ČVUT
ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

POSUDEK VEDOUCÍHO ZÁVĚREČNÉ PRÁCE

I. Identification Data

Title:	**Development of GT-Power Model of a Gasoline Engine with Low Pressure EGR Suitable for Model-Based Predictive Control of an Air Path**
Author:	**Jakub Jaroš**
Thesis Type:	diplomová
Faculty:	Fakulta strojní (FS)
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Thesis Supervisor:	Prof. Ing. Jan Macek, DrSc.
Department:	Center of Vehicles for Sustainable Mobility

II. Thesis Assessment

Thesis Topics	**Interdisciplinary, requiring broad knowledge, extraordinary demanding**
The thesis topics have been defined together with Toyota Motor Europe, Technical Center in Zaventem, Belgium. The topics have required the combination of specific ICE feature description and control engineering simplification (model-based predictive control, dynamic mean value model, etc.), aiming at model based control of EGR for a turbocharged SI ICE.	

Assignment Fulfillment	**Fulfilled**
The assignment of the thesis has been fulfilled by the search of available published models, development and testing the models. Unfortunately, only steady operation is modelled, which is not fully adequate to control purposes.	

Student's Approach and Activity during Thesis Elaboration	**C - Good**
Student visited preferentially the consulting persons at Toyota Motor Europe. It was natural due to necessary compatibility with in-house used methods and distance from Prague but it caused the use of some not clearly defined methods in turbocharger modelling. Namely, it is an absence of corrections to turbine unsteady operation under pressure pulses, typical especially for twin-scroll turbocharger turbines. The same problem occurs in the case of EGR rate under influence of pulsations, although for low-pressure EGR loop it is not so significant. The level of student's knowledge has increased during thesis elaboration. Due to some intellectual property issues, the supervisor received the final thesis just before a deadline for submission. It caused that some comments are stated in this review for the first time. It is advisable that the student will answer these comments during his defense..	

Technical Professional Level	**D – Satisfactory**
The analysis of current solutions of different EGR layouts and tools for simulation and control creates strong part of the thesis, although poor English might lead to misunderstanding time to time (e.g., the comment to area A on p. 31). Some specific remarks: The pressure traces from experiment results on p. 41 and especially the assumption of inlet manifold pressure at IVC are rather dubious. The formula (1) on p. 42 needs explanation of physics and acronyms, as well. Surprisingly, the condensation of water steam from burnt gas is not taken into account. The assumption of single trace for EGR throttle effective area (not discharge coefficient) should be checked, since Re dependence may occur. Altogether, it is much better to use closed loop approach for EGR control, using CO_2 contents. Mass flow rate depends on square root of pressure difference, not pressure difference squared, as might be understood from the p. 50. Mean value engine model is still dynamic model, just neglecting higher frequency parameters pulsations during a single cycle. From that reason, it is not very suitable to omit turbocharger lag from simulations, as it might be found in Fig. 43 on p. 56. Perhaps, something was not described here from security reasons, but the use of map approach without checking the dynamic features of MVEM	

might be dangerous for model accuracy. It seems that all calibration has been done from steady operation only, which might not be fully suitable. Definition of "feeding efficiency" on p. 57 et al. should be elucidated. Detailed model configuration and calibration are done properly, but it is not clear, how the results were used in the models of lower level. The exhaust manifold backpressure depends at least on waste-gate position, which is not mentioned on p.87. The twin scroll model cannot be applied in detailed model as a simple addition of both volutes upstream of a single-scroll turbine. If applied for models of lower level, it needs to correct the results by pulsation level or indirectly using turbine permeability corrected by the function of engine speed, bmep and boost pressure (at least).

Formal and Language Level	**D - Satisfactory**

The structure of thesis is good but close to the ends the description of assumptions is often omitted. Language level is rather poor, the sentences are sometimes hard to be understood.

It would be reasonable to present the list of symbols and to add units to any symbol, because some equations in text cannot be used without this knowledge.

Literature Search, Correctness of Citations	**D – Satisfactory**

The search for literature sources was done according to supervisor's knowledge in broader range but not all of them are referred to **and used** in the text of the thesis. Most of sources, being referred to, are on websites, which has very limited meaning. The conference papers are referred to in inadequate manner. Nevertheless, no citation ethics problems are present in the thesis as it is submit. The formal correctness of references is not good.

Other Comments

The student should mention the supervisor's comments in the presentation during the defence.

III. Resulting Assessment and Grade

The topics was extraordinary demanding for a student with general automotive and ICE background. The student's approach has been adequate and his expert level increased during the time of thesis elaboration. The lack of contact with a supervisor during elaboration of thesis is reflected by some inadequate explanation of physics for modelled processes. That is why my assessment is at the grade of D.

I propose the resulting grade **D - satisfactory**

Datum: 31.1.2019 Podpis: