Four-Stroke Engine: Fuel Systems

-Student Notes

Directions:
Fill in the blanks.

Fuel Segment

1. Gasoline

- Is a refined _____ used as fuel in four-stroke engines
- Should always be used according to the manufacturer's recommendations
- Is reformulated and refined to meet requirements of the Clean Air Act
  - exact specifications will vary in different areas to meet air quality needs, _____conditions and seasonal temperature changes

2. Octane Rating

- Determines gasoline's ability to resist detonation caused by excessive **heat** and/or pressure
- Indicates how much a fuel can be compressed or heated before it spontaneously ignites

Four-Stroke Fact: _____octane fuel does not burn hotter or colder, faster or slower.

3. Octane Ratings

- Are as follows:
  - regular gasoline
    - octane rating equal to _____and less than 88
  - mid-grade gasoline
    - octane rating equal to _____and less than or equal to 90
  - premium gasoline
    - octane rating greater than 90

Four-Stroke Fact: Lower octane gasoline will explode (detonate) at lower temperatures and pressures. Higher octane gasoline can spontaneously ignite (detonate) when exposed too much higher temperatures and pressures than lower octane gasoline.

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4. Octane Ratings

- Were significantly increased in the past by using _____lead in gasoline
  - lead has since been _____from gasoline because it is extremely toxic and is not compatible with catalytic converters
    - lead will quickly destroy a catalytic converter
- Have also been boosted by using alcohol and methyl tertiary butyl ether (MTBE)
  - MTBE has been found to contaminate ground water, so has been removed from gasoline sold in the U.S.

5. Volatility

- Refers to the gasoline's ability to become a _____
  - in order for quality combustion, gasoline must become vapor before being introduced to the _____
  - poor quality gasoline may have too much or not enough volatility to deliver quality combustion

6. Volatility

- Should vary in different conditions for best results
- Is measured by the following:
  - vapor _____
  - distillation profile
  - vapor-liquid _____

7. Vapor Pressure

- Refers to the pressure exerted by vapor above the surface of a _____in a closed container
  - an increase in pressure will make it _____to start an engine at ambient temperature
  - a decrease in pressure is better for preventing vapor lock and other problems related to the handling of hot fuel

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8. Distillation Profile

- Is engineered to give gasoline the following characteristics:
  - easy _____starting
  - easy hot starting
  - avoiding vapor lock
  - good fuel economy
  - low engine _____
  - good power
  - low emissions

9. Vapor-Liquid Ratio

- Relates to the _____at which gasoline creates a vapor
- Is relative to the _____conditions which the fuel will be used in

10. Fuel Chemical Makeup

- Is modified as the seasons change, especially where the climate has extreme change throughout the year
  - fuel refined for winter use will be _____resistant to vapor lock
  - fuel which has a summer blend will have lower _____emissions

11. Fuel Issues

- Include:
  - vapor _____
  - engine _____
  - contaminants

12. Vapor Lock

- Occurs when a fuel _____from excessive heat
- Can happen in the _____, fuel pump or carburetor

13. Engine Detonation

- Refers to the _____of a significant portion of the charge before the spark-induced flame front reaches it
- Is the collision of two flame fronts in the combustion chamber
  - one is the result of the _____and the other is the result of the undesired combustion
- Can also be caused by ignition timing, being incorrectly set or by excess carbon deposits in the combustion chamber

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14. Fuel Contaminants

- Can be anything from liquid to _____
  - solids in fuel should be captured by a fuel filter and can cause fuel starvation if the fuel filter gets plugged
    - some dissolved solids can flow through the fuel filter and accumulate in the fuel bowl
  - liquid contaminants tend to create poor performance issues

Four-Stroke Fact: Water is _____than gasoline and will fall to the bottom of the tank and migrate to the carburetor. Just a few drops can cause intermittent stalling and no-start issues. Stale gas will not support good combustion because of its inability to vaporize properly

15. Oxygenated Fuels

- Have oxygen added to burn more efficiently and reduce _____ emissions
  - oxygen is usually in the form of _____

16. Alcohol-Based Fuels/Ethanol Blends

- Are used to:
  - improve _____
  - boost octane
  - decrease U.S. _____on imported oil

17. Alcohol Types

- Include:
  - methanol
    - derived from _____or petroleum products
  - ethanol
    - comes from grain, corn and agricultural products

Four-Stroke Fact: Today, ethanol is the primary _____blended with gasoline.

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18. Alcohol Percentages

- Are regulated in most states
- Are posted on gasoline pumps to show the _____ethanol content in gasoline
  - E10 (10 percent)
  - E15 (15 percent)
  - E20 (20 percent)

Four-Stroke Fact: Several states have pushed for an overall usage of 20 percent alcohol to reduce gasoline imports.

Four-Stroke Fact: Currently, all _____engine manufacturers recommend using a fuel with a maximum rating of E10.

19. E85 (85% Ethanol)

- Is a fuel blended for vehicles designed for higher alcohol ratios
  - these vehicles contain chemical-resistant gaskets, _____, etc., as well as stainless steel components, impervious to the effect of sustained use of _____fuel

20. E85 (85% Ethanol)

- Is not meant to be used in typical _____small engines used in outdoor power equipment
  - running an engine on E85 can cause a lean condition, leading to hard starting, _____and can greatly affect engine performance

21. Alcohol Problems

- Include:
  - enleanment
  - phase _____
  - degreasing _____
  - corrosion

22. Enleanment

- Is altering the _____ratio due to an increase in alcohol
  - unlike gasoline, alcohol contains a significant amount of oxygen and using a significant percentage of alcohol (above 10 percent), has the same effect as leaning out the carburetor further or using a much smaller jet size

Four-Stroke Fact: Ethanol is _____percent oxygen.

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23. Phase Separation

- Causes the octane of the gasoline to _____two to three points
  - water and alcohol will combine and, being a heavier mixture than gasoline, will sink to the bottom of the tank
    - alcohol is not chemically stable in gasoline when water is present and is highly _____, meaning it attracts water or moisture

24. Degreasing Agent

- Will dissolve protective oils
  - alcohol is a very effective _____and dissolves the protective film of oil found on _____walls, piston surfaces, bearings, bearing cages, etc.

25. Corrosion

- Is breaking down or _____materials
  - a high concentration of alcohol can cause corrosion if left on unprotected surfaces
    - it can attack _____aluminum components
    - it can combine with water and, once the protective film of oil is gone, will oxidize or rust ferrous metal components of left for long periods, particularly in carburetors

26. Testing for Alcohol

- Can be effective to determine the approximate _____of alcohol present
  - providing water has not contaminated the gasoline sample
    - alcohol has a tendency to separate from gasoline when water is present
- Is competed by performing a "_____"

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27. "Shaker Test"

- Is performed in the following manner:
  - using a clear glass cylinder, with _____graduations and a sealed cap, water is added to the level of the first mark from the bottom
  - the fuel is added until the total reaches the top mark on the cylinder
  - after vigorous _____, the mixture should sit for three to five minutes
  - the percentage of alcohol can be read above the first mark

28. Fuel Shelf Life

- Is the recommended length of time a fuel can sit without being used
  - with the addition of alcohol to gasoline and changes to the refinery process, manufacturers do not recommend storing fuel for more than _____days
    - this period can be even shorter in hot and humid climates
  - fuel which exceeds its shelf life will become _____

29. Oxidized Fuel

- Will form _____, varnish and deposits inside the carburetor and fuel system components
  - this is a common issue found after _____storage of equipment

30. Fuel Stabilizer

- Can help _____fuel shelf life when used per the manufacturer's recommendations

Four-Stroke Fact: There is not a treatment available to rejuvenate fuel which has already _____.

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31. Elevation

- Has the ability to effect engine _____
  - horsepower will degrade as elevation increases
    - as the density of air diminishes, engines develop a fuel-rich condition
  - _____the amount of fuel by adjusting the carburetor's settings or changing jet sizes within the carburetor will bring the air/fuel ratio closer to the optimum 14.7:1 ratio and restore engine performance

Carburetors Segment

1. Carburetors

- Are a type of metering device which mix fuel and air
  - the correct mixture which flows into the combustion chamber is _____for the engine to run properly
- Are mounted to the _____of the engine

2. Carburetors

- Ensure the following:
  - the fuel is introduced to the _____air stream
  - the fuel is _____
    - liquid gasoline will not support rapid combustion without first being atomized into a mist

3. Carburetors

- Work in the following manner:
  - pre-atomized gasoline is introduced into the air stream inside the _____
  - there the air/fuel mixture becomes an atomized mist
  - the atomized mist then flows to the intake manifold because the intake stroke creates vacuum pressure in the combustion chamber and intake _____area of the engine

4. Float Carburetors

- Are used on products which run in a fixed or _____position
  - such as _____, motorcycles, marine inboard engines and snowmobiles
- Use a fuel bowl to hold the supply of fuel for the carburetor before it is processed and mixed with air

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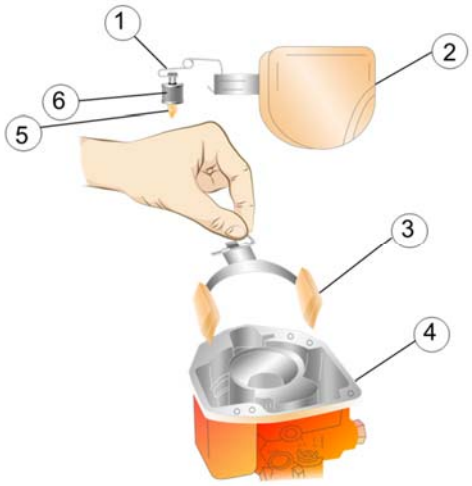
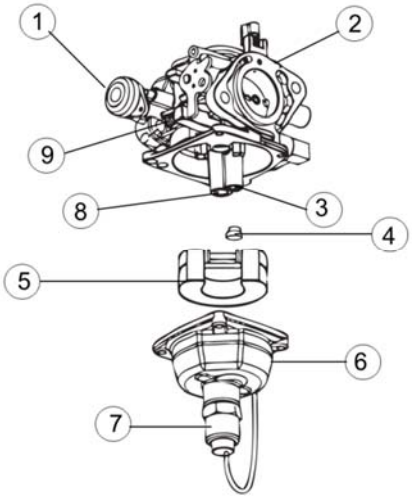
5. Float Carburetor

1. _____
2. Float (side view)
3. Float
4. Fuel Bowl
5. Inlet Needle
6. _____



6. Float Carburetor

1. _____
2. Carburetor Body
3. Idle Circuit/Jet
4. Plug
5. Float
6. Fuel Bowl
7. Fuel Solenoid
8. Main Circuit/Jet
9. _____



7. Carburetor Parts

- Include:
  - fuel supply _____
  - fuel bowl
  - fuel bowl _____
  - float assembly
  - inlet needle
  - pickup tube

8. Fuel Supply Inlet

- Is where fuel _____the _____from the engine's fuel tank

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9. Fuel Bowl

- Holds fuel for use by the _____metering circuits which are built into the _____

10. Fuel Bowl Vent

- Allows atmospheric air pressure to enter the _____system
  - the difference in _____pressure (relatively high) and the venturi pressure (relatively low) pushes the fuel from the fuel container into the carburetor venturi while the engine is operating

11. Fuel Bowl Vent

- Maintains the air pressure above the surface of the fuel in the bowl at _____levels
- May be external or internal
  - an external vent can be found on the outside of the carburetor body
  - most _____ carburetors feature an internal type of bowl vent

12. Float Assembly

- Is used to _____the level of fuel in the fuel bowl
  - an essentially _____level of fuel must be maintained
    - proper metering of air/fuel ratio is dependent on a constant distance from the venturi to the surface of the fuel in the bowl

13. Inlet Needle

- Allows fuel to enter the float bowl as fuel is consumed by the engine
  - the amount of fuel in the float bowl is _____during consumption, causing the float and inlet needle to fall, opening the inlet
    - as the fuel level rises, the float and inlet needle rise, pushing the inlet needle into its seat, _____the flow of incoming fuel

14. Pickup Tube

- Delivers fuel to the _____of the carburetor using the principles of the _____effect

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15. Venturi Effect

- Is the _____in pressure which results when fluid (liquid or gas) flows through a _____passage

16. Carburetor Operation

- Includes:
  - fixed speed
    - occurs during carburetor _____
      - carburetors have main jets with predetermined opening sizes (no adjustment system is provided) which control the _____of fuel allowed to enter the engine at wide open throttle
  - idle circuit
    - allows just enough fuel to keep the engine idling and controls the idle revolutions per minute (RPM)

17. Carburetor Operation

- Includes:
  - idle _____air bleed
    - mixes air with fuel in the low idle stage of the carburetor
  - main _____
    - meters fuel for the engine when the RPM range is high idle
    - is also known as the main jet

18. Choking Systems

- Are installed on a carburetor to _____the flow of air to make the air/fuel mixture rich while starting
- Are operated by a choke valve
  - manually by a lever or pull handle
  - automatically by a _____element

19. Manual Choke

- Is actuated by the operator with a lever which is attached directly to the carburetor or mounted remotely with the equipment controls
  - when the choke is _____, the airflow is restricted to the carburetor, making the air/fuel mixture rich (more fuel than air)
  - as the choke valve is _____, more air is introduced to the carburetor, making the air/fuel mixture more balanced for idling and faster engine operation

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20. Automatic Choke

- Uses a vacuum choking system to close the choke plate when the engine is not running
  - to ease starting, the choke plate is closed by _____pressure
  - when the engine creates enough vacuum to overcome the spring pressure, the choke plate _____opens, allowing the correct air/fuel ratio into the carburetor

21. Electronic Choke

- Uses a processor to _____engine speed and control stepper motor operations, which moves the choke plate as required based on engine _____and ambient temperature

22. Electronic Fuel Enrichment

- Is used with electronic fuel injection (_____) systems
  - through the engine sensors associated with the EFI, the engine control unit calls for more fuel to be delivered from the fuel injectors when cold starting or warming the engine to operating _____

23. Carburetor Fuel Solenoids

- Are _____plungers used to stop fuel flow through the carburetor
  - the _____closes, using mechanical (spring) power
  - when energized, the solenoid retracts the plunger, allowing fuel to flow
- Exist to limit afterbang after the engine is turned off

Fuel Delivery Segment

1. Fuel Delivery Methods

- Include:
  - _____feed systems
  - _____feed systems

2. Gravity Feed Systems

- Consist of a fuel tank positioned above the _____and uses the force of _____to feed the carburetor fuel

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3. Pressure Feed Systems

- Consist of a fuel tank placed _____the carburetor
- Require the use of a fuel pump to raise the fuel from the tank to the carburetor
  - electric fuel pumps are most commonly found in use with fuel injection systems and are used in conjunction with a pressure regulator
  - vacuum or "_____" fuel pumps are operated using a vacuum provided by negative crankcase pressure; the pulse line operates a diaphragm fuel pump which provides lift and/or feed, depending on the location of the fuel tank

4. Fuel Tanks

- Have been improved since 2007 to limit the escape of _____ (HC) vapor (evaporative emission) through tank walls
  - like other emission parts, tanks will have an ID number
  - prior to regulation, handheld fuel tanks would emit 11 grams of evaporative emissions per day
    - regulated tanks can only emit 1.5 grams per day
- Are either multi-layer or _____

5. Fuel Lines

- Are the lines _____the fuel tank which go to the carburetor
- Have been required to meet permeation requirements since January 2012

Four-Stroke Fact: Pre-regulation fuel feed lines emit _____grams of hydrocarbons per day while regulated lines emit only 15 grams per day.
Four-Stroke Fact: The fuel cap gasket must meet permeation requirements as well.

6. Fuel Line Regulations

- Require manufacturers to update their fuel feed lines to new materials such as _____and special rubber blends
  - fuel lines should also have an ID mark to indicate it is a _____fuel line

Low-Permeation Fuel Line ID Number

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7. Fuel Filters

- Protect the fuel _____system
- Should be replaced according to manufacturer's recommendations
- Include:
  - inline _____
  - pre-tank filters

8. Inline Filters

- Are often simple, _____filters in line between the fuel tank and carburetor or fuel injection
- Require very little service
  - other than removing the element periodically and _____it with a new filter

9. Pre-Tank Filters

- May be located in the fuel tank filler _____and are usually in the form of a screen basket
- Are easily _____to facilitate cleaning in solvent per the manufacturer's recommendations

10. Electronic Fuel Injection (EFI)

- Is a system for introducing fuel into _____combustion engines
- Is designed to be a fuel and ignition management system controlled by an engine control unit
- Provides _____fuel economy characteristics with benefits of enhanced engine performance

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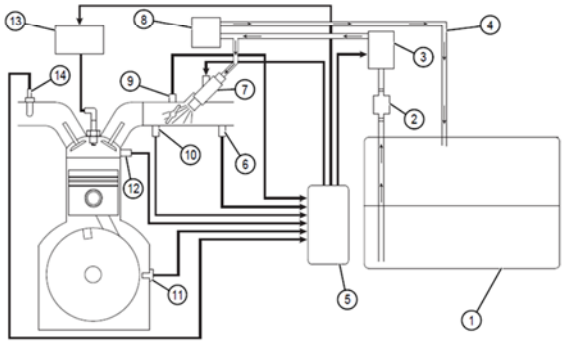
11. Electronic Fuel Injection (EFI) System

1. _____
2. Fuel Filter
3. Fuel Pump
4. Fuel Return Line
5. Engine Control Unit (ECU)
6. Intake Air Temperature (IAT) Sensor
7. Fuel Injector
8. Fuel Pressure Regulator
9. Throttle Position Sensor (TPS)
10. Manifold Absolute Pressure (MAP) Sensor
11. Crankshaft Position Sensor
12. Engine Temperature Sensor
13. Ignition Module
14. _____



12. Electronic Fuel Injection (EFI) System

- Incorporates the following components:
  - fuel pump
    - provides high fuel pressure for the _____systems
    - some models utilize duel fuel pumps; one mechanical and one pulse pump to draw fuel from the tank and deliver it to the high pressure fuel pump module
  - fuel filter
    - removes particles in the fuel to _____damage to components
  - fuel lines
    - made of stainless steel or hose rated for EFI fuel delivery from the tank to the fuel injectors

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13. Electronic Fuel Injection (EFI) System

- Incorporates the following components:
  - fuel pressure _____
    - controls the fuel pressure for the injectors and returns excess fuel to the tank
  - fuel injectors
    - atomize the fuel into a mist for better combustion
  - throttle body/intake _____
    - distributes the air/fuel mixture from the carburetor to the cylinder(s)
  - sensors
    - provide the engine control unit with information about engine operating conditions to allow the unit to react and adjust as needed

14. Electronic Fuel Injection (EFI) System

- Operate in the following manner:
  - an electric fuel pump moves the fuel from the tank through fuel lines and an inline filter
  - fuel flows into the _____and into the intake manifold or throttle body
  - when the intake valve opens, the air/fuel mixture is drawn into the combustion chamber, compressed, ignited and burned

Four-Stroke Fact: The ignition and injection performance is _____controlled, monitored and updated to maintain the best air/fuel ratio possible based on information provided by the sensors.

15. Fuel Delivery

- Is accomplished in a variety of methods
  - _____injection uses a single injector at the throttle body similar to the same location as conventional carburetors
  - in continuous injection, fuel will flow at all times from the injectors, but at a changing flow rate; this is different from most fuel injection systems, which provide fuel during _____bursts of varying times with a constant rate of flow during each pulse
    - continuous injection systems can be multi-point or single-point

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Engine Management Segment

1. Engine Control Unit (ECU)

- Uses _____received from various sensors to determine the correct amount of fuel and injection timing based on load, temperature and operator input
- Detects malfunctions or _____operating conditions in the sensors and sensor circuits
  - when this occurs, the ECU generates a diagnostic trouble code (DTC)

2. Wiring Harness & Connectors

- Should be _____and free of rust, corrosion and debris in order to deliver accurate electrical signals to the ECU and each other
  - this can be _____, amperage or resistance
  - wiring and connectors which are not pliable are more likely to break, increasing the possibility of a short, an open circuit or inaccurate data delivered to the ECU, causing performance problems

Four-Stroke Fact: Short circuit can cause costly damage to components related to the EFI system.

3. Sensors

- Are key components on many modern four-stroke engines
- Provide necessary _____required by machines and their operational systems
- Relay _____regarding temperature, pressures and positions of components

4. Sensors

- Include the following common types:
  - crankshaft _____sensor
  - inlet air temperature (IAT) sensor
  - manifold absolute pressure (MAP) sensor
  - temperature/_____absolute pressure (TMAP) sensor
  - throttle position (TPS) sensor
  - engine temperature (ET) sensor
  - Oxygen (O_2) sensor

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5. Crankshaft Position Sensor

- Monitors the _____per minute (RPM) of the crankshaft and its relative position in degrees of rotation
  - the signal sent to the ECU helps coordinate the EFI and the engine's ignition _____

6. Inlet Air Temperature (IAT) Sensor

- Provides a signal indicating the temperature of the incoming air change
- Is located in the _____housing or throttle body
- Works with the _____absolute pressure (MAP) sensor to allow the ECU to adjust the air/fuel ratio for ambient temperature differences

7. Manifold Absolute Pressure (MAP) Sensor

- Reads absolute _____of the intake air at the manifold and provides the ECU with a signal for determining engine load
  - this information coupled with the IAT sensor signal and the crankshaft position sensor allows the ECU to _____the proper fuel charge

8. Temperature/Manifold Absolute Pressure (TMAP) Sensor

- Is a _____of the IAT and the MAP in one sensor
- Is not found in all _____

9. Throttle Position (TPS) Sensor

- Indicates the throttle valve _____so the ECU can increase or decrease the fuel mixture and spark timing to adjust for _____, acceleration and changes in load

10. Engine Temperature (ET) Sensor

- Provides a signal to the ECU, indicating the engine temperature
- Can be _____in the cylinder head, engine oil pan or coolant system
- Allows the ECU to adjust _____to keep the engine operating within its own safe zone
- Is not found in all engines

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11. Oxygen (O_2) Sensor

- Monitors the _____of oxygen in the exhaust and determines fuel burn efficiency to determine if the fuel injector should be open more or less time
- May be installed in the _____or exhaust manifold
- Functions effectively only after warming up to the operating temperature
- Is not found in all engines