Important Formulas of Engine Dynamics PDF

Formulas
Examples
with Units

List of 21
Important Formulas of Engine Dynamics

1) Beale Number Formula

Evaluate Formula

Formula

$$B_n = \frac{HP}{P \cdot SV_p \cdot f_e}$$

Example with Units

$$0.1019 = \frac{160\,\text{hp}}{56\,\text{N/m}^2 \cdot 205\,\text{m}^3 \cdot 102\,\text{Hz}}$$

2) Brake Power given Mean Effective Pressure Formula

Evaluate Formula

Formula

$$BP = \left(P_{mb} \cdot L \cdot A \cdot \left(N \right) \right)$$

Example with Units

$$0.5529\,\text{kW} = \left(5000\,\text{Pa} \cdot 8.8\,\text{cm} \cdot 30\,\text{cm}^2 \cdot \left(4000\,\text{rev/min} \right) \right)$$

3) Brake Power given Mechanical Efficiency Formula

Evaluate Formula

Formula

$$BP = \left(\frac{\eta_m}{100} \right) \cdot IP$$

Example with Units

$$0.54\,\text{kW} = \left(\frac{60}{100} \right) \cdot 0.9\,\text{kW}$$

4) Brake specific fuel consumption Formula

Evaluate Formula

Formula

$$BSFC = \frac{\dot{m}_f}{BP}$$

Example with Units

$$0.0059\,\text{kg/h/W} = \frac{0.00090\,\text{kg/s}}{0.55\,\text{kW}}$$

5) Brake Thermal Efficiency given Brake Power Formula

Evaluate Formula

Formula

$$\eta_b = \left(\frac{BP}{m_f \cdot CV} \right) \cdot 100$$

Example with Units

$$0.2455 = \left(\frac{0.55\,\text{kW}}{0.14\,\text{kg/s} \cdot 1600\,\text{kJ/kg}} \right) \cdot 100$$

6) Engine displacement given number of cylinders Formula

Evaluate Formula

Formula

$$E_d = r \cdot r \cdot L \cdot 0.7854 \cdot N_c$$

Example with Units

$$3981.0355\,\text{cm}^3 = 12\,\text{cm} \cdot 12\,\text{cm} \cdot 8.8\,\text{cm} \cdot 0.7854 \cdot 4$$

7) Engine rpm Formula

Evaluate Formula

Formula

$$\omega_e = \frac{MPH \cdot i_g \cdot 336}{D}$$

Example with Units

$$288758.57\,\text{rev/min} = \frac{60\,\text{mi/h} \cdot 2.55 \cdot 336}{76\,\text{cm}}$$

8) Equivalence ratio Formula

Evaluate Formula

Formula

$$\Phi = \frac{R_a}{R_f}$$

Example

$$1.2245 = \frac{18}{14.7}$$

9) Friction Power Formula

Evaluate Formula

Formula

$$FP = IP - BP$$

Example with Units

$$0.35\,\text{kW} = 0.9\,\text{kW} - 0.55\,\text{kW}$$

10) Indicated Power given Mechanical Efficiency Formula

Evaluate Formula

Formula

$$IP = \frac{BP}{\frac{\eta_m}{100}}$$

Example with Units

$$0.9167\,\text{kW} = \frac{0.55\,\text{kW}}{\frac{60}{100}}$$

11) Indicated specific fuel consumption Formula

Evaluate Formula

Formula

$$ISFC = \frac{\dot{m}_f}{IP}$$

Example with Units

$$0.0036\,\text{kg/h/W} = \frac{0.00090\,\text{kg/s}}{0.9\,\text{kW}}$$

12) Indicated Thermal Efficiency given Indicated Power Formula

Evaluate Formula

Formula

$$IDE = \left(\frac{IP}{m_f \cdot CV}\right) \cdot 100$$

Example with Units

$$0.4018 = \left(\frac{0.9\,\text{kW}}{0.14\,\text{kg/s} \cdot 1600\,\text{kJ/kg}}\right) \cdot 100$$

13) Inlet-Valve Mach Index Formula

Evaluate Formula

Formula

$$Z = \left(\left(\frac{D_c}{D_i}\right)^2\right) \cdot \left(\frac{s_p}{q_f \cdot a}\right)$$

Example with Units

$$3318.9619 = \left(\left(\frac{85\,\text{cm}}{2\,\text{cm}}\right)^2\right) \cdot \left(\frac{73.72\,\text{m/s}}{11.80 \cdot 340\,\text{cm/s}}\right)$$

14) Kinetic Energy Stored in Flywheel of IC Engine Formula

Evaluate Formula

Formula

$$E = \frac{J \cdot \left(\omega^2\right)}{2}$$

Example with Units

$$10\,\text{J} = \frac{0.2\,\text{kg·m}^2 \cdot \left(10\,\text{rad/s}^2\right)}{2}$$

15) Mean piston speed Formula

Evaluate Formula

Formula

$$s_p = 2 \cdot L \cdot N$$

Example with Units

$$73.7227\,\text{m/s} = 2 \cdot 8.8\,\text{cm} \cdot 4000\,\text{rev/min}$$

16) Mechanical Efficiency of IC engine Formula

Evaluate Formula

Formula

$$\eta_m = \left(\frac{BP}{IP}\right) \cdot 100$$

Example with Units

$$61.1111 = \left(\frac{0.55\,\text{kW}}{0.9\,\text{kW}}\right) \cdot 100$$

17) Rate of cooling of engine Formula

Evaluate Formula

Formula

$$R_c = k \cdot \left(T - T_a\right)$$

Example with Units

$$147\,\text{1/min} = 0.035 \cdot \left(360\,\text{K} - 290\,\text{K}\right)$$

18) Relative Efficiency Formula

Evaluate Formula

Formula

$$\eta_r = \left(\frac{IDE}{\eta_a}\right) \cdot 100$$

Example

$$8.4 = \left(\frac{0.42}{5}\right) \cdot 100$$

19) Specific Power Output Formula

Evaluate Formula

Formula

$$P_s = \frac{BP}{A}$$

Example with Units

$$183.3333\,\text{kW} = \frac{0.55\,\text{kW}}{30\,\text{cm}^2}$$

20) Swept Volume Formula

Evaluate Formula

Formula

$$V_s = \left(\left(\left(\frac{\pi}{4}\right) \cdot D_{ic}^2\right) \cdot L\right)$$

Example with Units

$$442.3362\,\text{cm}^3 = \left(\left(\left(\frac{3.1416}{4}\right) \cdot 8\,\text{cm}^2\right) \cdot 8.8\,\text{cm}\right)$$

21) Time taken for engine to cool Formula

Evaluate Formula

Formula

$$t = \frac{T - T_f}{R_c}$$

Example with Units

$$0.3741\,\text{min} = \frac{360\,\text{K} - 305\,\text{K}}{147\,\text{1/min}}$$

Variables used in list of Important Formulas of Engine Dynamics above

- **a** Sonic Velocity *(Centimeter per Second)*
- **A** Area of Cross Section *(Square Centimeter)*
- B_n Beale Number
- **BP** Brake Power *(Kilowatt)*
- **BSFC** Brake Specific Fuel Consumption *(Kilogram per Hour per Watt)*
- **CV** Calorific Value of Fuel *(Kilojoule per Kilogram)*
- **D** Tire Diameter *(Centimeter)*
- D_c Cylinder Diameter *(Centimeter)*
- D_i Inlet Valve Diameter *(Centimeter)*
- D_{ic} Inner Diameter of Cylinder *(Centimeter)*
- **E** Kinetic Energy Stored in the Flywheel *(Joule)*
- E_d Engine Displacement *(Cubic Centimeter)*
- f_e Engine Frequency *(Hertz)*
- **FP** Friction Power *(Kilowatt)*
- **HP** Engine Power *(Horsepower)*
- i_g Gear Ratio of Transmission
- **IDE** Indicated Thermal Efficiency
- **IP** Indicated Power *(Kilowatt)*
- **ISFC** Indicated Specific Fuel Consumption *(Kilogram per Hour per Watt)*
- **J** Flywheel Moment of Inertia *(Kilogram Square Meter)*
- **k** Constant for Cooling Rate
- **L** Stroke Length *(Centimeter)*
- m_f Mass of Fuel Supplied per Second *(Kilogram per Second)*
- $\dot{m}_f$ Fuel Consumption in IC engine *(Kilogram per Second)*
- **MPH** Speed of Vehicle *(Mile per Hour)*
- **N** Engine Speed *(Revolution per Minute)*
- N_c Number of Cylinders
- **P** Average Gas Pressure *(Newton per Square Meter)*

Constants, Functions, Measurements used in list of Important Formulas of Engine Dynamics above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Measurement: **Length** in Centimeter (cm) *Length Unit Conversion*
- Measurement: **Time** in Minute (min) *Time Unit Conversion*
- Measurement: **Temperature** in Kelvin (K) *Temperature Unit Conversion*
- Measurement: **Volume** in Cubic Meter (m^3), Cubic Centimeter (cm^3) *Volume Unit Conversion*
- Measurement: **Area** in Square Centimeter (cm^2) *Area Unit Conversion*
- Measurement: **Pressure** in Newton per Square Meter (N/m^2), Pascal (Pa) *Pressure Unit Conversion*
- Measurement: **Speed** in Mile per Hour (mi/h), Meter per Second (m/s), Centimeter per Second (cm/s) *Speed Unit Conversion*
- Measurement: **Energy** in Joule (J) *Energy Unit Conversion*
- Measurement: **Power** in Horsepower (hp), Kilowatt (kW) *Power Unit Conversion*
- Measurement: **Frequency** in Hertz (Hz) *Frequency Unit Conversion*
- Measurement: **Mass Flow Rate** in Kilogram per Second (kg/s) *Mass Flow Rate Unit Conversion*
- Measurement: **Angular Velocity** in Revolution per Minute (rev/min), Radian per Second (rad/s) *Angular Velocity Unit Conversion*
- Measurement: **Moment of Inertia** in Kilogram Square Meter ($kg \cdot m^2$) *Moment of Inertia Unit Conversion*
- Measurement: **Specific Energy** in Kilojoule per Kilogram (kJ/kg)

- P_{mb} Brake Mean Effective Pressure *(Pascal)*
- P_s Specific Power Output *(Kilowatt)*
- q_f Flow Coefficient
- **r** Engine Bore *(Centimeter)*
- R_a Actual Air Fuel Ratio
- R_c Rate of Cooling *(1 Per Minute)*
- R_f Stoichiometric Air Fuel Ratio
- s_p Mean Piston Speed *(Meter per Second)*
- SV_p Piston Swept Volume *(Cubic Meter)*
- **t** Time Required to Cool Engine *(Minute)*
- **T** Engine Temperature *(Kelvin)*
- T_a Engine Surrounding Temperature *(Kelvin)*
- T_f Final Engine Temperature *(Kelvin)*
- V_s Swept Volume *(Cubic Centimeter)*
- **Z** Mach Index
- η_a Air Standard Efficiency
- η_b Brake Thermal Efficiency
- η_m Mechanical Efficiency
- η_r Relative Efficiency
- Φ Equivalence Ratio
- ω Flywheel Angular Velocity *(Radian per Second)*
- ω_e Engine RPM *(Revolution per Minute)*

Specific Energy Unit Conversion

- Measurement: **Specific Fuel Consumption** in Kilogram per Hour per Watt (kg/h/W)
  Specific Fuel Consumption Unit Conversion
- Measurement: **Time Inverse** in 1 Per Minute (1/min)
  Time Inverse Unit Conversion

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