

TYPE120-DieselEngineGeneratorSystem

Equations

TYPE120 - DIESEL ENGINE GENERATOR SYSTEM (DEGS)

MODEL DESCRIPTION

TYPE120 is a mathematical model for a diesel engine generator set (DEGS). The model is based on an empirical relation (1st order polynomial) for the fuel consumption expressed as a function of the electrical power output (normalized). Electrical and fuel efficiencies are both calculated. TYPE120 can be used to predict the performance of a specific DEGS, provided a fuel consumption curve is supplied. Alternatively, a generic model can be used to predict the performance of any DEGS in the power range 5-500 kW. The generic model extrapolates from a reference fuel efficiency curve (average of 5 different DEGS). The generic model incorporates a correction factor derived from actual data measurements on DEGS for 20 remote area power systems (RAPS) with average operating powers in the range 5-186 kW [1]. The default fuel is diesel (liquid), but a database with fuel properties [2,3] included in TYPE120 make it possible to calculate the equivalent fuel flow rates (liquid or gas) for 5 alternative fuels: liquefied gas (LPG), propane (C3H8), methane (CH4), natural gas, or hydrogen (H2). In this executable, the fuel type is limited to diesel and the selected diesel engine generator set is a Ford 140 kW.

ELECTRIC MODEL

Rated Power

$$P_{DEGS, rated} = \text{Lookup}(\text{'DEGS curvefit' , 1, 3})$$

Normalized Power

$$X = P_{DEGS} / P_{DEGS, rated}$$

Electrical efficiency

$$\eta_{el} = \frac{P_{DEGS}}{\left(\rho_{diesel} \cdot \dot{V}_{diesel} \cdot LHV_{diesel} \right)}$$

Total Power output

$$P_{total} = N_{units} \cdot P_{DEGS}$$

FUEL CONSUMPTION

Fuel consumption

$$\dot{V}_{diesel} = (a + b \cdot X)$$

Fuel efficiency

$$\eta_{fuel} = P_{DEGS} / \dot{V}_{diesel}$$

Total Fuel consumption

$$\dot{V}_{total} = N_{units} \cdot \dot{V}_{diesel}$$

THERMAL MODEL

Total Thermal losses

$$Q_{waste} = P_{DEGS} \cdot \frac{100 - \eta_{el}}{\eta_{el}} \cdot N_{units}$$

=====APPENDIX=====

Unit conversion

$$\dot{V}_{diesel'} = \dot{V}_{diesel} \cdot (1/3600)$$

$$N_{units} = 1 \quad \text{Number of identical units}$$

$$P_{DEGS} = 50 \quad \text{Power set point for a single unit}$$

Parameters

$$LHV_{diesel} = \text{Lookup}(\text{'Fuel Properties'}, 1, 3) \quad \text{lower heating value for diesel}$$

$$\rho_{diesel} = \text{Lookup}(\text{'Fuel Properties'}, 1, 5) \quad \text{density of diesel fuel}$$

Specific DEGS

$$a = \text{Lookup}(\text{'DEGS curvefit'}, 1, 4) \quad \text{Coefficient \#1 of 1st order polynomial}$$

$$b = \text{Lookup}(\text{'DEGS curvefit'}, 1, 5) \quad \text{Coefficient \#2 of 1st order polynomial}$$

REFERENCES

- 1.Lloyd C. R. (1999) Assessment of diesel use in remote area power supply. Internal report prepared for the Australian Greenhouse Office, Energy Strategies, Canberra.
- 2.Adler U., Bauer H., Bazlen W., Dinkler F. and Herwerth M. (Eds) (1986) Automotive Handbook. 2nd edn, Robert Bosch GmbH, Stuttgart.
- 3.McCarthy R. D. (1982) Mathematical models for the prediction of liquefied-natural-gas densities. Thermophysical Properties Division, National Bureau of Standards, USA.

Solution

$$\begin{array}{llll} \mathbf{a} = 6 \text{ [L/hr]} & \mathbf{b} = 37.72 \text{ [L/hr]} & \eta_{el} = 0.2605 \text{ [0...1]} & \eta_{fuel} = 2.568 \text{ [W/L]} \\ \mathbf{N}_{units} = 1 & \mathbf{P}_{DEGS, rated} = 140 \text{ [W]} & \mathbf{P}_{total} = 50 \text{ [W]} & \mathbf{Q}_{waste} = 19144 \text{ [W]} \\ \dot{\mathbf{V}}_{diesel} = 19.47 \text{ [L/hr]} & & & \end{array}$$