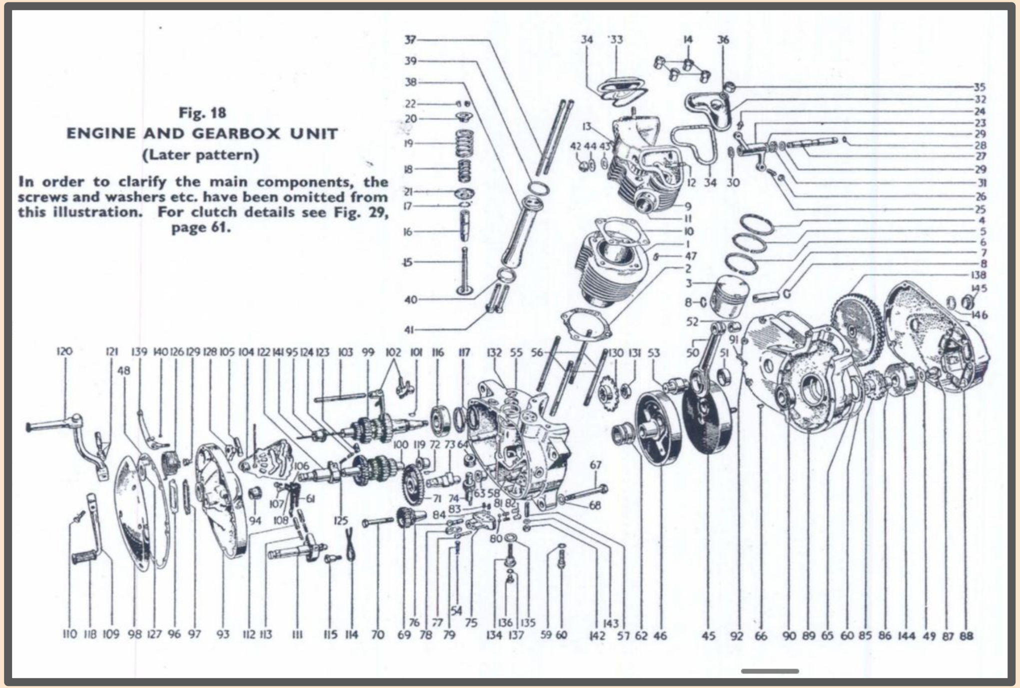
Top End Engine Team



Tasman Moskowitz and Mary Christian McCoy
FRS 106 - Spring ‘23

Before Picture: February 6th, 2023

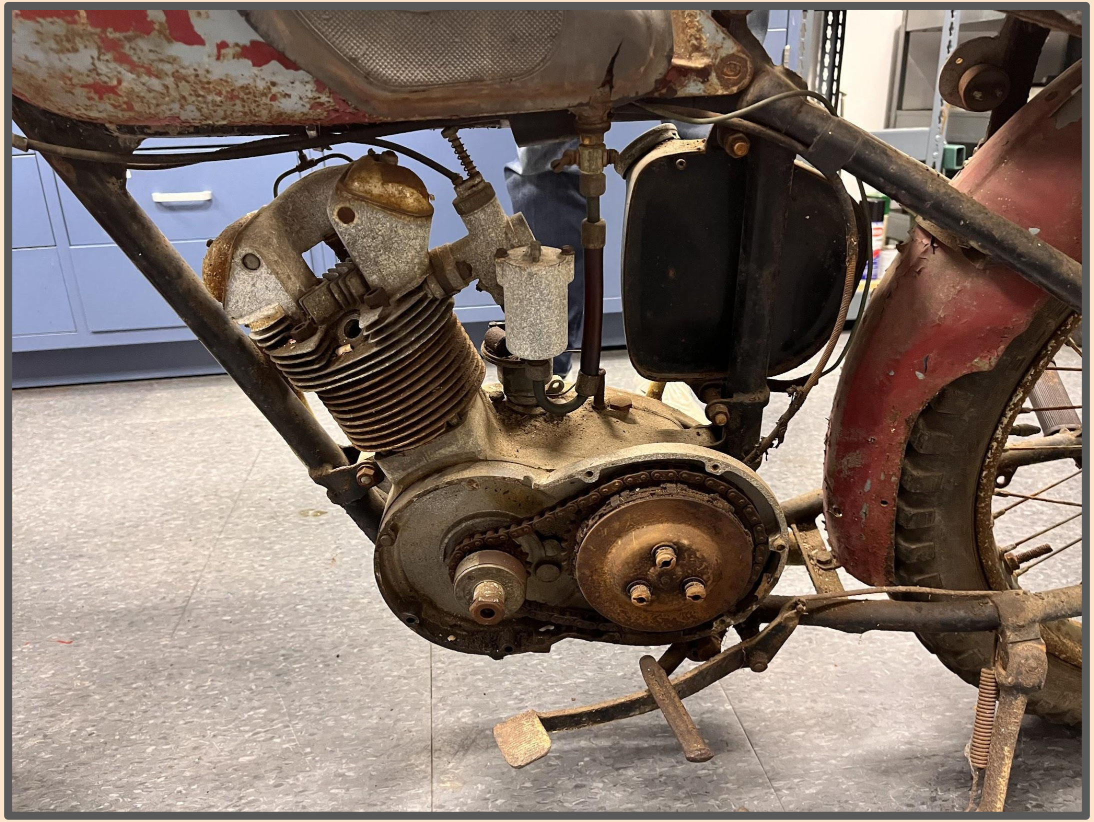
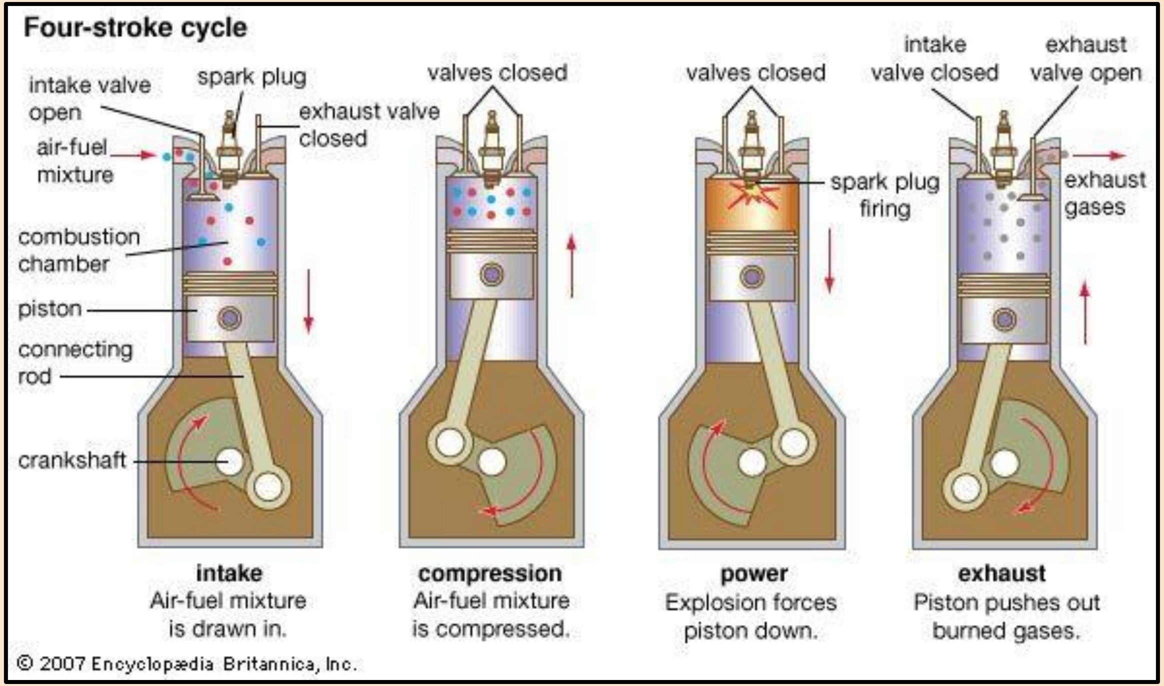


Photo Credit: Paige Walworth

Four-Stroke Engine Overview



- Cycle is complete after two revolutions of the crankshaft
- Power stroke provides the crankshaft with the angular momentum for other 3 strokes
- Air-fuel mixture travels in from the carburetor into head
- Ideal Gas Law

$$PV = nRT$$

- Chemical potential energy to mechanical work

Balanced Chemical Equation for Combustion: $2C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$ + Heat

Valve Timing

- As the cam turns, the pushrods move and push on the rockers. The rockers then push on the valve spring and move the valves.

- The stiffness of the valve spring controls how fast the valves close and determines rpm

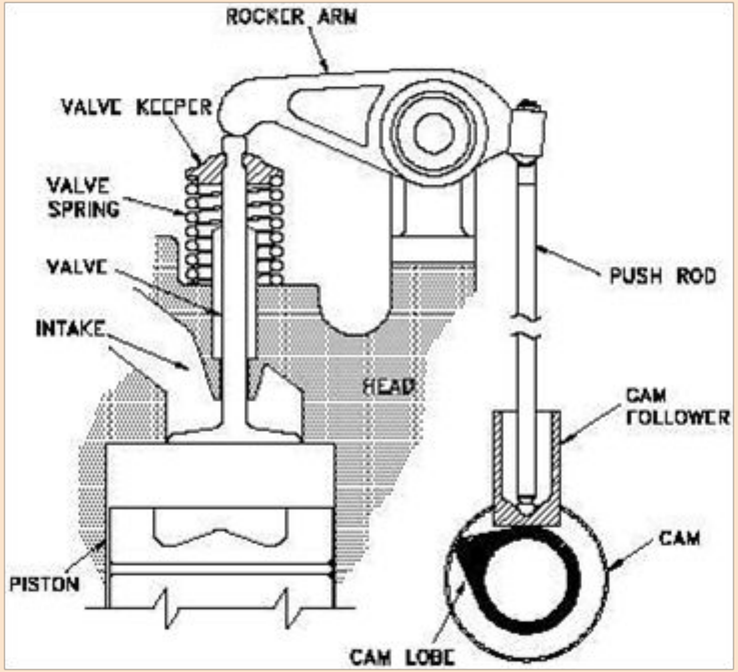


Photo Credit: Spring 2011's '63 Tiger Cub Top Engine Page

Key Terms from Class

Engine Knocking:

- A knocking sound of metal hitting metal within the engine
- May be caused by an incorrect air-fuel ratio or fuel may be igniting at the wrong time in the combustion cycle

Compression Ratio:

- the ratio of the maximum to minimum volume in the cylinder of an internal combustion engine
- 7:1 for our motorcycle
- In general, the higher the compression ratio, the more power output from the engine

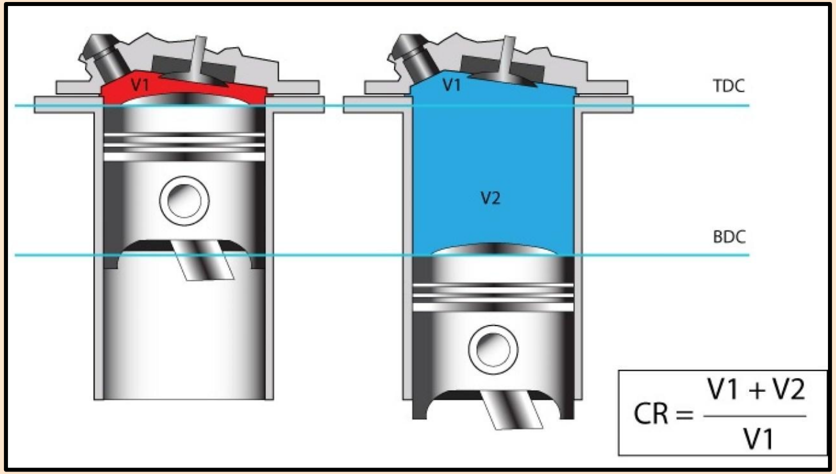
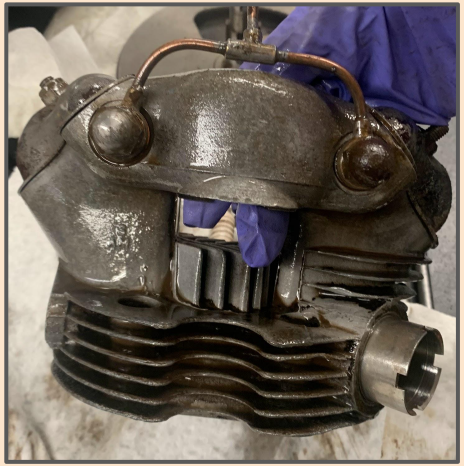


Photo Credit: AutoProtips.com

Our Parts

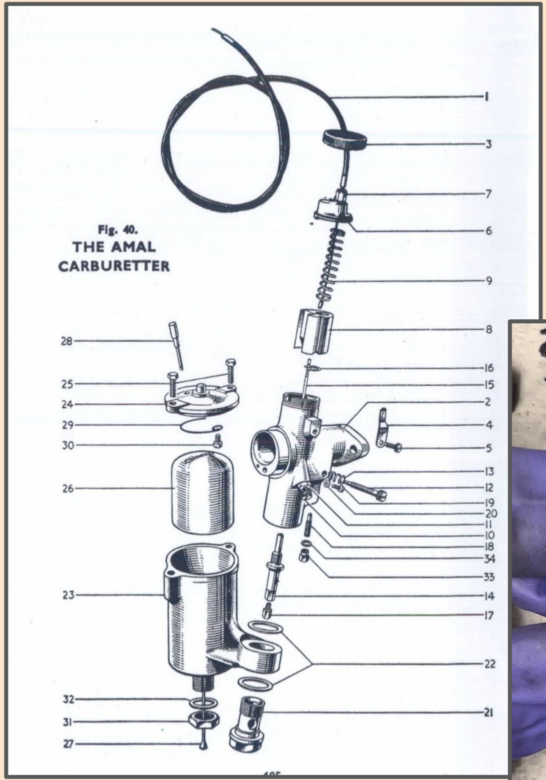
Engine Head



Carburetor

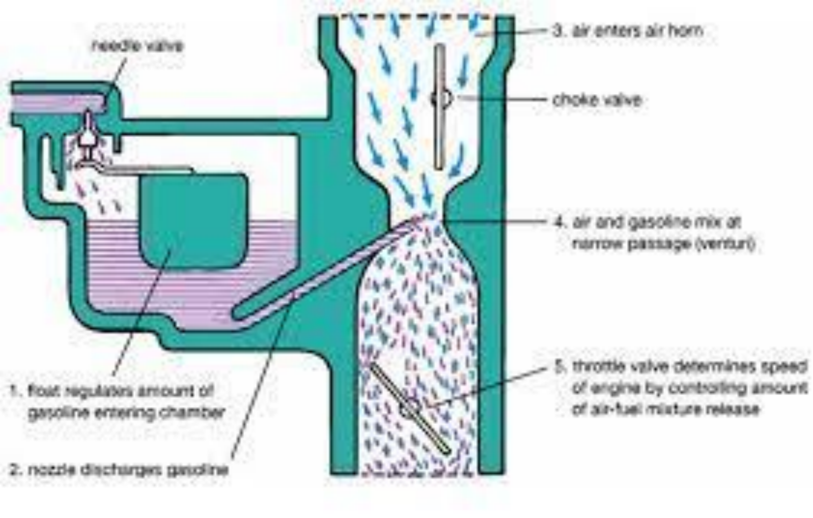
Barrel

Carburetor



- This is where fuel and air mix through the use of jets.
    - Throttle - Controls speed by adjusting air and fuel
- Float controls amount of fuel let in.
- Pilot jet works till about 20% throttle.
- Main jet works at 80% throttle and above.
- Needle jet works between 20% and 80% throttle.

Science of our Carburetor: How does it work?



* This model does not perfectly match our carburetor
http://ecoursesonline.iasri.res.in/mod/page/view.php?id=677

Bernoulli's Principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in static pressure.

- The venturi of a carburetor is a tube with decreasing cross sectional area
- When air flows through the narrowing tube, its velocity increases
- The static pressure in the tube decreases which creates a vacuum drawing in fuel
- $\Delta P \propto \Delta v^2$

Restoration

- Almost all parts went into sonic cleaner, and then a wire brush was used to clean most of the brass parts

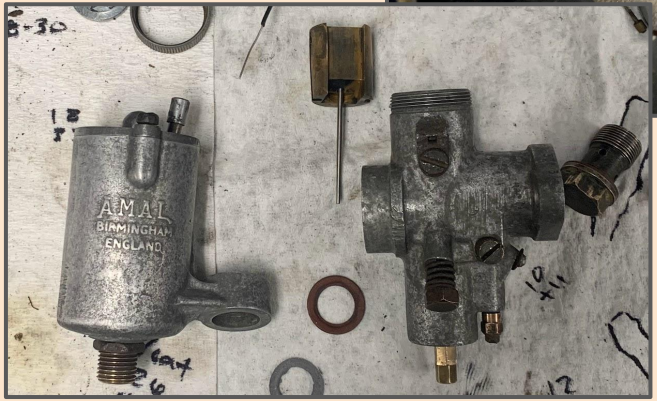
- Aluminum surface —> oxidized in the presence of air to have a coat of aluminum oxide on the surface

- Sandpaper, Scotch Brite, and brushes were used to remove oxidation from the outside

Before →

After

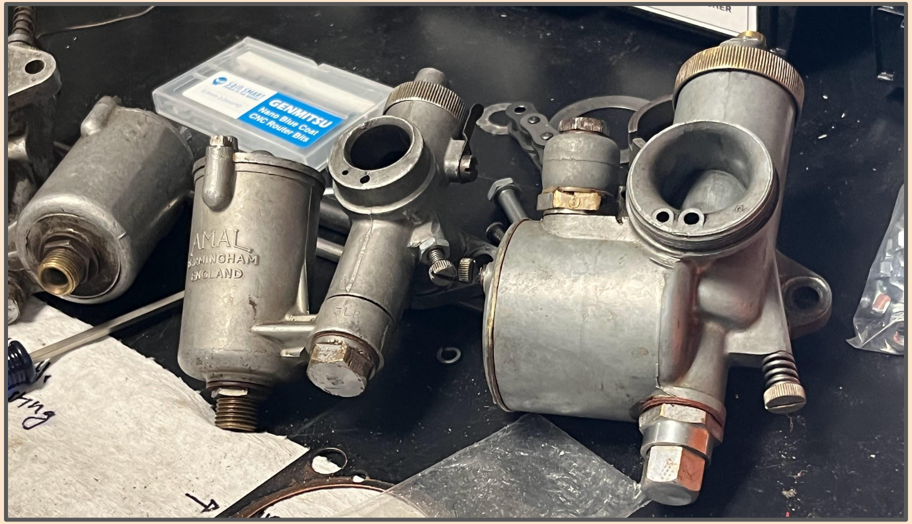
↓



Our Carburetor v.s. Others

Throttle Adjusting Screw (Part #10)

- Springs and a nut are both used to maintain the screw's position



Monobloc Carburetor

- Later carburetors will get rid of the two part carburetor and switch to a one part carburetor.

Head

- Home of the valves and spark plug.
- Combustion chamber.
  - Spark plug starts the combustion that starts the motorcycle.
  - Valves let the air/fuel mixture in and let out the exhaust gases.
- Fun Fact: We had a wasp’s nest in here

Disassembly

- Utilized the jam nut technique in order to help free the rocker from the head.

- Used a spring compressor tool in order to push the valve spring down to remove the keepers.

Restoration

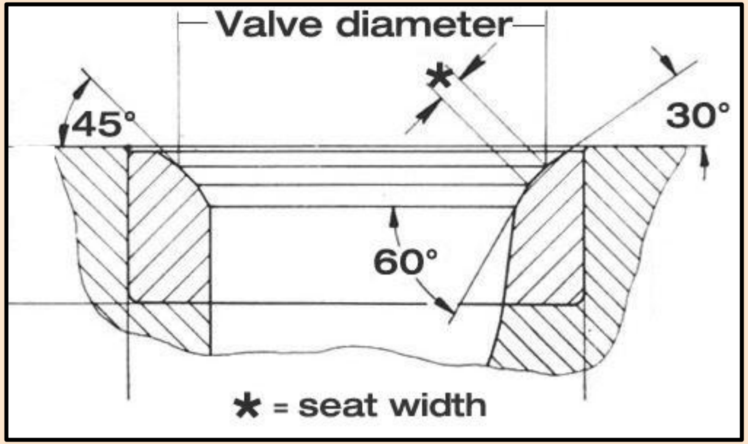
- Rust shows that materials are beginning to decay
- “Rust begets rust” - Prof. Littman
- Sandblasted, emory paper
- We used WD-40 in order to remove rusty bolts that were stuck.
- Oil was stuck between fins

Photo Credit: Theisen’s

Valve Seat Cutting

Cutting Valve Seats: Ensures that the valves come into contact with the head in a way that maximizes the engines performance and reduces wear

- 3 angles
- Allow gasses to pass valves with less turbulence
- Heat is transferred from valves via conduction, and the angles cut determine the SA of the valve in contact with the head

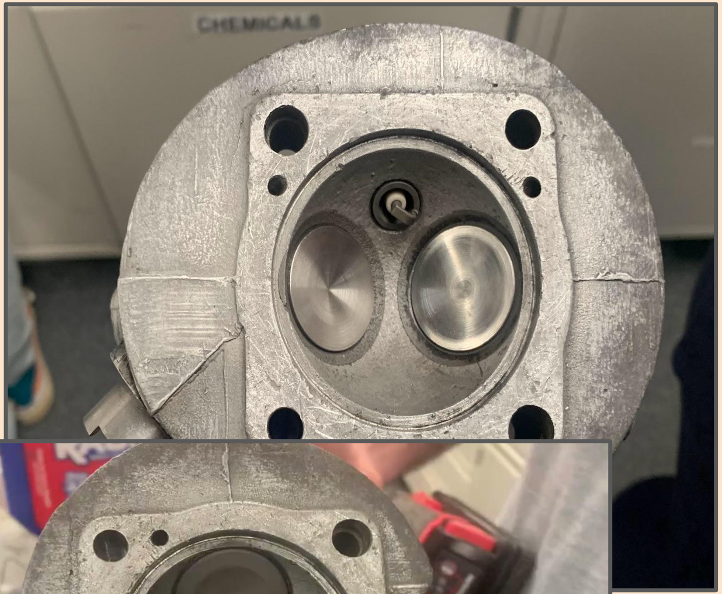


Valve Seat Cutter Photo Credit: Spring 2011's '63 Tiger Cub Top Engine Page
Diagram Credit: John Maher Racing

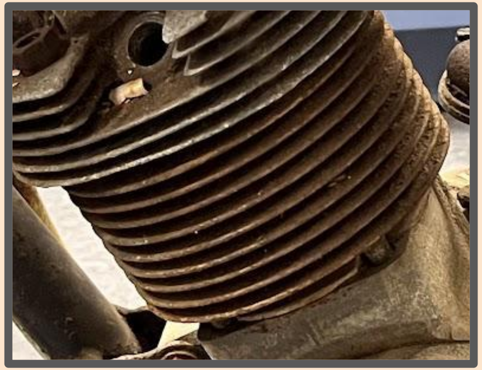
Lapping

- Used to create a sealing surface between the valve and its seat.

- With a gritty compound, we spun the valve around multiple time in order to make sure the two surfaces meet exactly.



Barrel



- Held on to the engine case with four large bolts
- Piston moves up and down inside the barrel
- Sandblasted to remove rust
- Painted black to return to factory appearance, most likely black, because color increases emissivity

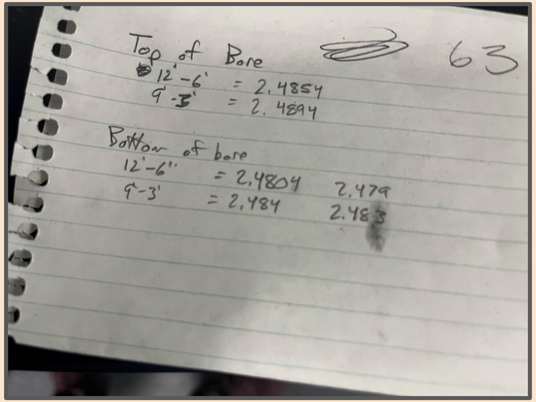
Honing & Boring

Honing: Removes surface layer of metal to remove surface defects and ensure proper piston ring seating

- Used a lathe and paddle hone the MAE shop
- Cutting Fluid: Lard Oil

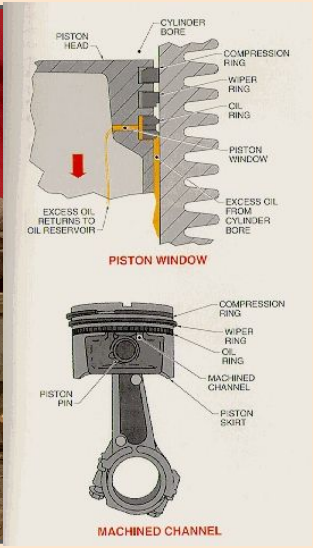
Boring: Repairs wear and tear due to friction in engine cylinders by widening and tapering it

- Used T-gages to determine that the cylinder was egg shaped and needed to be bored
- Prof. Northey bore our cylinder
- Was originally a standard bore of 63 mm



Piston and Rings

- Since our barrel was bored, we needed a larger piston and new rings
- Piston rings prevent fuel and combustion gasses from leaving combustion chamber and oil from entering it. Also transfer heat to cooling walls
- 3 rings: Two compression rings and one scraper
- Ring gaps should be offset from each other
- Ring gaps will close when the rings undergo thermal expansion



Removing our Piston 2/15/23
&
Photo Credit: University of Windsor

Evolution of the Barrel: Convective Heat Transfer

- We have a round barrel, but the shape of the barrel later changed to a square and then an oval shape
- Based upon Convection heat transfer equation,

$$Q = hA\Delta T$$

$$Q \propto A$$

- The surface area of the fin is proportional to the heat carried away
- Why not add more fins to have greater surface area?

—-> Impedes flow

1964 Tiger Cub

https://www.ebay.co.uk/itm/1665078891

1961 Tiger Cub

https://www.ebay.co.uk/itm/155078891561

More Science: Convective Heat Transfer Calculation

Calculate the heat dissipating off 0.05 m cooling fin attached to our 1954 Triumph Tiger Cub motorcycle engine as it travels at 40 $\frac{km}{h}$. The ambient air temperature is 27°C and the surface temperature of the fin is 236° C.

L = length of fin = 0.05 m $v = 40 \frac{km}{h}$

$q' = \frac{\text{heat dissipation}}{\text{length}} = \frac{q}{L} = \bar{h} L (T_s - T_\infty) 2$ Units: $\frac{W}{m}$

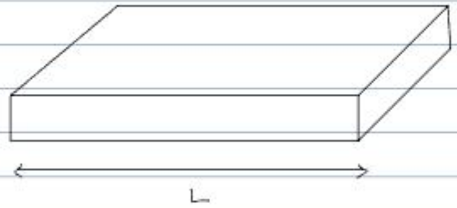
($\bar{h}$: constant; 2: there are two sides of the fin)

$\bar{h} = \frac{\bar{Nu}\, k_f}{L}$ ($\bar{Nu}$: constant; k_f: thermal conductivity)

$\bar{Nu} = f(Re, Pr)$ (Re: Reynolds constant; Pr: Prandtl number)

$Re = (v, \gamma, L)$ (v: velocity; γ: viscosity)

* approximate fin as flat plate



from a table:

$k_f = 0.0346 \frac{W}{mK}$

$\gamma = 27.85 \times 10^{-6} \frac{m^2}{s}$

$Pr = 0.69$

Calculation Continued

We need to know if this is Laminar to look up $\overline{Nu}$ ↙ unitless

$$Re = \frac{VL}{\nu} = 40 \times 10^3 \frac{m}{hr} \times \frac{1\ hr}{3600\ s} \times 0.05\ m \times \frac{1\ s}{27.85 \times 10^{-6}\ m^2} = 1.995 \times 10^4$$

↪ $< 5 \times 10^5$ so this is Laminar

$$\overline{Nu} = 0.664\ Re^{1/2}\ Pr^{1/3}$$

$$= 0.664\ (1.995 \times 10^4)^{1/2} (0.69)^{1/3} = 82.87$$

$$\bar{h} = \frac{(82.87)(0.0346\ \frac{W}{mK})}{0.05\ m} = 57.35\ \frac{W}{m^2 K}$$

Now we have everything to plug in:

$$q' = \bar{h} L (T_s - T_\infty)$$

$$= 57.35\ \frac{W}{m^2 K} (0.05 m)(236°C - 27°C)2$$

$$q' = 1198.615\ \frac{W}{m}$$

$$q' = \frac{q}{L} \qquad q = q'L = 1198.615\ \frac{W}{m} (0.05) m = 59.93075\ W$$

60 W

Question Adapted from Nathaniel Nelson's Heat Transfer Notes

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