes (for normal operation), emergency brakes and parking brakes. The various components of a typical brake system are integrated such that they perform all the above-mentioned functions.

An ideal brake system must be able to apply the necessary braking torque to the wheels to control the vehicle in a stable manner and at the same time dissipate the generated thermal energy efficiently. Braking action is usually achieved by the following two modes – (a) by mounting brakes on the wheels (called foundation brakes) that apply a braking torque directly on the wheels, and (b) by using brakes (called retarders) on the transmission shaft of the vehicle. The latter method has the advantage that it generates a higher braking force at the wheels when compared to the foundation brakes. But a retarder can only provide very little braking torque at low vehicle speeds and hence they are usually used in conjunction with the foundation brakes [1].

A typical brake system can be broadly broken down into four subsystems [2]:

- A source that produces and stores the energy required for braking,
- A subsystem that regulates the brake application process and thereby the amount of braking force,
- An energy transmission subsystem that transfers the energy required for braking to the brakes mounted on the axles, and
- Foundation brakes mounted on the axles that apply the braking force on the wheels.

Existing brake systems typically use either brake fluid (hydraulic brakes) or compressed air (air brakes) as their energy transmitting medium. The force applied by the driver on the brake pedal regulates the brake application process and is transmitted through the energy transmitting medium to the foundation brake units mounted on the axles. Common types of foundation brakes include the disc brake and the drum brake. In this dissertation, the main focus will be restricted to air brake systems that use S-cam drum foundation brakes.

A. Background & Motivation

The safe operation of vehicles on the road depends amongst other things, on a properly functioning brake system. In this dissertation, the focus will be on air brake systems which are widely used in commercial vehicles such as trucks, tractor trailer combinations and buses. Buses are equipped with air brake systems [3]. It has been well established that one of the main factors that increases the risk of accidents involving commercial vehicles is an improperly maintained brake system. For example, a report published in 2002 [4] points out that brake problems have been observed in approximately 31.4 % of the heavy trucks involved in fatal accidents in the state of Michigan. In roadside inspections performed between October 1996 and September 1999, 29.3 % of all the vehicle-related violations among Intra state carriers and 37.2 % of those among Interstate carriers have resulted due to defects in the brake system [5]. As a result of its large size and mass, an accident involving a commercial vehicle is also very dangerous to the occupants of other vehicles on the road. In fact, it has been pointed out as early as in 1972 that approximately 63 % of the fatalities in accidents involving interstate trucks were occupants of passenger cars [6]. It has been reported in [7] that nearly 77.5 % of the fatalities in accidents involving trucks in 2002 were occupants of other vehicles.

The air brake system currently found in commercial vehicles is made up of two subsystems – the pneumatic subsystem and the mechanical subsystem. The pneumatic subsystem includes the compressor, storage reservoirs, Dual Brake Valve (or the brake application valve), brake lines, relay valves, quick release valve, brake chambers, etc. The mechanical subsystem starts from the brake chambers and includes push rods, slack adjusters, S-cams, brake linings and brake drums. Thus, the compressor serves as the source of energy in the air brake system by providing a supply of compressed air which is stored in the storage reservoirs. The Dual Brake Valve is used by the driver to regulate the brake application process and compressed air serves as the energy transmitting medium. One of the most important differences between a hydraulic brake system (found in passenger cars) and an air brake system is in their mode of operation. In a hydraulic 4 brake system, the force applied by the driver on the brake pedal is transmitted through the brake fluid to the wheel cylinders mounted on the axles. The driver obtains sensory feedback in the form of a pressure on his / her foot. If there is a leak in the hydraulic brake system, this pressure will decrease and the driver can detect it through the relatively easy motion of the brake pedal. In an air brake system, the application of the brake pedal by the driver meters out compressed air from a supply reservoir to the brake chambers. The force applied by the driver on the brake pedal is utilized in opening certain ports in the Dual Brake Valve and is not used to pressurize air in the brake system. This leads to a lack of variation in the sensory feedback to the driver in the case of leaks, worn brake linings and other defects in the brake system. Another difference between the two braking systems is in the distribution of the braking force between the various axles. In passenger vehicles, the load distribution on the axles varies slightly whereas in commercial vehicles the distribution of the load on the various axles varies significantly depending on whether the vehicle is loaded or unloaded. Typically, commercial vehicle brakes are designed and balanced for the fully loaded condition and this results in excessive braking on some axles when the vehicle is not fully loaded [8]. This problem is compounded by the fact that the U.S. regulations, unlike the European standards, do not directly specify brake force distribution between the various axles [9].

B. Objectives

In this project, governing system between Engine & Air Compressor of Air Brake System are presented. When maximum designed pressure will be developed to the system, Air Compressor will be disengaged from Engine. Hence power loss of engine will be reduced. Also, Air Compressor life will be extended.

Chapter 2

LITERATURE REVIEW

Many mechanical systems have used and are using compressed air as their energy transmitting medium. Compressed air is being employed in a wide spectrum of applications including – machine shop tools (such as drills, impact wrenches, grinders, screwdrivers, tappers, nut runners, riveters, sand rammers, etc.), contractors' tools 1 (such as road / pavement breakers and rock drills), mining and quarrying equipment, air motors, material handling equipment (such as hoists, wrenches, cranes, conveyors, agitators, etc.), paint spraying, marine applications, pneumatic actuators, etc. [10].
One of the major applications of compressed air in the field of transportation has been in the development of the air brake system.

In the United States railway industry, air brake systems were initially introduced during the nineteenth century. Before the introduction of the air brake system, railway cars were retarded mainly by mechanical means (for example, by levers, chains and other linkages) and were hand-operated by brakemen usually through the rotation of a handwheel [11]. A variety of alternate braking systems were developed by many individuals, but the first practically applicable air brake system was developed by George Westinghouse when he introduced his "Straight Air Brake" in 1869 [12], [13]. Interesting accounts of this invention of Westinghouse and his further improvements and additions to the air brake system can be found in [14] and [15]. A detailed description of the evolution of the air brake system including the early mechanical brakes, vacuum brakes and finally the air brake system can be found in [16]. A review of various issues with these early train air brake systems can be found in [17]. A discussion of the development of different types of brakes including air brakes can be found in [18]

Before providing a detailed description of the air brake system that is currently used in commercial vehicles, a brief description of the air brake system used in trains is presented.

A. The train air brake system

The basic principle of operation of the air brake system used in trains in the United States is as follows (refer to Fig 2). When the locomotive is started, air is compressed and stored in storage reservoirs. Compressed air is also transferred through air hoses to the reservoirs located in each car. A valve referred to as the triple valve is mounted in each car and acts a relay valve in actuating the foundation brakes when the brake is applied. The main brake line is also filled with compressed air. When the driver applies the brake, he / she essentially decreases the pressure of air in the main brake line and this action opens a port in the triple valve. Then, air flows from the car's reservoir to the brake cylinder through this port. The amount of pressure in the foundation brake unit (and consequently the braking force) depends on the amount of pressure reduction in the main brake line. When the brake is released by the driver, the pressure of air in the main brake line is increased to its original value. This action opens up the exhaust port in the triple valve and the air from the brake cylinder is vented to the atmosphere. A detailed discussion of the air brake system used in trains can be found in [19].

Chapter 3

DESCRIPTION OF AIR BRAKE SYSTEM

The wide use of air brake systems in commercial vehicles started mainly in the early twentieth century. One of the earliest air brake systems for trucks was developed by George Lane in 1919 [20]. The initial air brake system consisted of storage reservoirs, control valves and brake chambers. As time progressed, the design of the air brake system underwent modifications to include several features such as foot-operated treadle valves, relay valves, spring brake chambers, tractor protection valves and many more [20], [21]. A description of the modern air brake system including its various components and their functioning can be found in [20]. A layout of the air brake system currently found in a commercial vehicle is presented in Fig. 1. Compressed air is provided by an engine driven compressor and is collected in storage reservoirs. A governor serves to control the pressure of the compressed air stored in the reservoirs. The pressure of air in the storage reservoirs is typically maintained between 8 Bar and 10 Bar. Compressed air is supplied from these reservoirs to the Dual Brake Valve. The driver applies the brake by pressing the brake pedal mounted on the Dual Brake Valve. This action meters the compressed air from the supply ports of the Dual Brake Valve to its delivery ports from where it travels through hoses to the brake chambers mounted on the axles.

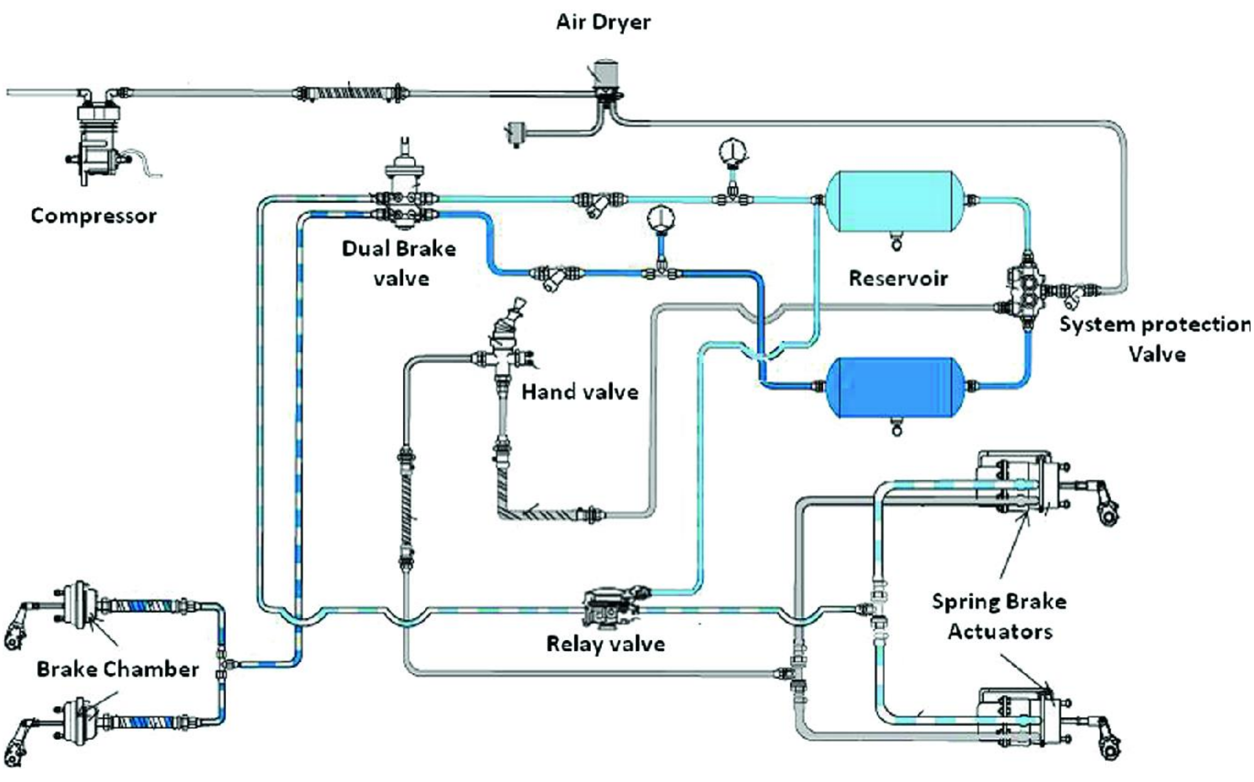


Fig. 3.1: General Layout of an Air Brake System

The S-cam foundation brake, found in more than 85 % of the air-braked vehicles in Commercial Vehicle is shown in Fig. 2.2

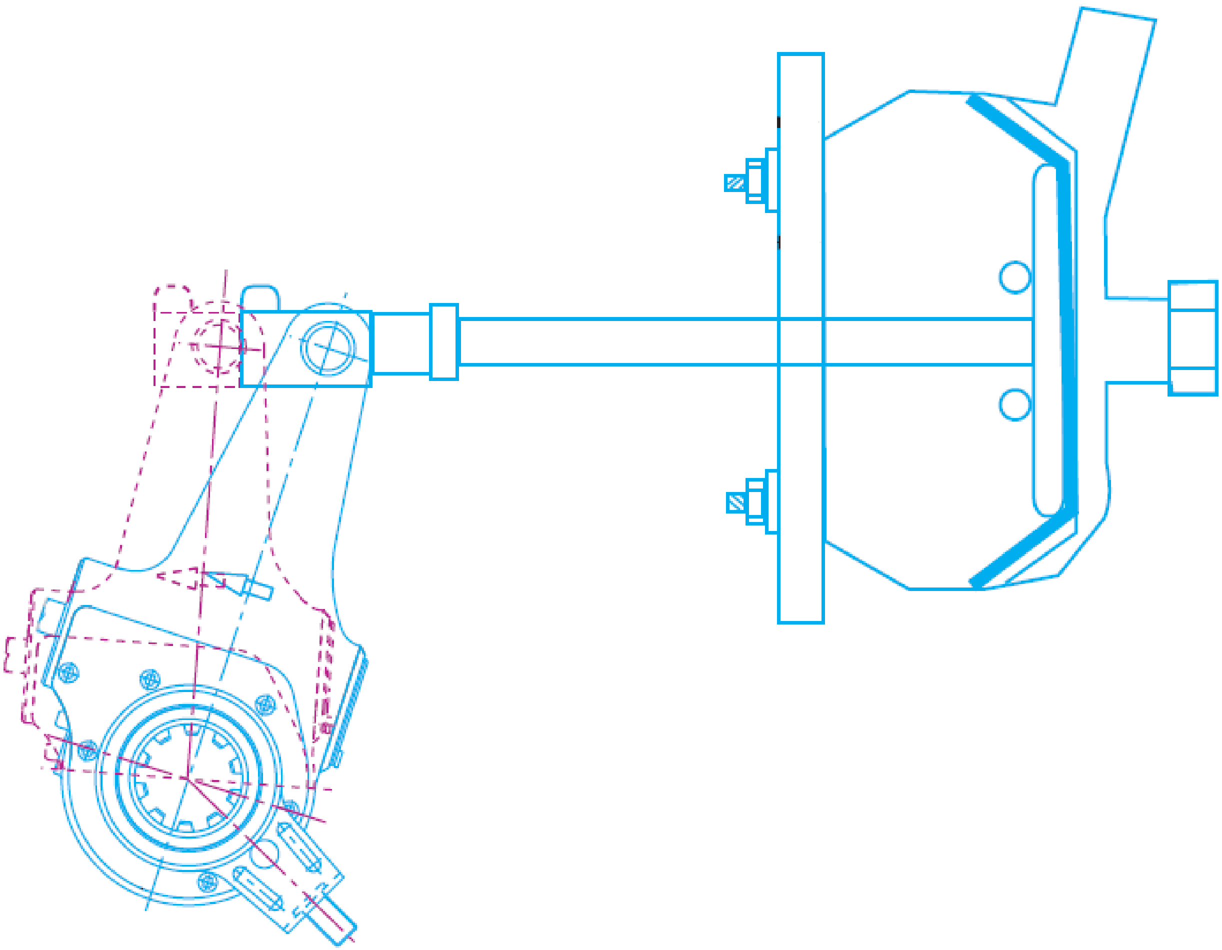


Fig. 3.2: S-Cam Foundation Brake

Compressed air from the Dual Brake Valve enters the brake chamber and acts against the diaphragm generating a force resulting in the motion of the push rod. The motion of the push rod serves to rotate, through the slack adjuster, a splined shaft on which a cam in the shape of an 'S' is mounted. The ends of two brake shoes rest on the profile of the S-cam and the rotation of the S-cam pushes the brake shoes outwards so that the brake linings make contact with the rotating drum. This action results in the deceleration of the rotating drum. When the brake pedal is released by the driver, air is exhausted from the brake chamber to the atmosphere causing the push rod to stroke back into the brake chamber and the S-cam now rotates in the opposite direction. The contact between the brake linings and the drum is now broken and the brake is thus released. A schematic of a drum brake is presented in Fig. 2.3.

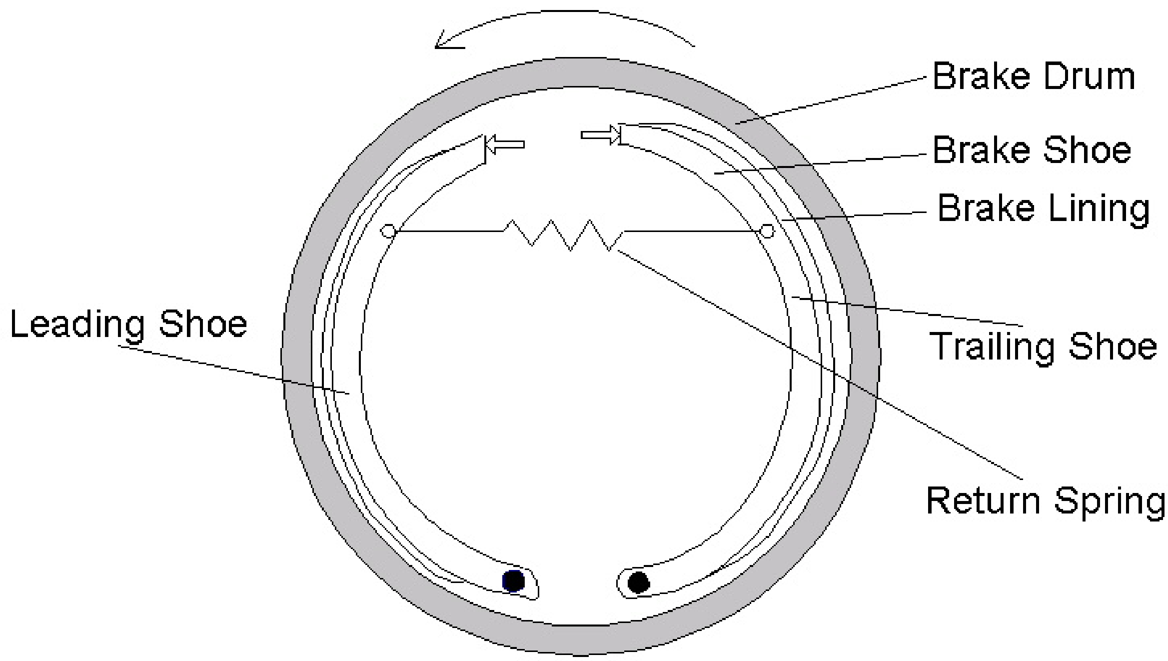


Fig. 3.3: Schematic of a Drum Brake

Some of the components of the typical air brake system used in commercial vehicles are briefly described below:

1. Compressor: Produce compressed air for brake application. This is a Single Cylinder reciprocating type compressor suitable for flange mounting. Single Cylinder 160cc compressor is run at 2/3rd of engine rpm. The engine driven compressor draws air from the inlet manifold/Air intake pipe of the engine through air cleaner. The compressor delivery is connected to system through Air Drier.

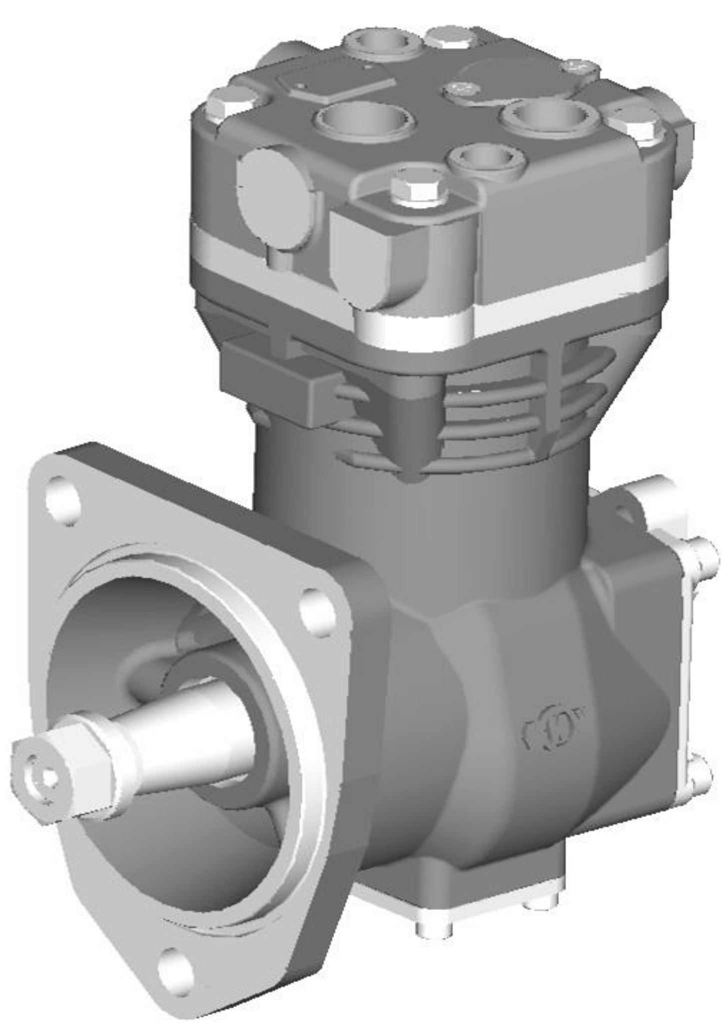


Fig. 3.4: Single Cylinder Reciprocating Type Compressor

2. Air Drier: Regenerative molecular sieve removes ambient humidity from the compressed air

- Clean and dry air in the braking system
- No corrosion caused by condensate
- Lubricants in the system components not washed away

Integrated filter removes oil and other contaminates
- In-line filters not required

Integrated unloader valve with adjustment. Integrated silencer to reduce exhaust noise.

Fig. 3.5: Single Cannister Air Drier

3. Air Reservoir: Store the compressed air and supply it to the Dual Brake Valve and Relay Valves.

Fig. 3.6: Air Reservoir

4. System Protection Valve: Facilitates branching-off to four independent circuits. Protects and maintains pressure in other circuits in case there is heavy leakage in one of the branches. Priority to fill primary and secondary circuits.

Fig. 3.7: System Protection Valve

5. Dual Brake Valve: Dual brake valve is used to gradually charge and exhaust the brake actuators and also to control the trailer brake systems through trailer control valve in a Dual Brake System

Fig. 3.8: Dual Brake Valve

6. Brake Chamber & Actuator: Brake Chamber converts air pressure in to force through push rod. Brake Actuator is combination of Brake Chamber & Brake Actuator.

Fig. 3.9: Brake Chamber

Fig. 3.10: Brake Actuator

7. Relay Valve: A small air signal is used to trigger a much bigger air flow in the air circuit. Concept similar to electrical relay. Improves speed of brake application and release.

Fig. 3.11: Relay Valve

8. Quick Release Valve: Used to speed up the exhausting of the air from the spring brake spring portion to reduce the possibility of brake drag.

Fig. 3.12: Quick Release Valve

9. Slack Adjuster: Slack adjuster perform two - fold Function. They serve as a lever during normal braking operation. Provide a quick and easy method of adjusting brakes.

Fig. 3.13: Automatic Slack Adjuster

10. Parking Brake Control Valve: Graduate-able charging and exhausting of the spring chambers which control the parking brake application.

Fig. 3.14: Parking Brake Control Valve

Table 3.1: Components of Pneumatic Subsystem of the Air Brake System

Components	Description
Compressor	Acts as the energy source providing compressed air
Air Drier	Clean and dry air in the braking system
Reservoirs	Store the compressed air and supply it to the treadle and relay valves
System Protection Valve	Facilitates branching-off to four independent circuits
Dual Brake Valve	Modulates the amount of air being supplied to the brake chambers
Quick Release Valve	Releases the front brakes quickly
Relay Valve	Regulates the brakes on the rear axles
Parking Brake Control Valve	Located in the driver's cab and is used to apply the parking brakes

Table 3.2: Components of Mechanical Subsystem of the Air Brake System

Components	Description
Brake Chamber & Actuator	Converts the energy provided by the compressed air into a mechanical force
Push Rod	Connected to the brake chamber diaphragm and transmits the force to the slack adjuster
Automatic Slack Adjuster	Converts the translational motion of the push rod into a rotation of the S-cam
S-Cam	Moves the brake linings during brake application and presses them against the brake drum

Chapter 4

EXISTING UNLOADER VALVE SYSTEM IN CURRENT AIR BRAKE SYSTEMS

In current Air Brake Systems, there is a governing system given for controlling the air pressure in this system. Below scheme given for clarification of the governing system in currently used Air Brake System.

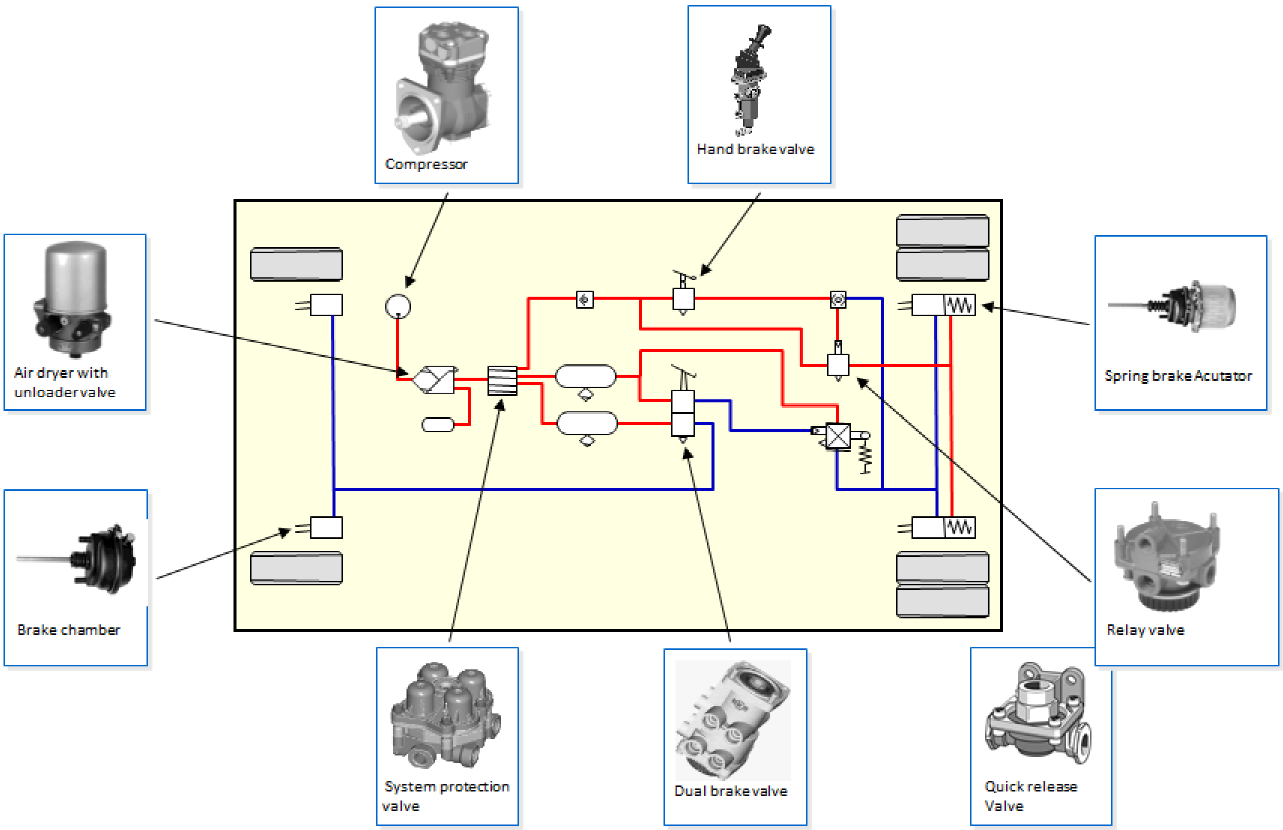


Fig. 4.1: Air Brake System with Unloader Valve

In this figure Air Dryer with Unloader Valve shown in the air circuit. Here compressor is directly drive from the Engine and always compress air to the air reservoirs. Air Compressor compress air by itself and send it to Air Dryer for purify the air (moisture & dust free). In Air Dryer another setup given for regulating the air pressure in the system before sending the compressed air to Air Reservoirs. This setup name is Unloader Valve setup. In this setup, when the maximum pressure will reach into the system, Unloader Valve will be opened and relief the pressure into atmosphere. Unloader Valve setup given with two pressure. Cut Out pressure where the Unloader Valve will start to relief excessive air pressures. And Cut In pressure where the Unloader Valve will off releasing pressures and start sending compressed air to Air Reservoirs again.

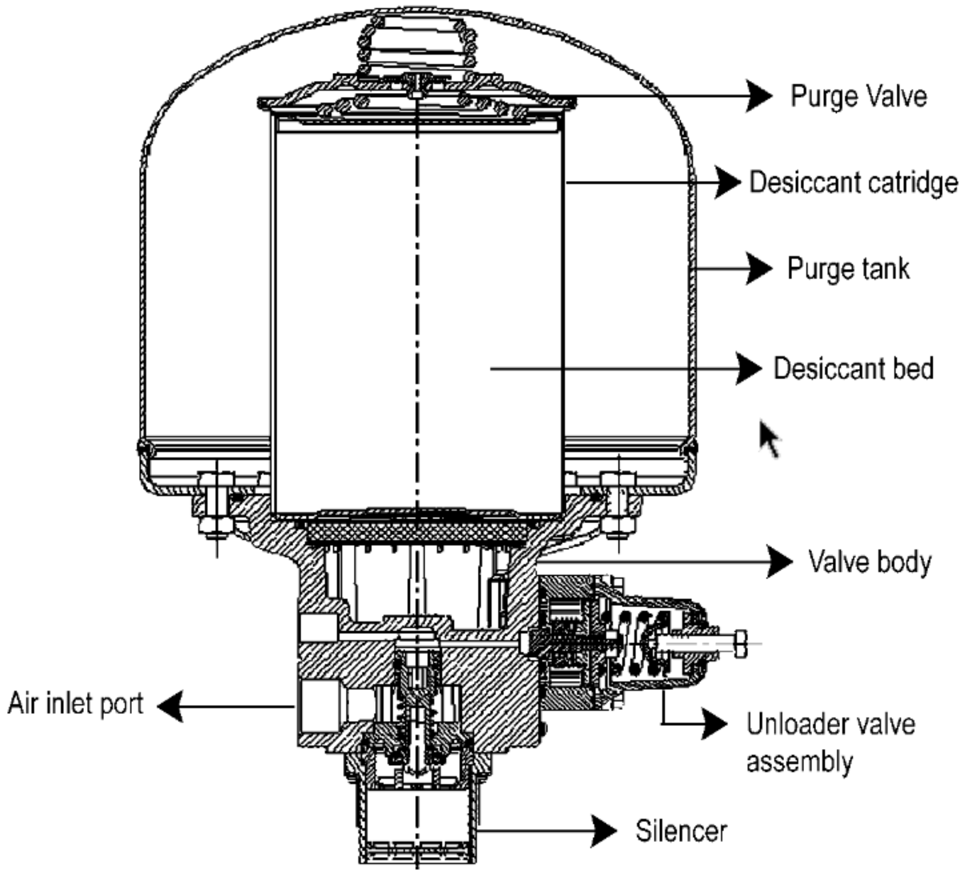


Fig. 4.2: Cross Sectional View of Unloader Valve

For more clarification, cross sectional area of an Air Dryer with Unloader Valve given. Here we can see that the unloader valve is loaded with a spring where pressure setting already done by the rating of the spring and compression calculation of the spring. Also, we can see a silencer is used to reduce unloading noise.

Chapter 5

EXPERIMENTAL SETUP FOR GOVERNOR

An experiment setup constructed as per below scheme: Fig. 15

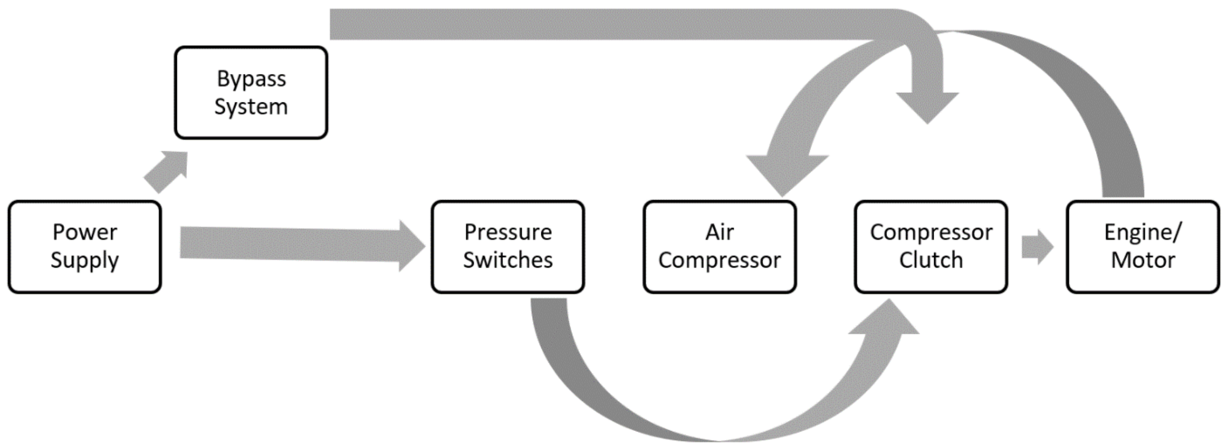


Fig. 5.1: Representation of Control Scheme

Single Cylinder Piston type air compressor used here. Compressor is driven by motor which is acting like engine of a vehicle. Compressor is mounted to the air reservoir. The compressor is driven by a belt from the motor. Electro-magnetic clutch is used to engage and disengage the compressor from the motor necessarily. Electro-magnetic clutch coil powered through an electrical diagram which is given on Fig. 16. In this control system, there is a bypass system given if electrical circuit failed to receive pressure sensing from switch, the bypass system will override the electrical system and always engage the clutch to compressor. Also, an Air Pressure Gauge is used to show the pressure available in the system directly to the driver seat.

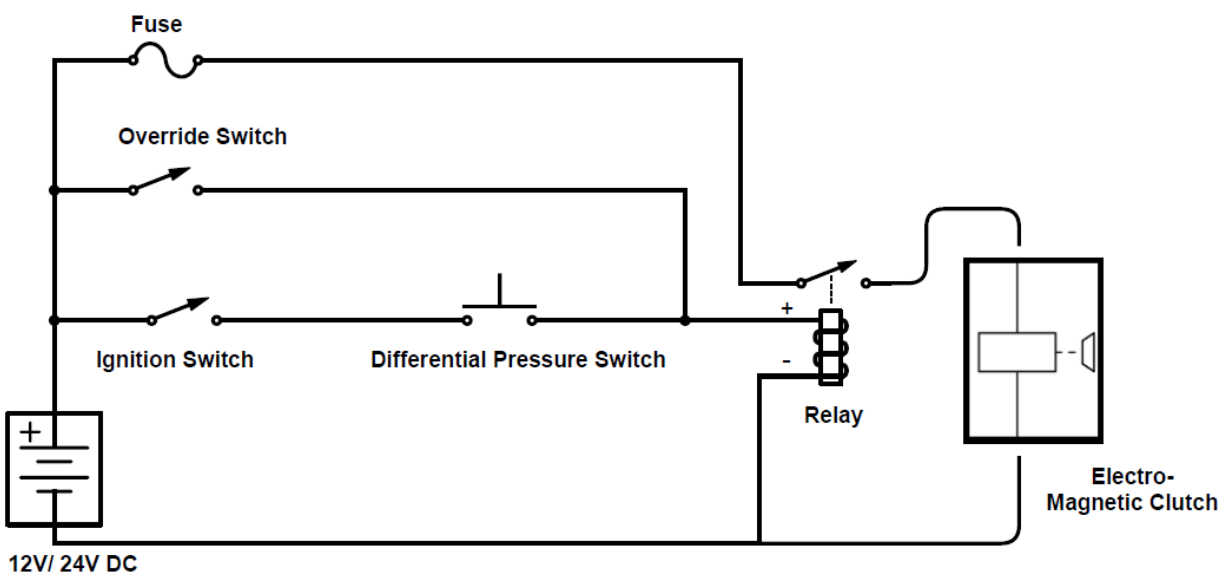


Fig. 5.2: Control Scheme of Electricals

In this control system, experimental setup can be classified under two categories- Mechanical Components, Electrical Components. Description of these categories is provided below-

A. Mechanical Components:

1. Air Compressor Electric Motor: In this experimental setup, Electric motor is categorized as mechanical components as it is representing the engine of a vehicle. Engine will be in ON condition always while the vehicle is rolling. An air compressor motor provides power to the compressor head through the drive belt (showed in Fig. 3.2). In turn, the compressor head compresses and forces quantities of air either into the storage tank. Essentially, the compressor motor is like the heart of an air compressor. Basically, it is single phase air compressor electric motor. Specification also given below:

Table 5.1: Specification of Air Compressor Electric Motor

Parameters	Unit	Value
Rated Output	W	750
Input Voltage	Vac	230

Fig. 5.3: Single Phase Air Compressor Electric Motor

2. Air Compressor Belt: It is actually just a driven belt which get drive from the electric motor and supply it to the Compressor. When the motor runs, the belt transfers the power through pulleys to run the Air Compressor.

Fig. 5.4: Air Compressor Belt

3. Air Compressor: Air compressor get drive through the drive from the motor and compress air to maximum 115 PSI. This compressor rotates with same RPM of electric motor.

Table 5.2: Specification of Air Compressor

Parameters	Unit	Value
Maximum Pressure	Kg/cm^2	8
Free Air Delivery	Cfm	1.26

Fig. 5.6: Single Cylinder Belt Driven Air Compressor

4. Air Reservoir: Air Reservoir just reserve the compressed air. It is made by thick sheet metal. The air reservoir stores the compressed air in it for later usage. We are using 30 Liter Air Reservoir.

Fig. 5.6: Air Reservoir

5. Air Pressure Gauge: Air Pressure Gauge just show the available pressure to the reservoir. It is actually Burdon tube pressure gauge. Driver can see actual available pressure into the system from the driving seat.

Fig. 5.7: Air Pressure Gauge

B. Electrical Components:

1. Battery: Battery is the power source of electric function. We are using 12V 110Ah lead acid cell battery for the experiment. Battery will supply the electric power to the circuit shown into Fig. 3.2.

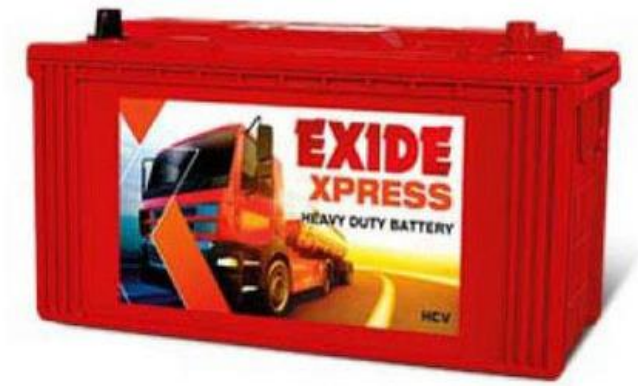


Fig. 5.8: Lead Acid Cell Battery

2. Ignition Switch: This switch is representing the Ignition Switch of a vehicle. Compressor clutch will be work if the ignition switch will be in ON condition.

Fig. 5.9: Ignition Switch

3. Differential Pressure Switch: This switch having two characteristics, one for selecting range where the switch will be off and another for differential pressure where the switch will be on. A Differential Pressure Switch, just like a regular pressure switch, is a simple electro-mechanical device that operates on the basic principles of levers and opposite forces. Mainly, they are used for sensing a difference between two points in a process.

Fig. 5.10: Differential Pressure Switch

4. Fuse: Fuse is to protect the electric circuit. a fuse is an electrical safety device that operates to provide overcurrent protection of an electrical circuit. We are using 40A blade type fuse.

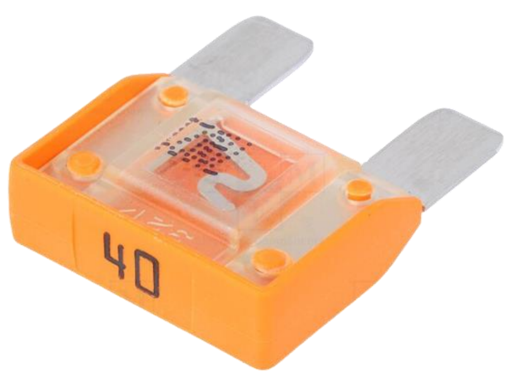


Fig. 5.11: Blade Type Fuse

4. Relay: As this circuit consume higher current, we are using a relay to avoid voltage drop in the circuit. A relay is an electrically operated switch.

Fig. 5.12: 4 Point Relay

4. Electro Magnetic Clutch: The main part of our project is Electro Magnetic Clutch (EMC). Here EMC is responsible to cut power in the driven side of Air Compressor. It takes switching sense from the Differential Pressure Switch. When maximum set pressure reaches into the Air Reservoir, EMC will be disengaged and stop to transmit the power into Air Compressor. After that this clutch will not engage immediately after dropping pressure into Air Reservoir. This will be engaged when only the differential pressure consumed from the Air Reservoir which we have done setting from the Differential Pressure Switch.

Like, we have done setting Highest Pressure @ 7.5 kg per square cm and Differential Pressure setting done into 1.5 kg per square cm. That means, the EMC will be disengage when the pressure will reach to 7.5 kg per square cm and then the EMC will be engaged when the pressure will be dropped to (Highest Pressure 7.5 – Differential Pressure 1.5) = 5 kg per square cm.

The EMC circuit will be controlled by DC Supply where supply source will be a 12V Batter as showing in Fig. 3.6. For circuit protection we are using a 40A fuse which will be blown if the current supply somehow exceeds 40A. Also, we are using a 4 Point Relay to avoid voltage drop from the system. Circuit override facility also given into the circuit if the main circuit or Differential Pressure Switch fail somehow.

Fig. 5.13: Electro Magnetic Clutch

C. Final Setup

Final setup of the project is given below-

Fig. 5.14: Final Setup

D. Working Principle:

First of all, the control system of clutch is operated by 12V DC Supply. Where we have used Lead Acid Cell Battery which is normally used in commercial vehicle. Circuit current flow will be on if we turn on the Ignition Switch. We have used Fuse for the protection of the circuit and used Relay to reduce voltage drop. Then the current flow will be through the Differential Pressure Switch. Differential Pressure Switch turned OFF when the system pressure reaches at maximum setting. This switch will not be turned ON immediately but after a certain pressure drop which is called differential pressure. When the Differential Pressure Switch will be turned ON Electro Magnetic Clutch will engage the compressor pulley and the compressor will start compressing air to Air Reservoir. When the maximum pressure will reach, Differential Pressure Switch will be turned OFF and this will disengage the Electro Magnetic Clutch and compressor will stop compressing air to the system.

Chapter 6

RESULT & DISCUSSION

Refer to the Chapter 2, current Air Brake System Air Compressor having direct drive from the engine where the Air Compressor will run if the engine is ON. In existing Air Brake System, if maximum designed pressure reaches into the system, air compressor will not stop. System will release the excessive pressure from the system through Unloader Valve which is described to Chapter 3. Hence, Air Compressor will compress air continuously either system reached into the highest designed pressure and it is nothing but a loss of engine power. Now in our prescribed design, the compressor will be TURNED OFF when the maximum pressure will be reached into the system.

We have analyzed some vehicles service history through IFAD Auto Services Ltd. service software SAP, that a HCV vehicle (GVW is greater than 16 tonnage) is run approximate 64,000 KM in 1 year. We have got some feedback of those customer that those vehicles mostly route into the highway as those are used for commercial uses only. Specifically, long route like Dhaka to Chottogram, Dhaka to Sylhet, Dhaka to Jashore etc. We have checked those route conditions also get some feedbacks from customer that those roads having upper than 70% Highways. In such highways, drivers rarely need brakes until they go through traffic jams and city areas. Also, we have been observing for years that maximum HCV vehicles Air Brake System air is unloading through the Unloader Valve while those are running in highway. Now we are going to evaluate the result of our project through filed level feedback from customers.

In HCV Vehicle, normally Indian, Japanese, Chinees & other suppliers at Bangladesh giving more than 200 HP engines. Also, every vehicle having air brake systems with at least 2 HP Air Compressor for the system. Now this 2 HP compressor is directly consuming the engine power in continuous way. Our project prevents it with a dynamic way we have described above. This project will be very efficient in highway routed vehicles.

A. Power Saving Calculation

HCV vehicle covered kilometers in a single year = 64,000 Km (As per service data)

Route into highway @ 70% = 44,800 Km

Highways where drivers rarely use brake @ 50% = 22,400 Km

22,400 Km is the figure where Air Compressor drive is not necessary from engine. And our project will show the effectiveness here.

Now assuming 1 Hr runtime of engine is equal to 26 Km of vehicle running (as per standardizations of Indian brands).

For 22,400 Km, engine runtime is $\frac{22400}{26} = 861$ Hrs.

For 200 HP or 150 kW engine where 2 HP or 1.5 KW Air Compressor used, we can prevent power loss of engine @22,400 Km: 1.5 kW x 861 Hrs = 1292 kWh

For 64,000 Km, engine runtime is $\frac{64000}{26} = 2461$ Hrs.

200 HP or 150 kW engine 1-year power consumption = 150 kW x 2461 Hrs = 369,150 kWh

We can consume less power by our prescribed system = 1292 kWh which is 0.35% of the total consumption over a year.

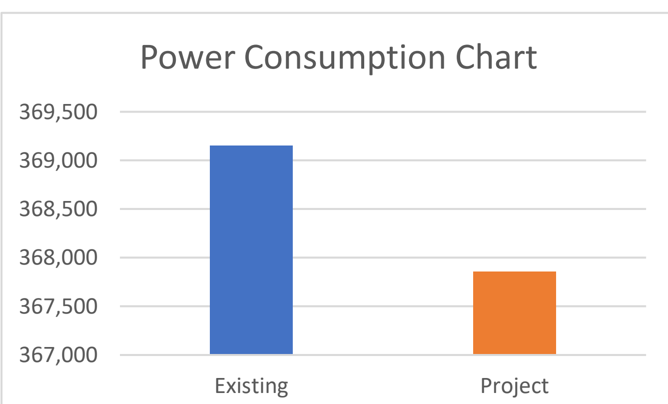
B. Fuel Saving Calculation

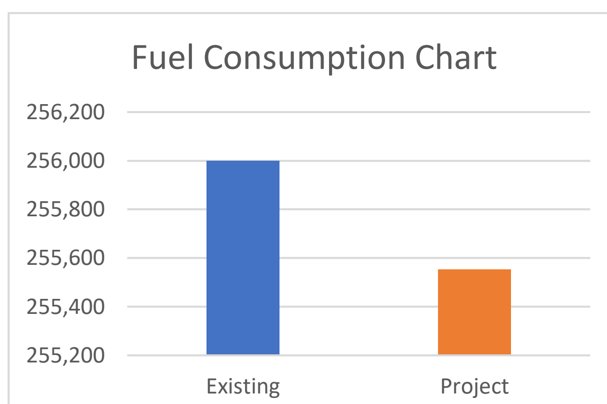
For HCV Vehicle (200 HP Engine) fuel consumption around = 4 Km per Liter

For 2 HP Compressor fuel consumption will be approximate: $\frac{4}{200} = 0.02$ Km per Liter

Hence 22,400 Km saving where compressor will be off = 0.02 KMPL x 22,400 Km = 448 Liter

Total fuel cost can be reduced: 448 Liter x 80 Tk/Liter = 35840 Tk





Chapter 7

CONCLUSION & RECOMMENDATIONS

A. Conclusion:

We have successfully completed the project and found the result refer to Chapter 5. By this prescribed project we can save approximate 1292 kWh power comparing to the existing Air Brake System found in Commercial Vehicle. Also approximate 448 Liter fuel can be saved per year by this prescribed project.

During this period of project preparing, we have been searching for feedback from field level customers and drivers to assume the approximate savings we can done with this project. This project can be implemented to the Air Brake System of Commercial Vehicle. This will not only save power consumption and fuel consumption, also this will help on a long life of Air Compressor. As brake is very vital aggregate of a vehicle, Air Compressor life will significantly help with a good and sustainable brake system.

B. **Recommendation**

This project can be improved through implementing reverse EMC system. As the runtime of Air Compressor is less like 891 Hrs. only, we recommending the clutch will automatically engaged without EMC current supply during low pressure (while pressure building up). EMC current supply will be ON when maximum pressure will reach into system.

Although, our Bangladeshi transport segment try to avoid electric items in Commercial Vehicle but our neighbor countries are rapidly getting into Electric Commercial Vehicle. We strongly recommend to implement this system in Commercial Vehicles. Also, we recommend convey proper knowledge regarding Electric Vehicles at Commercial Segments.

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