4. Have each student team draw a diesel engine, identifying the following:

   a. Engine design

   b. Type of cooling

   c. Type of cylinder sleeves

   d. Number of structural parts

Suggested Instructional Materials and References

Instructional Materials

1. Charts of the types of engine designs

2. A cutaway model of a diesel engine

3. A vertical design and a horizontal design diesel engine

4. Diesel engines for disassembly

References

Diesel and High-Compression Gas Engines. pp. 147-155.

III. To understand the function of the running gear and its parts

Teacher Preparation

Subject Matter Content

The moving parts of the engine that receive the gaseous energy produced in the combustion chamber and deliver it to the output end of the engine in the form of useful power are referred to as the running gear.

The piston and its rings seal the cylinders and transmit the gaseous pressure to the connecting rod.

The top section of the piston is referred to as the crown and the lower section as the skirt. The shape of the crown is determined by the design of the combustion chamber.

R E P O R T   R E S U M E S

ED 012 775 VT 000 502

DIESEL ENGINE SYSTEMS. AGRICULTURAL MACHINERY--SERVICE OCCUPATIONS, MODULE NUMBER 15.

OHIO STATE UNIV., COLUMBUS, CENTER FOR VOC. EDUC.

REPORT NUMBER OSU-AGDEX-761-017-15 PUB DATE AUG 65

EDRS PRICE MF-$0.25 HC-$1.28 32P.

DESCRIPTORS- *TEACHING GUIDES, UNITS OF STUDY (SUBJECT FIELDS), *AGRICULTURAL EDUCATION, *AGRICULTURAL MACHINERY OCCUPATIONS, *DIESEL ENGINES, POST SECONDARY EDUCATION, BIBLIOGRAPHIES, COLUMBUS

ONE OF A SERIES DESIGNED TO HELP TEACHERS PREPARE POSTSECONDARY STUDENTS FOR AGRICULTURAL MACHINERY SERVICE OCCUPATIONS AS PARTS MEN, MECHANICS, MECHANIC'S HELPERS, AND SERVICE SUPERVISORS, THIS GUIDE AIMS TO DEVELOP STUDENT UNDERSTANDING OF THE CONSTRUCTION AND OPERATING PRINCIPLES OF DIESEL ENGINES. IT WAS DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF RESEARCH FROM STATE STUDIES. SUGGESTIONS FOR THE INTRODUCTION OF THE MODULE ARE GIVEN. SUBJECT-AREA UNITS ARE--(1) OPERATING PRINCIPLES, (2) STRUCTURAL PARTS, (3) RUNNING GEAR, (4) AIR INTAKE AND EXHAUST, (5) FUEL SYSTEMS, AND (6) AUXILIARY SYSTEMS. EACH UNIT INCLUDES SUGGESTED SUBJECT-MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, AND SUGGESTED MATERIALS AND REFERENCES. CRITERIA FOR EVALUATION OF EDUCATIONAL OUTCOMES ARE LISTED. THE SUGGESTED TIME ALLOTMENT IS 30 HOURS OF CLASS INSTRUCTION AND 24 HOURS OF LABORATORY EXPERIENCE. TEACHERS SHOULD HAVE EXPERIENCE IN AGRICULTURAL MACHINERY. STUDENTS SHOULD HAVE MECHANICAL APTITUDE AND OCCUPATIONAL INTEREST IN AGRICULTURAL MACHINERY. THIS DOCUMENT IS ALSO AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 488 THROUGH VT 000 504) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212, FOR $7.50 PER SET. (JM)

Comf

DIESEL ENGINE SYSTEMS

One of Sixteen Modules in the Course Preparing for Entry in
AGRICULTURAL MACHINERY - SERVICE OCCUPATIONS

Module No. 15

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

The development of these materials was supported by a grant
from the
Division of Adult and Vocational Research
United States Office of Education

August, 1965

MEMORANDUM

TO: The ERIC Clearinghouse on Vocational and Technical Education
The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

(Address) 980 Kinnear Road, Columbus, Ohio 43212

DATE: August 4, 1967

RE: (Author, Title, Publisher, Date) Module No. 15, "Diesel Engine System," The Center for Vocational and Technical Education, August, 1965.

Supplementary Information on Instructional Material

Provide information below which is not included in the publication. Mark N/A in each blank for which information is not available or not applicable. Mark P when information is included in the publication. See reverse side for further instructions.

(1) Source of Available Copies:
Agency The Center for Vocational and Technical Education
Address 980 Kinnear Road, Columbus, Ohio 43212
Limitation on Available Copies No Limit Price/Unit $ 7.50/set
(quantity prices)

(2) Means Used to Develop Material:
Development Group National Task Force
Level of Group National
Method of Design, Testing, and Trial Part of a funded project of the USOE, OE-5-85-009; materials based on research from state studies; see preface material in the course outline.

(3) Utilization of Material:
Appropriate School Setting Post high school
Type of Program General post high school class in agricultural machinery
Occupational Focus Agricultural machinery service occupations
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Materials
Teacher Competency Background in agricultural machinery
Student Selection Criteria Post high school, mechanical aptitude, high school background, goal in agricultural machinery service occupation.
Time Allotment Estimated time listed in module. (P)

Supplemental Media --
Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

DIESEL ENGINE SYSTEMS

CONTENTS

DIESEL ENGINE SYSTEMS

Major Teaching Objective

To understand the construction and principles of operation of diesel engines

Suggested Time Allotments

At School

Class instruction	30 hours	
Laboratory experience	24 hours	
Total at school		54 hours
Occupational experience		0 hours
Total for module		54 hours

Suggestions for Introducing the Module

Until recent years farm tractor power has been limited primarily to gasoline engines. With improvements in diesel engines and with farming requiring heavier power units, diesel engines are fast gaining in popularity for use on the farm.

For this reason, it is highly important for those planning careers in the agricultural machinery field to have an understanding of the construction and principles of operation of a diesel engine. Also, persons planning for employment in the field of agricultural machinery should have a knowledge of the economics involved in diesel engines as compared with gasoline engines.

The following technique should be used to create interest in the module:

Bring before the class both a gasoline and a diesel tractor engine. Have students identify on each engine the fuel system, governing system, lubricating system, and the cooling system. Emphasize the difference in systems and construction of the two engines.

Competencies to be Developed

I. To understand what a diesel is and how it works

Teacher Preparation

Subject Matter Content

The essential feature of the diesel engine is the compression of a charge of air producing a temperature beyond the self-ignition point of the fuel, and the subsequent injection of fuel, and instantaneous ignition of the fuel in this highly compressed hot air.

A diesel engine is a machine which produces power by burning fuel in a body of air which has been compressed by a moving piston.

To understand what a diesel engine is, one must have a knowledge of the principles of operation of the engine. Actions that take place inside the engine are referred to as basic actions and occur in the following order:

1. Air is drawn into the cylinder.

2. Air is compressed to a high pressure, causing its temperature to rise.

3. The fuel is injected into the cylinder in the form of a fine spray. Fuel in the form of a spray produces a "homogeneous" mixture of fuel and air.

4. Combustion occurs immediately after fuel is injected into the cylinder because the temperature of the air is high enough, sometimes as high as 1,000 degrees F., to ignite the fuel. Combustion produces an expansion of the gaseous mixture, which pushes on the piston and causes the engine to produce mechanical power.

5. Having lost their pressure, the gases are exhausted.

The diesel engine introduces fuel into its combustion chamber by means of an injector after air alone has been squeezed to about one-sixteenth of its original volume by the piston (16 to 1 compression ratio).

The fuel charge is forced into the combustion chamber by the injector action through a number of tiny holes, each approximately .005 inches in diameter, and at pressures of 10,000-20,000 pounds per square inch. This produces a fine mist or spray, and the atomizing effect aids in vaporizing the fuel and mixing it more intimately with the air present.

At the 16 to 1 compression ratio, compression pressures in the diesel combustion chamber reach 500-800 pounds per square inch with accompanying high temperatures of approximately 1000° F.

This "heat of compression" spontaneously ignites the fuel injected. The diesel method of ignition simply utilizes a law of nature - when air is compressed, its temperature rises in proportion to the compression ratio. The same result may be noticed to a lesser degree when using a hand air pump to inflate a tire or a basketball.

Up and down movements of the piston in the cylinder are known as strokes. During a stroke one or more events or actions occur. The strokes described above are known as:

1. Intake

2. Compression

3. Power

4. Exhaust

In a four-stroke-cycle engine one event occurs during each stroke and four strokes are required to complete a cycle. In a two-stroke-cycle engine more than one event occurs during a stroke and only two strokes are required to complete a cycle.

Although the outward appearance of a diesel tractor may not be greatly different from that of a gasoline tractor, there are a number of differences in the engine.

1. Diesel engines do not have ignition systems.

2. Diesel engines draw only air into the cylinder on the intake stroke.

3. Diesel engines use much greater compression ratios.

4. Diesel engines use less volatile, heavier liquid fuels.

5. Diesel engines use fuel pumps and injectors instead of carburetors.

6. Diesel engines are heavier than gasoline engines of the same size.

Suggested Teaching-Learning Activities

1. Through the use of charts, diagrams, and teacher-made mockups, illustrate the up and down movements (strokes) in the cylinder of both a two-stroke-cycle and a four-stroke-cycle diesel engine.

2. Bring a cutaway model of a diesel engine before the class and demonstrate the four-stroke cycle.

3. Bring gasoline and diesel engines of comparable size before the class and point out the differences in the two engines.

4. Have students survey their local communities to determine the extent to which diesel engines are used on farms.

Suggested Instructional Materials and References

Instructional Materials

1. Charts, diagrams. and mockups of the stroke action in both types of diesel engines

2. A cutaway model of a diesel engine

3. A gasoline engine

4. A diesel engine

References

S*1. Diesel and High Compression Gas Engines, pp. 1-15.

S 2. Engineering Bulletin. No. AD-206, pp. 3-11.

*The symbol T (teacher) or S(student) denotes those references designed especially for the teacher or for the student.

II. To understand the structural parts of a diesel engine

Teacher Preparation

Subject Matter Content

In general, the engine structure includes those parts which are fixed and have as their main function holding the engine together. Its primary job is to support and keep in line the moving parts, which resist the forces set up by the operation of the engine. The engine structure also supports auxiliary systems and provides jackets and passages for cooling water, a pump for lubricating oil, and a protecting enclosure.

The two kinds of forces acting on the structure are:

1. Firing pressures, which act on the cylinder heads and crankshaft bearings

2. Inertia forces, which are caused by motion of the pistons, connecting rods, and crankshaft

Frame designs of diesel engines vary, since they may be of either vertical design or horizontal design. Vertical frames may be of the automotive design used for smaller, stationary engines or A-frame design used for large engines. Also the frame may be either two-piece or three-piece, depending upon its design, which may be determined by its size and use.

The two-piece vertical frame construction is the most widely used. The lower part, or bedplate, of the two-piece frame forms the base, supports the main bearings, encloses the lower part of the crankcase and cylinder block.

Most designs include all cylinders in a single block; however, some designs cast cylinders individually.

Frames for horizontal engines are constructed very much like those of vertical engines. They are usually in two parts.

Resistance to wear and cooling is the prime requirement of cylinders of diesel engines. To build up resistance, the cylinder is fitted with a sleeve or liner, which may be either the "dry" or the "wet" type. The main difference between "wet" liner and a "dry" liner is that the "dry" liner makes metal-to-metal contact with the cylinder casting which contains the water jacket. The "wet" liner does not make metal-to-metal contact with the cylinder casting and its outside surface is wetted by the cooling water. "Wet" cylinder liners are used most commonly in tractor engines.

Since cylinder heads of diesel engines must be stronger and more carefully cooled than gasoline engine cylinder heads, a more complicated structure is required. Thus, many large engines use individual cylinder heads.

Suggested Teaching-Learning Activities

1. Show students a dry and wet type sleeve.

2. Bring a cutaway model of a diesel engine before the class, identify the various parts of the engine structure, and explain the function of each part.

3. Bring before the class two diesel engines, one of the vertical design and the other of the horizontal design. Explain the differences in the construction of each type engine.

4. Have each student team draw a diesel engine, identifying the following:

   a. Engine design

   b. Type of cooling

   c. Type of cylinder sleeves

   d. Number of structural parts

Suggested Instructional Materials and References

Instructional Materials

1. Charts of the types of engine designs

2. A cutaway model of a diesel engine

3. A vertical design and a horizontal design diesel engine

4. Diesel engines for disassembly

References

Diesel and High-Compression Gas Engines. pp. 147-155.

III. To understand the function of the running gear and its parts

Teacher Preparation

Subject Matter Content

The moving parts of the engine that receive the gaseous energy produced in the combustion chamber and deliver it to the output end of the engine in the form of useful power are referred to as the running gear.

The piston and its rings seal the cylinders and transmit the gaseous pressure to the connecting rod.

The top section of the piston is referred to as the crown and the lower section as the skirt. The shape of the crown is determined by the design of the combustion chamber.

Piston connection to connecting rods may be according to two designs.

1. Trunk piston--This design is used in most engines. The connecting rod acts directly on the piston. The side thrust caused by this design causes the piston to press against the cylinder wall, first on one side and then on the other, causing considerable wear near the middle of the stroke.

2. Cross head piston--The connecting rod does not act directly on the piston in this design, since the crosshead and crosshead guides prevent this action. (Example: See Diesel and High Compression Gas Engines, page 160.)

The advantages of a crosshead are:

1. Easier lubrication

2. Uniformly distributed clearance around the piston

3. Simpler piston construction because the wrist pin and its bearings are eliminated

Even though crosshead designs offer advantages over trunk piston design, they are offset by disadvantages such as added weight and height and need for more careful adjustment.

Piston rings serve several important purposes and are classified according to the service they perform.

1. Compression rings--Usually numbering four to six, they are located in the crown of the piston. They serve two main purposes.

    a. They seal the space between the piston and the liner.

    b. They transmit heat from the piston to the water-cooled cylinder liner.

2. Seal rings--As the face of the compression ring or the cylinder bore wears, the gap at the joint of the ring becomes larger. To reduce compression loss from leakage through the gap, special seal rings are used. Seal rings are also located on the top portion of the piston, below the compression rings.

Usually one or two, occasionally three, oil control rings are located near the bottom of the piston skirt. These rings scrape off, on the downstroke, most of the lubricating oil splashed on the cylinder wall by the crankshaft and connecting rod, and rode over the remaining oil film on the up stroke.

Oil control rings prevent surplus oil from being carried into the combustion chamber. This surplus oil is only partially consumed, leaving a carbon deposit. Oil rings also allow sufficient oil to be carried to the upper part of the cylinder liner during the upstroke to lubricate the piston surface and the compression rings.

A connecting link between the connecting rod and the piston is known as the wrist pin. There may be three arrangements of wrist pins.

1. The wrist pin is secured in the piston and the bearing is held in the connecting rod end.

2. The wrist pin is fastened to the connecting rod and the bearing is part of the piston.

3. The wrist pin is free and bears against bearings in both the piston and the connecting rod.

Crankshafts deliver force to the transmission and power train as a result of the thrust from the connecting rod.

Some crankshafts are designed with counterweights opposite the crank pins. These relieve the load on the main bearing by offsetting the inertia forces.

The purpose of bearings is to support rotating shafts and other moving parts and aid in transmitting loads from one engine part to another.

Bearings reduce the friction between the moving surfaces by separating them with a film or lubricant and carry away the heat produced by unavoidable friction.

The flywheel is a heavy wheel or disk attached to the crankshaft. Through rotation, the flywheel acquires kinetic energy. It stores additional kinetic energy when it speeds up, and it gives back that energy when it slows down.

The main purpose of the flywheel is to reduce the speed fluctuations of the crankshaft that are caused by the difference in the amount of energy exerted on the piston during the power stroke and the compression stroke.

Single-cylinder engines require larger flywheels than multi-cylinder engines, because energy variations during a complete cycle are greater in single-cylinder engines.

Suggested Teaching-Learning Activities

1. Bring before the class several types of each kind of ring. Explain the advantages and disadvantages of each.

2. Bring a piston with rings to the class and point out the crown, skirt oil rings, compression rings, and seal rings.

3. Measure cylinder wear on new and old cylinders.

4. Using a cutaway model of an actual diesel tractor engine, demonstrate to the class the function of the connecting rods, the wrist pins, the crankshaft, and the flywheel.

5. Have the diesel engine running gear completely disassembled. Have students reassemble it and replace it in the engine.

6. At the end of the discussion of the running gear, lay out the parts of the running gear and have students identify them.

Suggested Instructional Materials and References

Instructional Materials

1. Various types and kinds of rings

2. A piston complete with rings for a diesel engine

3. Two diesel engines, one using cross head pistons and the other using truck pistons

4. A cutaway model of a diesel engine

5. Diesel engine running gear parts

References

Diesel and High Compression Gas Engines, pp. 156-177.

IV. To understand the diesel air intake and exhaust system

Teacher Preparation

Subject Matter Content

The main purpose of the air intake and valve systems is to charge the cylinder with air and remove the products of combustion (the burned gas).

In four-cycle engines, separate piston strokes fill and discharge the cylinders. The only additional parts needed are valves and actuating gear to control the flow of air and exhaust gas.

In two-cycle engines, fresh air must be forced in to push out the exhaust gas and charge the cylinder. This is the function of the scavenging system.

Components of the air intake and valve systems and their functions are:

1. Valves--Valves control the admission of the air charge in four-cycle engines, the discharge of exhaust gases in all four-cycle and many two-cycle engines, the admission of fuel in some engines, and the admission of compressed air for starting many large engines.

2. Valve actuating gear--The function of the valve actuating gear is to cause and control the opening and closing of the intake and exhaust valves. The actuating gear may also actuate the fuel injection valves, the fuel pumps, or the air starting valves.

   Valve actuating gear usually consist of:

   a. Camshaft drives

   b. Camshafts

   c. Pusher rods and rockers

3. Superchargers--The purpose of the supercharger is to force more air into the cylinder so that more fuel can be burned and the engine output boosted.

   Superchargers are usually either the positive displacement rotary blower type or the centrifugal blower type.

4. Scavenging systems--In two-cycle engines the pressure of the incoming air charge must be used to scavenge or push out the exhaust gases during a short period of time when the piston is near the bottom of its stroke.

   The three basic methods of supplying the incoming air charge at the low pressure needed to accomplish this are:

   a. Crankcase scavenging

   b. Power piston scavenging

   c. Pump or blower scavenging

Suggested Teaching-Learning Activities

1. Lay out various parts of the air intake system and have students attempt to identify them.

2. Through the use of pictorial diagrams in wall chart form and strip films, demonstrate the various parts of the air intake system.

3. Bring several types of superchargers to class to familiarize the students with them and their functions.

4. Have students disassemble an air system on a diesel engine. Have students identify the parts and observe how they function in the motor. Included in the system should be valves, valve actuating gear, superchargers, scavenging systems, camshaft, and drive.

Suggested Instructional Materials and References

Instructional Materials

1. Parts of a diesel air intake and exhaust system

2. Strip films and charts of the air system in diesel motors

3. Several diesel motors for students to disassemble

4. A supercharger of each type

References

Diesel and High-Compression Gas Engines, pp. 178-205.

V. To understand diesel fuel systems

Teacher Preparation

Subject Matter Content

The heart of the diesel engine is the fuel injection system. The function of the fuel injection system is to deliver fuel to the combustion chamber. In doing so it must:

1. Meter or measure the correct quantity of fuel to be injected

2. Time the fuel injection

3. Control the rate of fuel injection

4. Atomize, or break up, the fuel into fine particles

5. Properly distribute the fuel in the combustion chamber

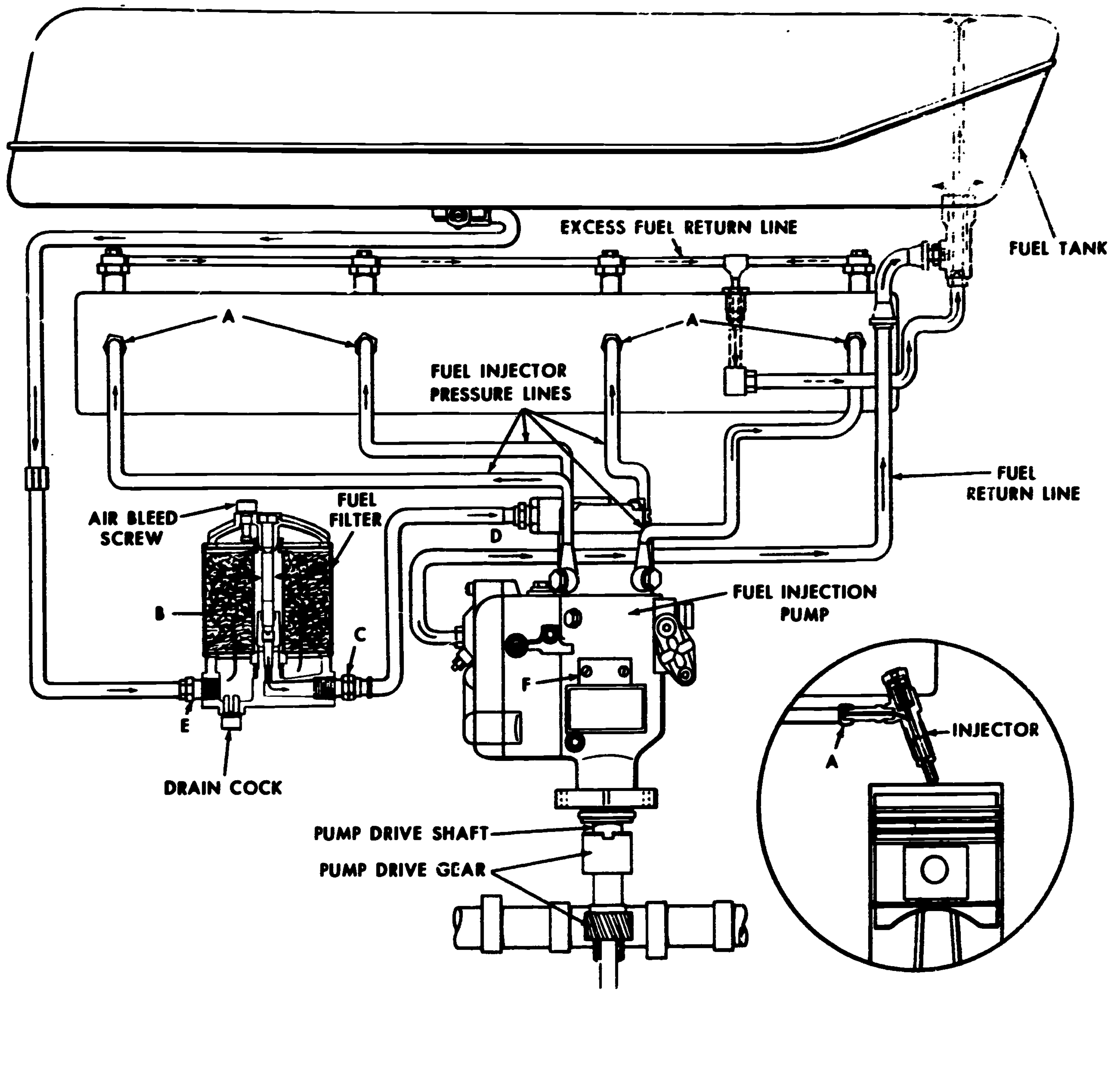
Most modern diesels use mechanical or solid injection instead of the original air injection method. Pumps and spray valves are the basic elements of solid injection systems. The three main classes of solid injection systems are:

1. Common rail

2. Individual-pump

3. Distributor systems

"Diesel Fuel Systems"



Diesel Fuel System

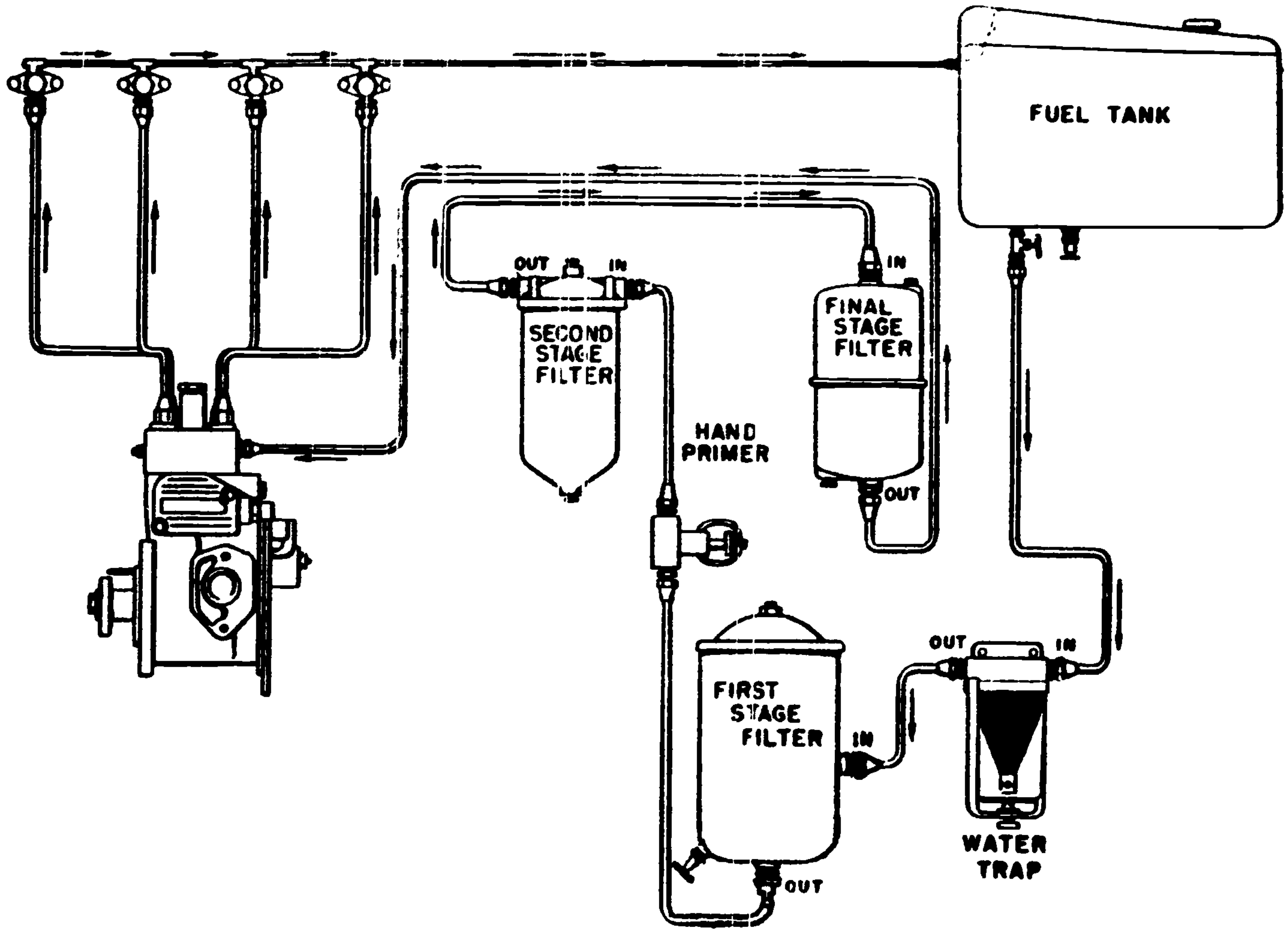


Diagram of a diesel fuel system showing several in-line filters and traps for the removal of foreign material and moisture from fuel.

There are two designs of the common rail or header systems.

1. Cam-operated spray valve design--This design uses a single pump which supplies high-pressure fuel to the "common rail" connected by tubing to spray valves (fuel nozzles). The spray valves are mechanically operated by cam action and control the metering and timing. (Example: See Diesel and High-Compression Gas Engines, p. 209.)

2. Self-actuated spray valve design--A cam-operated fuel injector and a spring-loaded nozzle perform the functions of the fuel-needle valve. This is the chief difference between the self-actuated spray valve design and the cam-operated spray valve design. (Example: See Diesel and High-Compression Gas Engines, p. 210.)

In the individual pump system of fuel injection the pump performs the major job. The functions of the pump are:

1. To raise the pressure of the fuel

2. To meter the charge

3. To time the injection

(Example: See Diesel and High Compression Gas Engines, diagram 3, p. 212.)

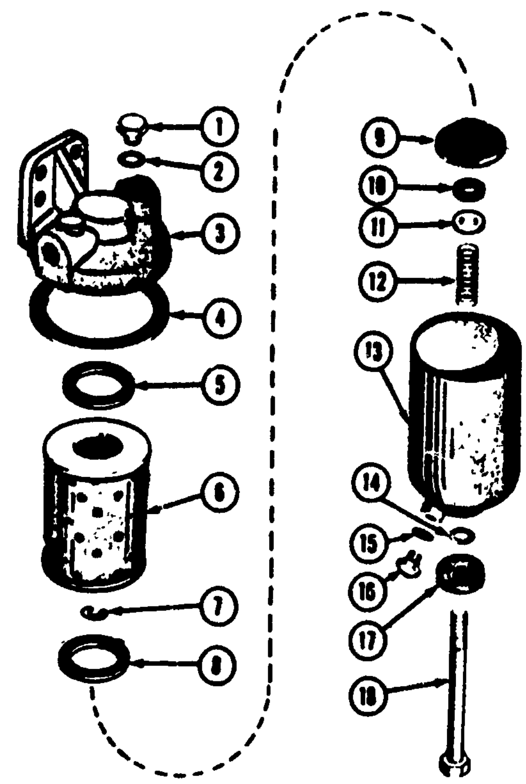
Distributor injection systems may be either high-pressure or low-pressure.

In this system the fuel is metered at a central point and then directed by the distributor to each cylinder in the proper firing order. (Example: See Diesel and High-Compression Gas Engines, diagram 4, p. 214, and diagram 5, p. 215.)

An important part of the fuel assembly of a diesel engine is the fuel filter system. The number of filters used ranges from one to three. Filters are usually referred to as:

1. First stage (primary or auxiliary), which removes most of the water and coarse material

"First Stage Fuel Filter Assembly"

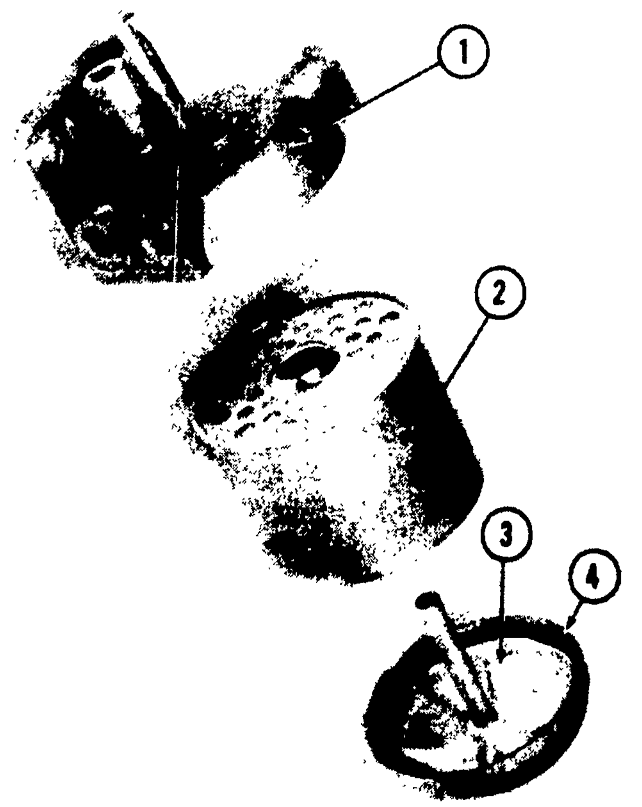


First Stage Fuel Filter Assembly

1. Vent Plug
2. Vent Plug Washer
3. Filter Head Assembly
4. Gasket - Body to Head
5. Gasket - Element End
6. Filter Element
7. Snap-Ring
8. Gasket - Element End
9. Element Lower Plate
10. Element Plate Oil Seal
11. Spring Washer
12. Element Tension Spring
13. Filter Body Assembly
14. Body Oil Seal
15. Drain Plug Washer
16. Drain Plug
17. Oil Seal Retainer
18. Center Bolt

2. Second stage (intermediate or final if only two are used), which removes the finer particles and a small amount of water

"Second Stage Fuel Filter Assembly"



Second Stage Fuel Filter Assembly
1. Filter Head
2. Filter Element
3. Filter Base Assembly
4. Element Seal

3. Third stage, which (if used) removes any remaining small particles

Although combustion chambers are not a part of the fuel system, they are closely related to it and must be understood to know a diesel engine fully.

The entire job of vaporizing, mixing, and igniting fuel takes place inside the cylinder in an extremely short time. In order for this job to be performed properly and efficiently, the combustion chamber must be designed for the most efficient performance possible.

Successful combustion depends upon:

1. Fine atomization

2. High temperature for prompt ignition

3. High relative velocity between fuel and air particles

4. Good mixing of fuel and air particles

Combustion chamber designs vary according to manufacturers but basically can be grouped as:

1. Open chambers--This design, because it is simple, is used primarily in engines which do not run at high maximum speeds and through a wide speed range.

2. Special design chambers--Special design chambers are necessary in engines that run at high maximum speeds and through a wide speed range. Because speed changes unbalance the correct proportioning of spray, incomplete combustion and a smoky exhaust result. Special design chambers may be grouped in four main classes.

    a. Turbulence chambers

    b. Precombustion or antechambers

    c. Air cells

    d. Energy cells

It is very important that the proper fuel be used in a diesel tractor engine. If the fuel is not of the proper specification, damage to the engine will result. Manufacturers of diesel engines list in the operator's manual, for each machine they make, the type of fuel to be used in their engines. The recommendations of the manufacturer should be followed when selecting diesel fuels.

Mechanics and mechanics' helpers should understand all the properties of diesel fuel in order to provide long, trouble-free operation of the engine. If a diesel engine doesn't operate satisfactorily, check the fuel properties. Two standard grades of diesel fuel are distilled by manufacturers.

1. Number One Diesel Fuel (No. 1-D)

2. Number Two Diesel Fuel (No. 2-D)

The following factors affect the burning of fuel and ultimately the efficiency of operation of the diesel engine.

1. Cetane rating--Cetane rating is a measure of the self-ignition and burning qualities of diesel fuel. If a fuel has the proper cetane rating for the engine it is to be used in it will:

    a. Cause easier starting

b. Produce less smoke

c. Reduce fuel knock

The most satisfactory cetane rating for diesel engines is between 40 and 60.

2. Volatility of fuel--The volatility of a fuel has reference to the ease at which the fuel will change into a vapor or gas.

3. Carbon residue--Carbon residue is the carbon deposit left after all the good qualities in the fuel have burned. This residue forms on all parts of the engine that come in contact with it.

4. Viscosity--The viscosity of the fuel has reference to the length of time it takes for a fuel to flow through the orifice in the injector nozzle tip.

   a. Most fuels have different viscosity rates because of the size of the injector orifice and the size of the engines.

   b. Diesel fuels must have more lubricating qualities than other fuels because the injector and injector pump are lubricated through the fuel.

   c. Proper viscosity provides a better spray pattern.

5. Sulphur content--The sulphur content has reference to the amount of non-combustible materials in the fuel, that, when burned, form gases that mix with water in the cylinder and form a corrosive liquid. This corrosion causes the engine parts to gum up and work improperly.

6. Ash content--When a fuel burns, a certain amount of non-combustible ashes are left in the cylinder. These ashes take on the form of an abrasive in the cylinders.

7. Water and sediment content--Water and sediment can cause serious damage to the fuel system of a diesel engine.

   a. It may cause the fuel system parts to rust.

   b. It may interfere with proper injector lubrication.

   c. It may cause plugging of nozzle tips.

8. Flash point--Fuel flash point refers to the lowest temperature at which the fuel vapor will ignite. The compression ratios of diesel engine systems are higher than those for spark ignition systems. This is necessary because the compressed air serves to ignite the fuel in the compression chamber. The average compression ratio for diesel tractors is approximately 16.3 to 1.

9. Pour point--Pour point is the point at which the fuel oil congeals or solidifies by cooling. If a fuel oil does not have the correct pour point in cold weather it will not move into or through the injector lines, injector, and the injector pump.

10. Cloud point--At some temperature slightly above the pour point diesel fuel becomes cloudy due to the formation of wax crystals. The temperature at which this begins to occur is called the cloud point. Since the wax crystals cause clogging of fuel filters and supply lines, and since this occurs at temperatures above the pour point, the cloud point may be an even more important consideration as a fuel specification than the pour point. The cloud point also depends on the hydrocarbon composition of the fuel. Cloud points usually occur from 8 to 10 degrees Fahrenheit above the pour points, but cloud points as high as 15 or even 20 degrees above the pour points are not uncommon.

<u>Suggested Teaching-Learning Activities</u>

1. Bring a diesel motor before the class. Call attention to the fuel system. Disassemble and discuss the fuel system part by part.

2. Have the class compare the following diesel engine fuel systems:

    a. Cam-operated valve design

    b. Self-activated spray valve design

    c. Individual pump system

    d. High-pressure distributor system

    e. Low-pressure distributor system

3. Have students replace the fuel filter in several diesel engines. Call to their attention the construction of the filter and parts associated with it.

4. Have students observe the types of combustion chambers mentioned in the content in diesel motors.

5. Have students disassemble and study the parts of the fuel pump.

6. Bring to the class several fuel injectors. Have students disassemble them and become familiar with the parts of each one.

7. Demonstrate pour and cloud points by heating and cooling diesel fuel samples in a test tube.

8. Visit a local agricultural machinery dealership and observe calibration testing of fuel pumps.

9. Have students check injector nozzles for proper spray pattern.

Suggested Instructional Materials and References

Instructional Materials

1. Diesel motors
2. Fuel filters
3. Fuel pumps
4. Fuel injectors

References

1. Diesel and High Compression Gas Engines, pp. 206-239.

S 2. Tractor Fuels and Lubricants, pp. 11-14.

VI. To understand the auxiliary systems of a diesel engine

Teacher Preparation

Subject Matter Content

An understanding of diesel engines is not complete without a knowledge of the auxiliary systems.

Auxiliary systems include:

1. Governing system
2. Lubricating system
3. Cooling system

The purpose of a governing system is to maintain a constant engine speed automatically even under varying loads.

The basic principle which makes a governing system work is that any change in load immediately causes a change in speed. To keep the engine running at a steady speed, the flow of fuel must be regulated in such a way that the power developed is just equal to that needed at the desired speed. The governor does this by noting a change in engine speed and then adjusting the rate of fuel flow to meet the needs of the engine to maintain a steady speed.

Governors may be either:

1. Mechanically operated
2. Hydraulically operated

Governors which are mechanical or hydraulic may vary in design and function and may be classed as:

1. Constant speed
2. Variable speed
3. Speed-limiting
4. Load-limiting
5. Pressure-regulating
6. Torque-converter
7. Overspeed trip
   (Example: See Diesel and High-Compression Gas Engines, diagram 7, p. 278.)

An essential system for the operation of an engine is the lubricating system.

The function of the lubricating system is to keep all moving parts properly lubricated. To do this, the lubricating system must:

1. Maintain an oil film between the shafts and bearing surfaces at the main, crankpin, and wrist pin bearings

2. Maintain an oil film for the camshaft, valve gear, and engine auxiliaries

3. Provide oil film between the piston and the cylinder wall

Most diesel engines have a pressure-circulating lubricating system. The design of the system varies according to the engine size and design.

The main components and their functions of a typical lubricating system are:

1. Sumps (wet or dry)--The purpose of the sump is oil storage. In many designs it is part of the crankcase. In other designs the oil storage is outside the engine itself and is known as a dry sump.

2. Main pump--Usually this is mechanically driven and forces oil under pressure to the lubricating piping of the engine.

The auxiliary pump is usually driven by an electric motor. It lubricates cylinder and bearing surfaces before the engine reaches necessary speed and after it is shut down.

The purpose of the oil strainer is to prevent dirt passing into the engine.

The function of the oil cooler is to maintain the temperature of the oil within desired limits.

Only about one third of the heat energy of the fuel is converted into mechanical energy and leaves the engine in the form of brake horsepower. Thus, about two-thirds of the heat energy of the fuel shows up in hot exhaust gases, friction heat, and heat in the walls of the combustion chamber.

The purpose of the cooling system is to remove the unwanted heat from the engine.

Heat Input and Disposal in a Diesel Engine
(Three-Quarters to Full Load)

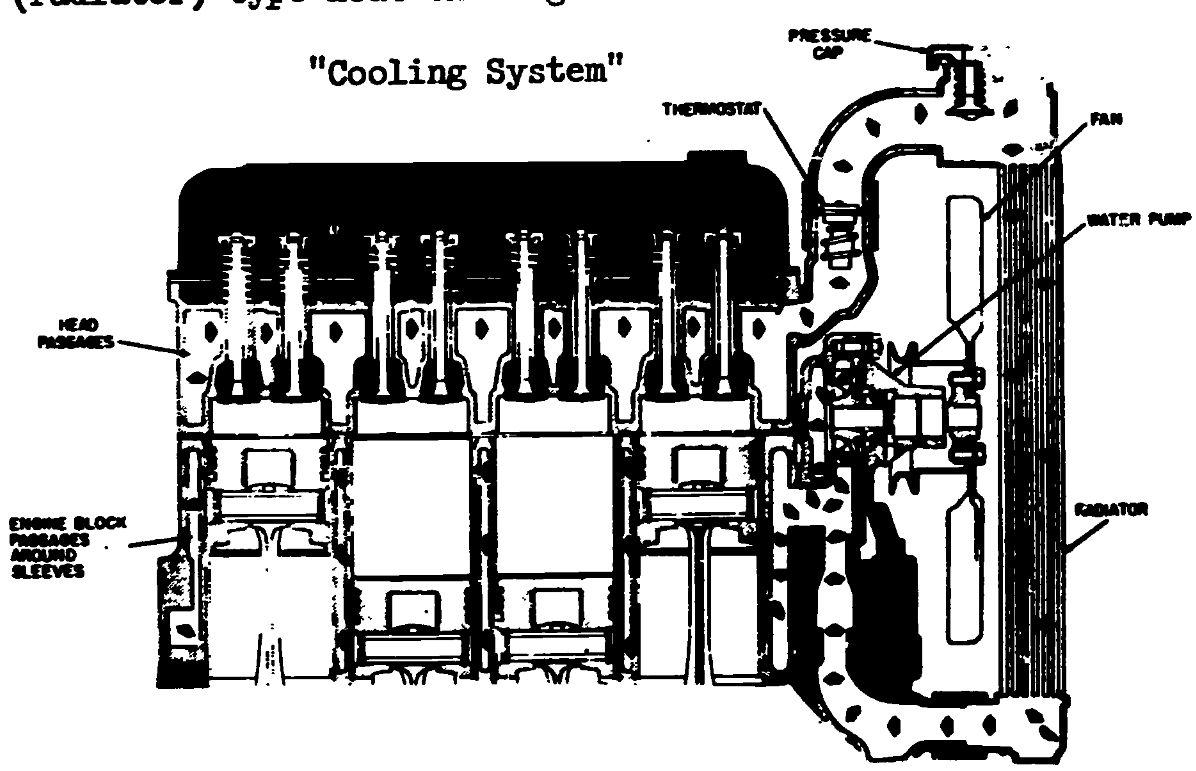
Thermal Transfer	BTU per BHP-Hr.	Per Cent
Heat input	7,367	100.0
Heat disposal:		
Useful work	2,544	34.6
To cooling water and lubricating oil	2,194	29.8
To exhaust gases	2,259	30.6
Lost by radiation	370	5.0
Total heat disposal	7,367	100.0

Cooling systems vary according to engine size and design. Classes of cooling systems are:

1. Open cooling system
2. Steam systems
3. By-pass systems
4. Closed cooling systems

The closed cooling system is used on diesel engines in the same way that it is used on other farm machinery. It uses a water to air (radiator) type heat exchanger

"Cooling System"



Suggested Teaching-Learning Activities

1. Through the use of charts, pictorial diagrams, and cutaways, explain how the governing, lubricating, and cooling systems of a diesel engine function.

2. Have students disassemble and become acquainted with the types of governors mentioned in the content.

3. Have students trace the lubrication system of a diesel tractor.

4. Through the use of a cutaway model of a diesel engine, demonstrate how the lubrication, governing, and cooling systems function.

Suggested Instructional Materials and References

Instructional Materials

1. Charts, pictorial diagrams, and cutaways of governing, lubricating, and cooling systems

2. A governor for each student

3. A diesel motor

d. A cutaway model of a diesel engine

References

Diesel and High-Compression Gas Engines, pp. 251-375.

Suggestions for Evaluating Educational Outcomes of the Module

The educational outcomes of the module should be evaluated according to knowledge gained by and attitudinal changes in each student.

The following criteria should be used:

1. Student interest in the materials covered in the module

2. Student participation in class and laboratory activities

3. Student performance at the end of study of the module as compared with their performance at the beginning

Sources of Suggested Instructional Materials and References

1. Automotive Diesel Engines, Engineering Bulletin AD 206. Chicago: Standard Oil Company.

2. Kates, Edgar J. Diesel and High-Compression Gas Engines, Chicago: American Technical Society, 1964. Price: $8.

3. Moses, Ben D. and Frost, Kenneth. Farm Power, New York: John Wiley and Sons, Inc., 1952.

4. Tractor Fuels and Lubricants, Agricultural Engineering Building. Athens, Georgia: Southern Association of Agricultural Engineering and Vocational Agriculture, 1964. Price: $1.20.

THE CENTER FOR RESEARCH AND LEADERSHIP DEVELOPMENT
IN VOCATIONAL AND TECHNICAL EDUCATION
THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name________________________________

2. Name of school________________________State______________

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
_____Ornamental Horticulture--Service Occupations
_____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report________________________

5. To what group (age and/or class description) was this material presented?____
____

6. How many students:
   a) Were enrolled in class (total) ________
   b) Participated in studying this module ________
   c) Participated in a related occupational work experience program while you taught this module ________

7. Actual time spent teaching module: / Recommended time if you were to teach the module again:

Actual time spent teaching module:		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (√) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE	NOT APPROPRIATE
8. The suggested time allotments given with this module were:	|___.___.___.___.___|	
9. The suggestions for introducing this module were:	|___.___.___.___.___|	
10. The suggested competencies to be developed were:	|___.___.___.___.___|	
11. For your particular class situation, the level of subject matter content was:	|___.___.___.___.___|	
12. The Suggested Teaching-Learning Activities were:	|___.___.___.___.___|	
13. The Suggested Instructional Materials and References were:	|___.___.___.___.___|	
14. The Suggested Occupational Experiences were:	|___.___.___.___.___|	

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes____No____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes____No____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

____________________ ____
(Date) (Instructor's Signature)

____
(School Address)