

Unit C: Agricultural Power Systems

Lesson 6: Using Multiple Cylinder Engines

Student Learning Objectives:

Instruction in this lesson should result in students achieving the following objectives:

1. Explain general maintenance guidelines associated with multiple cylinder engines.
2. Describe the concept of power as it relates to multiple cylinder engines.
3. Discuss common maintenance practices associated with multiple cylinder engines.
4. Describe the operating characteristics of a diesel engine.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

- Johnson, Donald M., et al. *Mechanical Technology in Agriculture*. Danville, Illinois: Interstate Publishers, Inc. 1998. (Textbook, Chapters 9 & 12)
- Herren, Ray V., and Elmer L. Cooper. *Agricultural Mechanics Fundamentals and Applications*. Albany, New York: Delmar Publishers, Inc., 2002. (Textbook, Chapter 30)
- Phipps, Lloyd J., et al. *Introduction to Agricultural Mechanics*, Second Edition. Upper Saddle River, New Jersey: Prentice Hall Interstate, 2004. (Textbook and Activity Manual, Chapter 18)

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets
- Large engine parts

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide 2):

- Bleed
- Coolant hydrometer
- Diesel engine
- Drawbar power
- Engine horsepower
- Fuel injectors
- Horsepower
- Multiple cylinder engines
- Power
- Power-take-off (PTO) shaft
- PTO power
- Preventative maintenance
- Turbocharger

Interest Approach:

Begin the lesson by asking the class to name the ways that engines may be classified. Possible answers may include number of piston strokes per cycle, engine displacement, engine power, and number of cylinders. Focus on the answers regarding the number of cylinders to introduce the lesson.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Explain general maintenance guidelines associated with multiple cylinder engines.

Anticipated Problem: What are some common preventative maintenance practices associated with multiple cylinder engines?

(PowerPoint Slide 3)

- I. Engines may be classified by the number of cylinders. Single cylinder engines have one cylinder. **Multiple cylinder engines** have 2, 3, 4, 5, 6, 8 or more cylinders. For multiple cylinder engines to perform well, preventative maintenance must be practiced. **Preventative maintenance** is performing periodic practices to keep equipment in good working order. General preventative practices associated with multiple cylinder engines and other equipment include:

(PowerPoint Slide 4)

- A. Read the operator's manual and know the equipment you are maintaining.
- B. Know the history of the equipment you are maintaining.
- C. Follow all manufacturer recommendations. Equipment makers provide recommended practices which will allow the equipment to last for a reasonable time.
- D. Use quality materials as recommended by the manufacturer. Select only fluids, filters, and other products that meet or exceed manufacturer recommendations.
- E. Keep accurate records. Accurate records assist in accounting for equipment usage and previous maintenance.
- F. Use common sense. Do not be afraid to ask questions of the manufacturer or dealer. Using common sense can save many hours of labor and additional expense.
- G. Conduct all maintenance using appropriate safety practices. Examples of safety practices include:
 1. Recognizing safety symbols and warning signs.
 2. Wearing appropriate personal protective equipment.
 3. Using proper supports such as engine stands.
 4. Operating engines in only well ventilated areas.

Discuss the general preventative maintenance guidelines associated with multiple cylinder engines. Identify safety symbols and signs posted in your shop or lab.

Objective 2: Describe the concept of power as it relates to multiple cylinder engines.

Anticipated Problem: What is power? How does it apply to multiple cylinder engines?

(PowerPoint Slide 5)

- II. **Power** is defined as the rate of performing work. In the United States, engine power is usually stated as horsepower. Multiple cylinder engines can be rated based on the types of power they produce. These types of power are as follows:

(PowerPoint Slides 6)

- A. **Engine horsepower** is a method used to rate engines based on their displacement and configuration. One **horsepower** is the force needed to lift 75 kilograms one meter in one second. The term horsepower was derived from the amount of work a horse could perform in one minute. One determinant of horsepower is the time it takes to do work. For example, a tractor with a 20-horsepower engine can do the same amount of work as a tractor with a 100-horsepower engine. The difference is that it will take the tractor with the smaller engine longer to accomplish the work.
- B. **Drawbar power** is linear in nature and is derived as machines are pushed or pulled by the engine as power is delivered to the drive wheels. It is tractor power available for pulling a load attached to the drawbar.

(PowerPoint Slides 7 and 8)

- C. Rotary or twisting power is delivered by the tractor **power-take-off (PTO) shaft**. Many different types of attachments are mounted to PTO shafts. Power is transferred from the engine to the implement. The resulting rotary power can be used to cut grass, grind feed, pump water, and perform many other operations. **PTO power** is rotary power that is converted to hydraulic or electrical energy. PTO power is also measured by either horsepower or kilowatts.

Display TM: 6-1 to provide an illustration of the concept of horsepower and how it is calculated. Use TM: 6-2 to provide an illustration of a PTO shaft. A good exercise is to have students examine various multiple cylinder engines to determine their horsepower ratings. This will help reinforce the concept of horsepower.

Objective 3: Discuss common maintenance practices associated with multiple cylinder engines.

Anticipated Problem: What are common maintenance practices associated with multiple cylinder engines?

- III. Maintenance of multiple cylinder engines is important for their proper operation. Although multiple cylinder engines are more complex than single cylinder or small engines, there are still a number of maintenance practices that can be performed by most engine owners. Some of these practices include:

(PowerPoint Slides 9 and 10)

- A. Maintaining the intake system—the purpose of the air intake system is to clean dirt and other particles from the air and bring it into the combustion chamber. This should occur without sever restrictions to the free flow of air, which decreases engine output. Air filters should be checked and cleaned or replaced on a regular basis.
- B. Maintaining the fuel system—the fuel system is designed to deliver clean fuel to the combustion chamber and to meter the correct amount of fuel for efficient operation. Fuel filters should be checked and cleaned or replaced on a regular basis. Whenever working on a fuel system, be sure to shut off the fuel supply at the tank. It is important to bleed the fuel filters and fuel system. To **bleed** is to remove air from the system. Most fuel systems will have bleed screws or vents that will allow air to be removed from the system.
- C. Maintaining the exhaust system—the exhaust system performs the task of removing burnt gases and particles from the combustion chamber. Periodic checks should be made for exhaust leaks. Discolored parts and excessive noise may indicate exhaust leaks.
- D. Maintaining the cooling system—engine cooling systems are designed to manage the heat produced by the combustion of air and fuel. It is the task of the cooling system to allow the engine to reach its optimum temperature and then maintain the temperature under varying conditions.
 - 1. Liquid cooling systems should be checked on a regular basis. The system should be kept clean and proper coolant levels maintained. Coolant should be changed and the system flushed every one to two years. A coolant hydrometer should be used to check the specific gravity of the coolant. A **coolant hydrometer** is an instrument that determines the proportion of antifreeze to water. In most systems, this is usually a mixture made up of 50% ethylene glycol type antifreeze and 50% water.
 - 2. Air direct cooling systems work well as long as the system remains clean. Air should move freely. All engine shields and shrouds should be in place to direct the movement of air.

(PowerPoint Slide 11)

- E. Maintaining the ignition system—the ignition system provides the spark for a spark ignition type engine. It is important to maintain a fully charge battery and to check the condition of all wires and connections. Spark plugs should be replaced as called for in manufacturer recommendations. New spark plugs should have their gaps set before installation.
- F. Maintaining the lubrication system—proper maintenance of the lubrication system is critical for the engine to run properly. Typically, engine oil levels should be checked at least after every 10 hours of engine operation. Oil and oil filters should be replaced when they become dirty. When changing the oil supply, the engine should be allowed to warm up. It should then be shut off the oil allowed to drain for several minutes. The recommended amount of new oil should be added. Once the oil is added, the engine should be started for a couple of minutes and checked for leaks. After shutting off the engine, the oil

level should again be checked for proper fluid level. Do no overfill the oil reservoir.

G. Maintaining starting systems—the failure of an engine to start is not only frustrating, it also may cause economic loss. Regular maintenance practices are dependent on the type of starting system used. Most multiple cylinder engines depend on an electrical starting system. Maintenance of an electrical starting system includes checking the condition of wiring and the distributor cap. The battery connections should be checked, and if corrosion is present, cleaned. Wiring should be inspected for damaged insulation and bad connections. For breaker-type electrical systems, the condition and gap of the points inside the distributor cap should be checked.

Use TM: 6-3 to illustrate the location and appearance of a fuel filter. TM: 6-4 will provide a good example of a diesel fuel injection system. Relate the concepts of this objective to those of Objective 1.

Objective 4: Describe the operating characteristics of a diesel engine.

Anticipated Problem: What are the characteristics of a diesel engine?

(PowerPoint Slides 12 and 13)

IV. A **diesel engine** is an engine with a very high compression ratio in which the air-fuel mixture is ignited by the heat of compression. Diesel engines are available as either two-stroke or four-stroke engines. The main difference between the diesel cycle and spark ignition (Otto cycle) is the method of mixing the fuel and air, and igniting the charge for the power stroke. In a diesel cycle, a fuel injector squirts the fuel charge into the cylinder after the air has been compressed. The compression pressure is very high and heats the air enough to ignite the fuel. The burning mixture expands and furnishes the power stroke. Unlike a spark ignition engine, a diesel engine does not have a carburetor or spark plugs. However, diesel engines do have fuel pumps and fuel injectors. **Fuel injectors** measure the correct amount of fuel for injection at the correct time. It is important to always use clean fuel, replace the filters, and drain sediment or water collection bowls in an engine with fuel injection. Diesel engines routinely use turbochargers to increase available power. A **turbocharger** is a turbine-type air pump that is driven by the engine's exhaust gases. It is designed to increase the volumetric efficiency of the engine.

(PowerPoint Slide 14)

- A. General characteristics of spark ignition (Otto cycle) engines include:
 - 1. Lighter weight components
 - 2. Easier starting
 - 3. Lower fuel efficiency
 - 4. Quicker acceleration
 - 5. Lower engine torque
- B. General characteristics of compression ignition (Diesel cycle) engines include:
 - 1. Heavier weight components

2. More difficult starting
3. Higher fuel efficiency
4. Slower acceleration
5. Higher engine torque

Display TM: 6-5. It provides a good side by side comparison between spark ignition and Diesel cycle engines. Use classroom discussion to identify why the characteristics of diesel cycle engines make them especially applicable to agriculture.

Review/Summary: The review and summary of the lesson may be accomplished by viewing the transparency masters with the students. (**PowerPoint Slides 15 and 16**) A discussion should be performed with students before proceeding with the laboratory activities and testing.

Application: Include one or more of the following student activities using the attached lab sheet.

Diesel fuel injection system—LS: 6-1. Use TM: 6-4 for the answers.

Evaluation: Objectives should be reviewed by the students. Laboratory activities should be performed before the written test is given to students.

Answers to Sample Test:

Matching

1. E
2. D
3. A
4. B
5. C

Fill-in-the-blank

1. Coolant hydrometer
2. Multiple cylinder engines
3. Lubrication
4. Bleed screws
5. Electrical starting
6. Fuel injectors
7. Carburetor, spark plugs
8. Fuel pumps, fuel injectors
9. turbochargers

Short Answer

1. Maintaining the intake system, maintaining the fuel system (it is important to bleed the fuel filters and fuel system), maintaining the exhaust system (periodic checks should be made for exhaust leaks), and maintaining the cooling system.
2. Lighter weight components, easier starting, lower fuel efficiency, quicker acceleration, and lower engine torque.
3. Heavier weight components, more difficult starting, higher fuel efficiency, slower acceleration, and higher engine torque.

Using Multiple Cylinder Engines

Name: _____

Matching: Match each word with the correct definition.

- | | |
|----------------------|----------|
| a. horsepower | d. power |
| b. engine horsepower | e. bleed |
| c. PTO power | |

- _____ 1. To remove air from the fuel filters and fuel system.
- _____ 2. The rate of performing work.
- _____ 3. The force needed to lift 75 kilograms one meter in one second.
- _____ 4. Method used to rate engines based on their engine displacement and configuration.
- _____ 5. Rotary power that is converted to hydraulic or electrical energy.

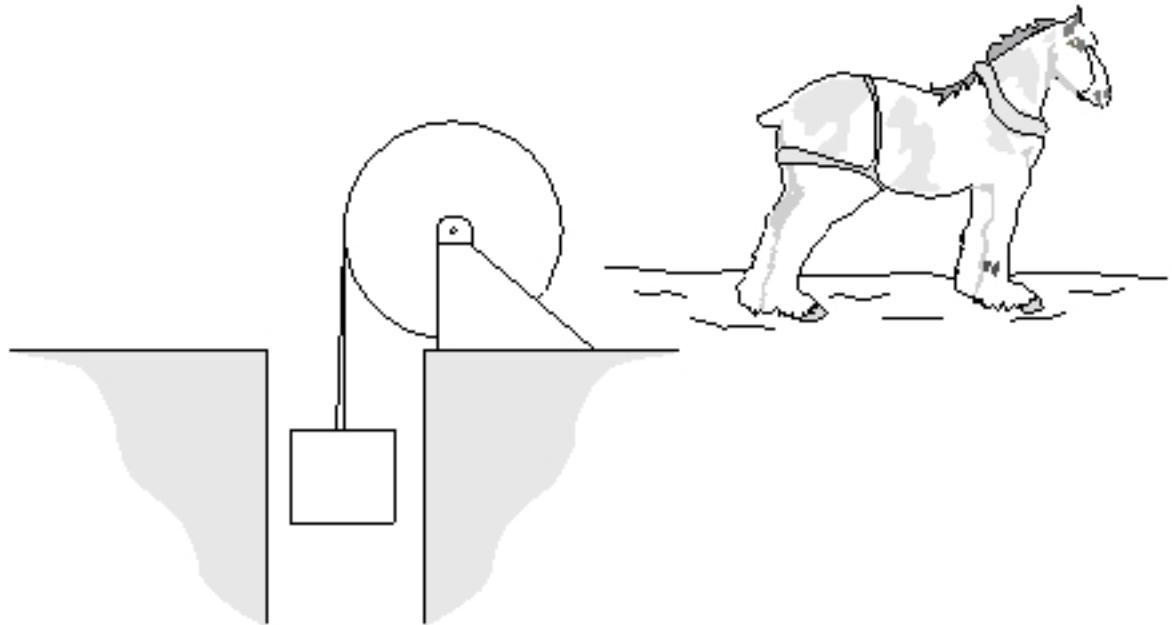
Fill-in-the-blank: Complete the following statements.

1. A _____ is an instrument that determines the proportion of antifreeze to water.
2. _____ have 2, 3, 4, 5, 6, 8, or more cylinders.
3. Proper maintenance of the _____ system is critical for the engine to run properly.
4. Most fuel systems have _____ or vents that will allow air to be removed from the system.
5. Most multiple cylinder engines depend on an _____ system.
6. _____ measure the correct amount of fuel for injection at the correct time.
7. A diesel engine does not have a _____ or _____.
8. Diesel engines do have _____ and _____.
9. Diesel engines routinely use _____ to increase available power.

Short Answer: Answer the following questions.

1. What are some common maintenance practices associated with multiple cylinder engines?
2. Describe some general characteristics of a spark ignition (Otto cycle) engine.
3. Describe some general characteristics of a compression (Diesel cycle) engine.

HORSEPOWER



$$Hp = \frac{F \times D}{t}$$

where,

Hp = horsepower

F = Force, kilograms

D = Distance, meters

t = Time, seconds

TM: 6-2

EXAMPLE OF A PTO SHAFT AND IMPLEMENT

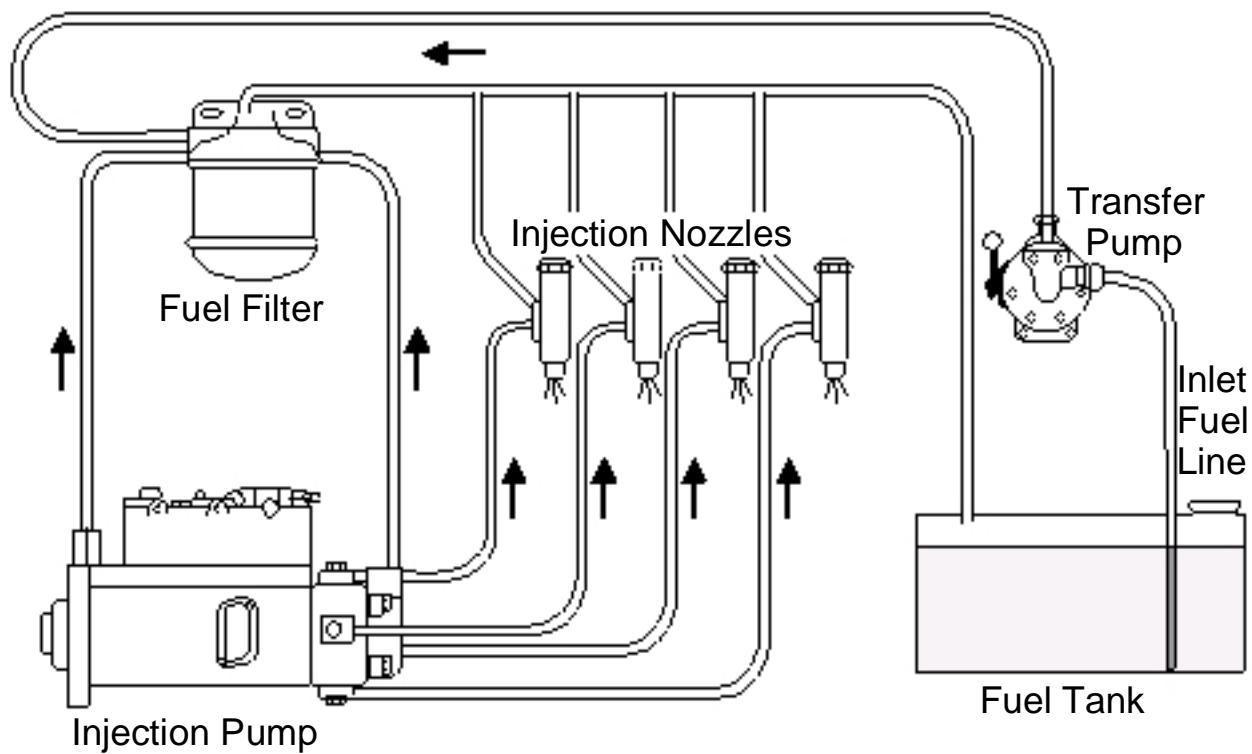


TM: 6-3

EXAMPLE OF A FUEL FILTER



DIESEL FUEL INJECTION SYSTEM

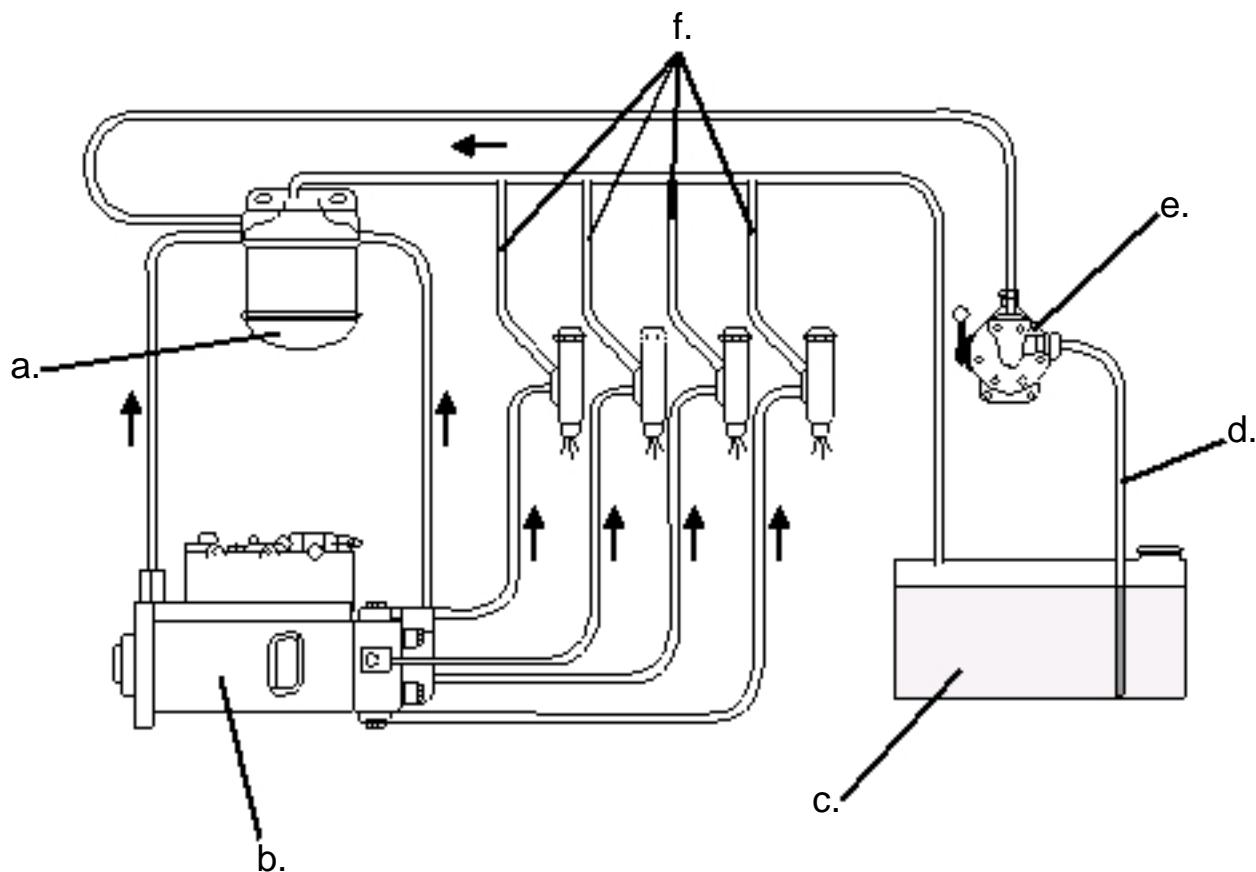


COMPARISON BETWEEN SPARK IGNITION AND DIESEL CYCLE ENGINES

| Spark Ignition (Otto Cycle) Engines | Compression Ignition (Diesel Cycle) Engines |
|--|--|
| Lighter weight components | Heavier weight components |
| Lower compression ratios | Higher compression ratios |
| Easier starting | More difficult starting |
| Lower fuel efficiency | Higher fuel efficiency |
| Quicker speed acceleration | Slower speed acceleration |
| Higher engine speeds | Slower engine speeds |
| Lower engine torque | Higher engine torque |

DIESEL FUEL INJECTION SYSTEM

Instructions: Identify the components of a diesel fuel injection system on the diagram.



- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____