

Component-Level Model Validation
Project 1 – TSFS09

Vehicular Systems

Chapter 1

Introduction

This document provides reference inputs and outputs for component-level validation of the engine model developed in Project 1. The purpose is to help identify implementation errors before the complete engine model is simulated.

The validation cases are supplementary checks and do not replace the model validation against measured engine-map data. Unless otherwise stated, use the parameter values obtained in Project 1B.

Recommendation: Validate each component individually before integrating the complete engine model. If a component fails the validation tests below, fix the implementation before continuing.

Important note: The reference values in this document have been generated using one reference parameter set. Different parameter values identified in Project 1B may result in different numerical outputs even if the model implementation is correct. The validation cases should therefore primarily be used to verify model implementation and signal flow. For the throttle model, volumetric-efficiency model, and torque model, deviations of approximately 10–20 % may occur due to differences in identified parameter values.

Chapter 2

Validation of Components

2.1 Gas pedal

2.1.1 Validation input

Use

```
1 AlphaRef = 1;  
2 Alpha(0) = 0;
```

and simulate the model for 0.1 s.

2.1.2 Expected output

The throttle angle should follow

$$\alpha(t) = 1 - e^{-t/\tau_{th}}$$

and reach approximately

$$\alpha(\tau_{th}) = 0.632$$

after one time constant.

At $2 \cdot \tau_{th}$ s the output should be approximately

$$\alpha(2\tau_{th}) = 0.865.$$

2.2 Fuel injector

2.2.1 Validation inputs

Use the parameter values obtained in Project 1B. Apply the following injection times simultaneously to the fuel injector subsystem:

```
1 t_inj_val = [0.0010 0.0015 0.0020 0.0030 0.0040]; [s]  
2
```

Listing 2.1: Fuel injector validation inputs.

2.2.2 Expected output

The fuel injector subsystem should give approximately

```
1 m-fi-ref = [5.898e-06 1.435e-05 2.280e-05 3.970e-05 5.660e-05]; [kg/cycle/  
2 cylinder]
```

Listing 2.2: Expected injected fuel mass.

2.3 Throttle

2.3.1 Validation inputs

Use the reference parameter values provided with the project files.

```
1 alpha_val = [0.05 0.15 0.30 0.50 0.80];  
2 p_bef_thr_val = 101325*ones(size(alpha_val));  
3 p_im_val = [30000 40000 50000 60000 70000];  
4 T_bef_thr_val = T_bef_thr_ref*ones(size(alpha_val));
```

2.3.2 Expected output

The throttle subsystem should give approximately

```
1 m_dot_th_ref = [0.00615 0.02247 0.07387 0.19090 0.44950]; [kg/s]
```

2.4 Volumetric efficiency

2.4.1 Validation inputs

Use the parameter values obtained in Project 1B.

```
1 p_im_val = [40000 60000 80000 100000 120000]; [Pa]  
2  
3 N_e_val = [1000 1500 2000 3000 4500]/60; [rps]  
4  
5 ivo_eff = 0;  
6 evo_eff = 0;
```

Listing 2.3: Volumetric efficiency validation inputs.

2.4.2 Expected output

The volumetric efficiency model should give approximately

```
1 eta_vol_ref = [0.7927 0.8579 0.8997 0.9136 0.8960];
```

Listing 2.4: Expected volumetric efficiency.

2.5 Torque generation

2.5.1 Validation inputs

Use the parameter values obtained in Project 1B.

```
1 m_fi_val = [1.0e-5 2.0e-5 3.0e-5 4.0e-5 5.0e-5];  
2 N_e_val = [1000 1500 2000 3000 4000]/60; [rps]  
3 lambda_val = [1 1 1 1 1];  
4 p_im_val = [50000 70000 90000 110000 120000]; [Pa]  
5 p_em_val = [101325 101325 101325 101325 101325]; [Pa]
```

Listing 2.5: Torque model validation inputs.

2.5.2 Expected output

The torque model should give approximately

```
1 M_e_ref = [33.0 84.49 135.2 181.0 222.1]; [Nm]
```

Listing 2.6: Expected engine torque.

2.6 Exhaust temperature

2.6.1 Validation inputs

Use the parameter values obtained in Project 1B.

```
1 m_dot_exh_val = [0.01 0.02 0.05 0.10 0.20]; [kg/s]
```

Listing 2.7: Exhaust temperature validation inputs.

2.6.2 Expected output

The exhaust temperature model should give approximately

```
1 T_e_ref = [900.4 966.8 1098.7 1247.2 1457.3]; [K]
```

Listing 2.8: Expected exhaust temperature.

2.7 Exhaust-system flow

2.7.1 Validation inputs

Use the parameter values obtained in Project 1B.

```
1 p_amb_val = 101325*ones(5,1);  
2 p_es_val = [105000 110000 120000 140000 180000]; [Pa]  
3 T_es_val = [900 900 900 900 900]; [K]
```

Listing 2.9: Exhaust-flow validation inputs.

2.7.2 Expected output

The exhaust-flow model should give approximately

```
1 m_dot_es_ref = [0.1314 0.2067 0.3167 0.4923 0.7961]; [kg/s]
```

Listing 2.10: Expected exhaust mass flow.

2.8 Lambda sensor

2.8.1 Validation input

Use

```
1 lambda_c = 1.2;  
2 lambda_exh(0) = 1.0;
```

and simulate the model for approximately

$$5\tau_s + \tau_d.$$

The transport delay is

$$\tau_d \text{ s}$$

and the sensor time constant is

$$\tau_s \text{ s.}$$

2.8.2 Expected output

The lambda sensor output should remain constant during the transport delay,

$$\lambda_{exh}(t) = 1.0$$

for

$$t < \tau_d.$$

After the delay, the sensor output should follow

$$\lambda_{exh}(t) = 1.2 - (1.2 - 1.0)e^{-(t-\tau_d)/\tau_s}$$

for

$$t \geq \tau_d.$$

The sensor output should be approximately

$$\lambda_{exh}(\tau_d) = 1.000$$

$$\lambda_{exh}(\tau_d + \tau_s) = 1.126$$

$$\lambda_{exh}(\tau_d + 2\tau_s) = 1.173$$

$$\lambda_{exh}(\tau_d + 5\tau_s) = 1.199.$$