Component-Level Model Validation
Project 2 – TSFS09

Vehicular Systems

Chapter 1

Introduction

This document provides reference inputs and outputs for component-level validation of the engine model developed in Project 2 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 2B.

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 2B 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 Turbocharger shaft dynamics

2.1.1 Validation inputs

Use the following compressor and turbine power inputs:

```
W_dot_c_val = [5000 10000 5000];  [J/s]
W_dot_t_val = [10000 5000 5000];  [J/s]
```

and simulate the model for 10 s.

2.1.2 Expected output

The turbocharger shaft dynamics should give approximately

```
w_tc_ref = [20000 1000 1104];  [rad/s]
```

2.2 Compressor

2.2.1 Validation inputs

Use the parameter values obtained in Project 2B. Apply the following turbocharger speeds, ambient pressures, and compressor outlet pressures to the compressor subsystem:

```
w_tc_val = [4000 6000 8000 10000 12000];  [rad/s]
p_amb_val = [101325 101325 101325 101325 101325];  [Pa]
p_ic_val = [106100 112450 122050 135700 154500];  [Pa]
```

Listing 2.1: Compressor validation inputs.

2.2.2 Expected output

The corrected compressor mass flow should give approximately

```
m_dot_c_corr_ref = [0.04329 0.06254 0.07935 0.09351 0.10510];
```

Listing 2.2: Expected corrected compressor mass flow.

The compressor mass flow should give approximately

```
m_dot_c_ref = [0.04295 0.06204 0.07872 0.09277 0.10420];  [kg/s]
```

Listing 2.3: Expected compressor mass flow.

The compressor efficiency should give approximately

```
eta_c_ref = [0.5924 0.6140 0.6240 0.6370 0.6606];
```

Listing 2.4: Expected compressor efficiency.

The compressor power should give approximately

```
W_dot_c_ref = [286.3 909.4 2053 3777 6023];  [J/s]
```

Listing 2.5: Expected compressor power.

2.3 Turbine

2.3.1 Validation inputs

Use the parameter values obtained in Project 2B. Apply the following exhaust-manifold pressures, exhaust-manifold temperatures, exhaust-system pressures, and turbocharger speeds to the turbine subsystem:

```
p_em_val = [120000 140000 170000 200000 250000];  [Pa]
T_em_val = [900 950 1000 1050 1100];  [K]
p_es_val = [101325 101325 101325 101325 101325];  [Pa]
w_tc_val = [4000 6000 8000 10000 12000];  [rad/s]
```

Listing 2.6: Turbine validation inputs.

2.3.2 Expected output

The turbine flow parameter should give approximately

```
TFP_ref = [0.002516 0.003301 0.003920 0.004273 0.004611];
```

Listing 2.7: Expected turbine flow parameter.

The turbine mass flow should give approximately

```
m_dot_t_ref = [0.01006 0.01499 0.02107 0.02637 0.03476];  [kg/s]
```

Listing 2.8: Expected turbine mass flow.

The turbine efficiency should give approximately

```
eta_t_ref = [0.6303 0.6556 0.6705 0.6979 0.7089];
```

Listing 2.9: Expected turbine efficiency.

The turbine power should give approximately

```
W_dot_t_ref = [218.6 671.3 1591 2807 5100];  [J/s]
```

Listing 2.10: Expected turbine power.

The turbine outlet temperature should give approximately

```
T_04_ref = [878.3 905.2 924.5 943.6 953.3];  [K]
```

Listing 2.11: Expected turbine outlet temperature.

2.4 Driver gas pedal interpretation

2.4.1 Validation inputs

Apply the following accelerator-pedal positions and engine speeds to the driver gas pedal interpretation subsystem:

```
ped_pos_val = [0.10 0.25 0.50 0.75 1.00];  [-]
N_e_val = [1000 1500 2000 3000 4000];  [rpm]
```

Listing 2.12: Driver gas pedal interpretation validation inputs.

2.4.2 Expected output

The intake-manifold pressure reference should give approximately

```
p_im_ref = [1.581e4 4.460e4 9.849e4 1.566e5 2.107e5];  [Pa]
```

Listing 2.13: Expected intake-manifold pressure reference.

The intercooler pressure reference should give approximately

```
p_ic_ref = [2.581e4 5.460e4 1.085e5 1.666e5 2.207e5];  [Pa]
```

Listing 2.14: Expected intercooler pressure reference.

2.5 Throttle feedforward

2.5.1 Validation inputs

Apply the following intake-manifold pressure references, engine speeds, and actual intercooler pressures to the throttle feedforward subsystem:

```
p_im_ref_val = [40000 60000 80000 95000 110000];  [Pa]
N_e_val = [1000 1500 2000 3000 4000];  [rpm]
p_ic_act_val = [101325 105000 115000 130000 150000];  [Pa]
```

Listing 2.15: Throttle feedforward validation inputs.

2.5.2 Expected output

The throttle feedforward subsystem should give approximately

```
alpha_thrFF_ref = [0.03994 0.07803 0.11220 0.15060 0.17830];  [-]
```

Listing 2.16: Expected feedforward throttle position.