

Project report
Project 1A – TSFS09

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1 Project 2A Assignments

To pass Project 2A, Answer the theoretical questions and fill in the model sections below with your equations.

2 Questions

- 2.1 What are the main components of a turbo and what is their purpose? Are there any limitations in the operating region of the components?
- 2.2 How are the compressor- and turbine maps measured? What are corrected quantities and why are they used? What are reference states in this context?
- 2.3 What benefits/drawbacks does a large/small naturally aspirated engine have? How can turbocharging be used to remove the drawbacks? What other drawbacks are a consequence of turbocharging?
- 2.4 What extra actuators are present on a turbocharged engine compared to a naturally aspirated engine and what is their purpose?
- 2.5 Given a compressor flow (\dot{m}_c), compressor pressure ratio (Π_c), compressor efficiency (η_c) and compressor inlet temperature (T_{01})
 - 2.5.1 How can the compressor outlet temperature (T_{02}) be calculated?
 - 2.5.2 Given the temperature increase over the compressor, $\Delta T = T_{02} - T_{01}$, how can the compressor power be calculated?
 - 2.5.3 Given the turbo speed (ω_{tc}) and the compressor power (\dot{W}_c); how can the required torque of the compressor ($T_{q,c}$) on the turbo shaft be calculated?
- 2.6 Given a turbine mass flow (\dot{m}_t), turbine pressure ratio (Π_t), turbine efficiency (η_t) and turbine inlet temperature (T_{03})
 - 2.6.1 How can the turbine outlet temperature (T_{04}) be calculated?
 - 2.6.2 Given the temperature drop over the turbine, $\Delta T = T_{03} - T_{04}$, how can the turbine power be calculated?
 - 2.6.3 Given the turbo speed (ω_{tc}) and the turbine power (\dot{W}_t); how can the driving torque of the turbine ($T_{q,c}$) on the turbo shaft be calculated?

3 Models

3.1 Turbine Flow

The turbine flow model predicts the turbine flow parameter (TFP) through the pressure ratio over the turbine, p_{04}/p_{03} . Important to note is that when converting from TFP to actual mass flow, the pressure should be in kPa.

Model:

$$\text{TFP} = k_0 \sqrt{1 - \Pi_t^{k_1}}, \quad \Pi_t = \frac{p_{04}}{p_{03}} = \frac{p_{es}}{p_{em}} \quad (1)$$

$$\dot{m}_t = \text{TFP} \times \frac{p_{03} \text{ [kPa]}}{\sqrt{T_{03} \text{ [K]}}} \quad (2)$$

Known model parameters:

Unknown model parameters: k_0, k_1

Measurement signals: p_{04}, p_{03}

Measurement type: Stationary

3.2 Turbine Efficiency

Describe the model for turbine efficiency η_t .

Model:

$$\dots \quad (3)$$

Known model parameters:

Unknown model parameters:

Measurement signals:

Measurement type:

3.3 Compressor Flow

A model describing the compressor flow \dot{m}_c .

Model:

$$\dots \quad (4)$$

Known model parameters: -

Unknown model parameters:

Measurement signals:

Measurement type:

3.4 Compressor Efficiency

A model for the compressor efficiency η_c .

Model:

$$\dots \quad (5)$$

Known model parameters:

Unknown model parameters:

Measurement signals:

Measurement type:

3.5 Shaft Dynamics

Describe the model for the dynamics of the turbocharger rotational speed ω_{tc} .

Model:

$$\dots \quad (6)$$

Known model parameters:

Unknown model parameters:

Measurement signals:

Measurement type: