Tárgytematika / Course Description

Drivetrain development of racing vehicle

AJNB_BMTA013

Tárgyfelelős neve / Teacher's name: dr. Hanula Barna

Félév / Semester: 2020/21/1

Beszámolási forma / Assesment: Vizsga

Tárgy heti óraszáma / Teaching hours(week): 2/0/0/0

Tárgy féléves óraszáma / Teaching hours(sem.): 0/0/0/0

OKTATÁS CÉLJA / AIM OF THE COURSE

Goal of the subject

Students can learn high-level application of individual engineering competencies and the ability to work efficiently in a team within the frame of project work while designing racing applicated optimized components. During the documenting and presenting this project on a weekly basis, as well as active participation in the lecturer's lectures, the course aims to assist in the preparation of diploma, TDK documents, professional publications and any other scientific and engineering work.

TANTÁRGY TARTALMA / DESCRIPTION

The content of the subject

On the first week of the semester, after the introduction of various topics related to motorsport - pre-defined by the Department of Internal Combustion Engines -, student teams will be compiled to fulfill the given project. Of course, consular help is available for each topic for the student teams. Requirements for the completion of the course will be defined, covering both the expected result of the given task, the level of presentations and documentation submitted, as well as the field of continuous class attendance and consultation.

In the following weeks, in the lecturer's presentations, students will learn about the characteristics of racing engines, the need for unique developments and the challenges they face. They can also gain insights into the design and optimizing processes of crankcases, crankshafts, and other components optimized for motorsports, the use of various types of chargers, and other essential elements for successful racing such as engine applications. During the lectures, students can acquire engineering-level presentation competencies, and in the second half of the lesson, use forms of practical application of consulting skills. The weekly schedule of lectures is as follows:

1) ***I'll be an engineer***
This is the introductory lecture of the course, which aims to motivate students to work actively, passionately and successfully on their work during the presentation of the competencies required for becoming an engineer. By introducing examples, you can learn about the essential elements of efficient work (timeplan making, appointment of responsible, consultation, presentation, documentation)

2) ***What is an ideal FS engine?***
As in every field of engineering work, we need compromise in the field of competitive sports, and we need optimum search. During this lecture, we can gain insight into a wide range of engine construction

based on the Formula Student (FS) rules. Selected elements of this palette, based on various aspects, such as power, weight, efficiency, cost, compactness, and the selection of a decision matrix, are used to select the optimal design. In the second half of the lecture, the steps of designing individual parts are listed.

3) Crankcase

As the largest volume of internal combustion engines in sport, special attention needs to be paid to crankcase's mass and tension optimization. After presenting the tasks and requirements of this engine part, the presentation gives a detailed description of its design and optimization process. Mass and stress optimization is described in detail by the now widely used finite element analysis method. In addition, we can learn about the steps of the crankcase construction, the necessary cylindrical coating post-machining, and the possibility of testing the seal.

4) Crank mechanism

The conversion of chemical energy released by combustion into motion energy is carried out by a group of parts called the crank mechanism. In order to make this transformation as effective as possible, we need to take into account a number of influencing factors as quickly as possible and with the lowest possible mass. The purpose of this presentation is to explore these factors in detail, thus presenting the forms of component design. Differences in design between racing engine components and the same units used in serial production are explained. Using finite element and vibration simulations, we can observe the stress of the overlap between the gas and mass forces and the components, as well as the effects of the counterweights applied in the system.

5) Conrod development

The vertical (alternate) forced movement of the piston due to the gas pressure can be transformed into a rotating motion corresponding to the drive chain by means of the connecting rod. We have distinguished between the mounted and one-piece, I, H, X and knife profiles. During the lecture, we will learn about the advantages and disadvantages of using these forms of design in competitive sports. The mathematical determination of the various stresses is deduced, and through an example, we can follow step by step the dimensioning phases of the connecting rod. The stress checking process is done by finite element analysis. The high-speed ranges and the associated high mass force values require that this component is optimized as much as possible while maintaining the appropriate strength values. In addition to finite element analyses, the presentation also presents a material selection decision matrix for the solution of this task and finally describes the manufacturing process and the necessary post-production processes of the component.

6) Lubrication

In an internal combustion engine, a number of locations can be determined where the parts are frictionally moving in the presence of a relative speed difference. In order to reduce friction and thus reduce wear, we need lubrication at the specified contact points. The presentation presents the practical implementation of this on a complete lubrication system of a race engine. The list starts with the friction parts pairs of the piston group, and the various bearing options are listed. With a decision matrix, you can get an idea of how to choose the optimal lubrication system used in competitive sports, while detailing the dry, wet, and semi-dry carter structures. At the end of the lecture, you will learn about some of the components of the lubrication system, such as various oil pumps, oil filters, oil tank designs, diaphragms, nozzles.

7) Valvetrain

Indicated power of internal combustion engines is greatly influenced by its valve timing parameters. In this presentation, we can learn the steps of designing a unique slider valve through optimizing these parameters of the SZEngine engine development team. The air charge optimization is illustrated by various power, torque and valve lift diagrams. In addition to finite element simulations, we can also acquire thermodynamic and valve spring design skills. At the end of the lecture, additional valve control mechanisms, fixed and stepping camshafts are presented.

8) ***ECUs***

With the advancement of technology, the control processes of internal combustion engines have changed. Injection systems, programmable electronic ignition solutions and other intervention methods have been released. These component units form the so-called electronic engine controller (ECU). The presentation presents the functions of ECU, the properties of its building blocks and its software programming for various engine control strategies. The mechanism of injection and ignition is described in detail. In addition, you can learn about other interesting features such as lambda and knock control.

9) ***Air charge***

In this presentation, systems for influencing the exchange of charges, such as suction, exhaust system, and filler changes in the cylinder head, are defined. Firstly, the Formula Student Rules are described for these parts groups. In the case of the suction system, we can get acquainted with the 3D flow dynamics simulations and the importance of choosing the right tube length, the concept of Airbox and its practical utility. The design of the exhaust system presented in terms of their main function, the limitations of the noise level specified in the regulations, is, of course, at the appropriate power/weight ratio. At the end of the lecture, constructional designs for improving cylinder head port replacement are listed.

10) ***Developing an intake system for a Formula Student racing car***

After describing the functions of the suction system and the relevant sections of the prescribed competition rules, you can gain insight into the selection of the optimum suction tube length and the selection of the appropriate volume of the airbox. All of these can be analyzed with 3D flow geometry, so-called CFD simulations and Flow Bench measurements. The presentation also aims to provide a variety of manufacturing technology skills in the field of 3D printing and laminating technology.

11) ***Measuring and controlling system of an engine testbench***

Knowledge of the internal combustion engine's control system is essential for carrying out engine testbench tests. The presentation presents the components of these complex systems. You can get to know the CRio type measuring system and its functions, the software background of the measurement and control system, and the MS4 engine control unit that Bosch distributes.

12) ***System of engine testbech***

The final presentation of the semester presents the utility, tasks and structures of the testbench system used by a unique designed testbench of SZEngine. It provides a detailed view of the most important components, such as the measuring system, the control panel, the brake motor and the inverter, the exhaust and supply system and the Boombox.

SZÁMONKÉRÉSI ÉS ÉRTÉKELÉSI RENDSZERE / ASSESMENT'S METHOD

Rating

This project work is conditional on the presentation of actual workflows on a weekly basis and the preparation of project documentation for these workflows. The professional level and formal criteria of the documentation are the same as those described in the thesis requirements. The rules of the BSc thesis template on the bmt.sze.hu website apply to the structure of the thesis. The full scope of the document must be a work of its own. In the case of plagiarism, the dissertation is inadequate. Content references are governed by the rules of the thesis template. The team's work must meet the engineering standards of an MSc thesis.

During the semester the teams present their own works twice (mid-term and end-of-term). During these presentations, students can use their previously mentioned lecture skills within the frame of the course.

The course also requires the execution and documentation of the work done at the engineering level. With the preparation of this and its consultative feedbacks, the course aims to provide assistance in the creation of thesises, TDK documents, and other engineering publications.

Students are awarded the mark for their semester project work in the following divisions:

- 40% The professional content of the documentation.
- 40% Level of the presentations.
- 20% Formal requirements of the documentation.
- The min. 60% of the points from each section is required

The individual marks are based on individual performance allocation and the feedbacks of the consultant.

KÖTELEZŐ IRODALOM / OBLIGATORY MATERIAL

Literatures

1) Michael Trzesniowski: Rennwagentechnik [Wiessbaden 2008]
2) Gál Péter, Csizmazia József: Gépjárműmotorok II-III [Nemzeti Tankönyv kiadó]
3) Dezsényi György, Emőd István, Finichiu Liviu: Belsőégésű motorok tervezése és vizsgálata, [Nemzetközi Tankönyvkiadó Rt, Budapest 1999]
4) Bosch kézikönyvek: Motorelektronika
5) Frank Tibor, Kovács Miklós: Befecskendező és motorirányító rendszerek [Maróti könyvkereskedés]
6) Hermann Hiereth, Peter Prenninger: Charging the internal combustion engine [Springer-Verlag, Wien 2003]
7) Michael Costin, David Phipps: Racing and sports car chassis design, B.T. Batsford LTD London
8) Alan Staniforth, Competition car suspension, 2006 Haynes Publishing
9) Carroll Smith, Engineer to win understanding car dynamics, Motorbooks Workshop
10) Prof. Dr.-Ing. Mario Theissen, Dipl.-Ing. Markus Duesmann, Dipl.-Ing. Jan Hartmann, Dipl.-Ing. Matthias Klietz, Dipl.-Ing., 10 Years of BMW F1 engines, Ulrich Schulz , BMW Group, Munich
11) C.H.A. Criens, T. ten Dam, H.J.C. Luijten, T. Rutjes, Building a MATLAB based Formula Student simulator
12) Anthony M O’Neill, Chassis design for SAE racer, University of Southern Queensland 2005
13) Bradley John Moody, Control and instrumentation for the USQ Formula SAE-A race car, University of Southern Queensland 2005
14) Cristopher Scott Baker, FoES Formula SAE-A space frame chassis design, University of Southern Queensland 2004
15) Cristina Elena Popa, Steering system and suspension design for 2005 Formula SAE-A racer car, University of Southern Queensland 2005
16) Jeremy Little, Developement of the drivetrain including brakes and wheels for the Formula SAE-A vehicle, University of Southern Queensland 2004
17) Matthew Harber, Developement of a drivetrain system for a Formula SAE-A race car, University of Southern Queensland 2005
18) Travis William Mauger, Selection of an engine and design of the fuelling system for a Formula SAE car, University of Southern Queensland