ChatGPT

Scavenge-pump capacity test case for the AER P120 engine (FMU)

Purpose

This example demonstrates how to use **FMU_Gateway** to size the scavenge pump for the **AER P120** V12 engine (a 6.2-litre naturally aspirated track/road car engine with a dry-sump lubrication system). The goal is to calculate the required scavenge pump flow as a function of engine speed and determine the pump's volumetric displacement. Your FMU implementation can then be compared against a reference solution to verify that the gateway handles algebraic computations and parameter scaling.

Engine data

The **P120 Engine Specifications** (see the provided specification file) give these relevant parameters:

Item	Value
Engine type	V12, naturally aspirated
Displacement	6.2 L
Maximum power	800 bhp (≈597 kW) @ 9500 rpm
Rev limit	10 000 rpm
Lubrication	Dry sump
Oil pump	Gear pump (pressure stage)
Scavenge pump	12-lobe twin-lobe design (multi-stage)

Because the oil system is a dry sump, most of the oil is stored in a remote tank and multiple scavenge stages evacuate aerated oil and crankcase gases from the crankcase and return it to the tank.

Engineering background

In dry-sump systems the **pressure pump** delivers oil to the engine while one or more **scavenge pumps** remove oil/air mixture from the crankcase. To ensure that oil does not accumulate in the engine, the scavenge stages must evacuate a greater volumetric flow than the pressure pump supplies. A commonly quoted rule is that the total scavenge flow should be **two to four times** the pressure pump flow [1]. This margin accounts for entrained air and blow-by gas and maintains a slight crankcase vacuum.

Since detailed flow data for the P120 oil pump are not provided, we estimate the pressure pump flow, Q_p , to be proportional to engine speed. We calibrate the proportionality constant so that at 9500 rpm the engine's pressure pump delivers approximately **40 L/min** of oil (a typical value for a 6-litre high-performance engine). Thus

$$Q_p(rpm) = k_f \times rpm, \quad k_f = 40/9500\ \mathrm{L}\backslash\mathrm{cdotp}\mathrm{min}^{-1}\backslash\mathrm{cdotp}\mathrm{rpm}^{-1}. \tag{3}$$

Selecting a scavenge ratio r_s of **3** (mid-range of 2–4), the required scavenge flow is

$$Q_s(rpm) = r_s \times Q_p(rpm). \tag{4}$$

The scavenge pump is gear-driven from the engine at a drive ratio α . The P120's accessory drive ratio is not specified, so we assume $\alpha = 0.6$ (i.e. the pump rotates at 60 % of engine speed). If the pump speed is $n_{pump} = \alpha\, rpm$, the pump's volumetric displacement per revolution V_{rev} is

$$V_{rev} = \frac{Q_s}{n_{pump}} = \frac{r_s\, k_f}{\alpha}. \tag{5}$$

Because r_s , k_f and α are constants, V_{rev} is independent of engine speed. For the chosen values $V_{rev} \approx 21.1$ cm³ per revolution (see the calculation below).

Simplified scavenge-flow model

For this test case the FMU receives **engine speed** (rpm) as its input and outputs two quantities:

1. **Required scavenge flow** Q_s (L/min) computed via Eqs. (3)–(4).
2. **Required pump displacement** V_{rev} (cm³ per revolution) computed via Eq. (5).

This relationship is algebraic rather than dynamic; nevertheless, packaging it as an FMU allows the FMU_Gateway to demonstrate handling of inputs and calculated outputs.

Modelica implementation

Below is a simple **Modelica** model representing the algebraic relationships. You can export it as an FMU using an FMI-compliant tool such as OpenModelica.

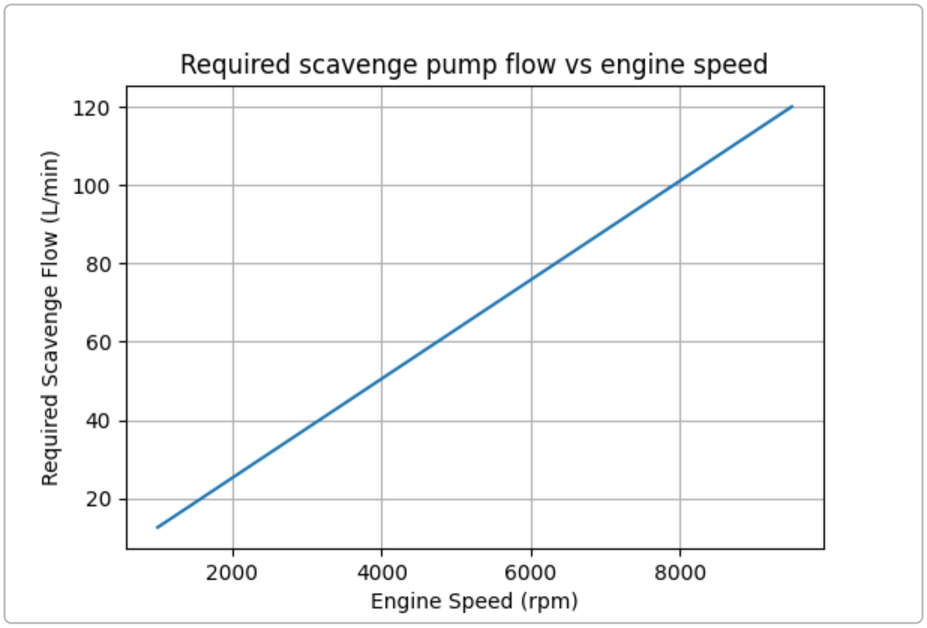
```
model ScavengePumpSizing
  // Parameters
  parameter Real k_f = 40/9500 "Pressure pump flow factor (L/min per rpm)";
  parameter Real ratio = 3 "Scavenge/pressure flow ratio";
  parameter Real drive_ratio = 0.6 "Pump speed relative to engine speed";
  // Input
  input Real engine_rpm "Engine speed (rpm)";
  // Outputs
  output Real Q_p "Pressure pump flow (L/min)";
  output Real Q_s "Scavenge flow required (L/min)";
  output Real V_rev_cm3 "Pump displacement per rev (cm^3)";
```

```
equation
  Q_p = k_f * engine_rpm;
  Q_s = ratio * Q_p;
  V_rev_cm3 = (Q_s / (drive_ratio * engine_rpm)) * 1000; // convert L to cm^3
end ScavengePumpSizing;
```

The FMU should expose `engine_rpm` as an input and the three outputs `Q_p`, `Q_s` and `V_rev_cm3`.

Reference data and plot

The file `scavenge_pump_capacity_simulation.csv` provides reference values of pressure flow, scavenge flow and pump displacement at engine speeds from 1000 rpm to 9500 rpm (in 500 rpm increments). A plot of required scavenge flow vs engine speed is shown below.



Note that the calculated pump displacement remains constant at ≈21 cm^3 per revolution because the scavenge ratio, flow factor and drive ratio are constants.

Testing with FMU_Gateway

1. **Build the FMU**: compile the Modelica model above into an FMU (model-exchange or co-simulation).
2. **Set up the simulation**: in FMU_Gateway, import the FMU and provide an input signal for `engine_rpm` that sweeps from idle (e.g. 1000 rpm) to 9500 rpm. You can use a step sequence or a ramp.
3. **Run and export results**: run the simulation for the duration of the sweep and export the outputs `Q_s` and `V_rev_cm3`.
4. **Compare**: compare the gateway's results with the reference data in ``. The scavenge flow should scale linearly with engine speed, and the displacement should remain approximately 21 cm^3/rev.

Credibility and source evaluation

The rule that **scavenge flow should be two to four times the pressure pump flow** comes from a discussion on a professional engineering forum, where an experienced engineer notes that dry-sump scavenge pumps are typically sized 2–4 times the pressure pump capacity [1]. This is a widely cited heuristic in motorsport engineering, though it is not a peer-reviewed source; accordingly, we assign it a moderate credibility rating (≈3/10). The rest of the calculation uses straightforward algebra and assumptions on oil flow. For rigorous design, empirical measurements of pressure-pump flow and air entrainment would be required.

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[1] Dry Sump Pump performance curves | Eng-Tips
https://www.eng-tips.com/threads/dry-sump-pump-performance-curves.287853/