Application of CRUISE Software on Course Design for Car Design

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Abstract. Considering increasing applications of virtual simulation technology in education and the background of thorough revolution on vehicle engineering practical teaching, this paper tried to introduce CRUISE software—a kind of virtual simulation technology into curriculum design for car design in undergraduate education. In this paper, teaching organization model and specific implement steps have been proposed. Teaching reform practice showed that CRUISE software provided a simulation platform to students with analysis and design. A knowledgeable course has been turned into a researching course based on this platform, which is an effective method for increasing students’ engineering ability.

Introduction

“Course Design for Car Design” is a compulsory course in vehicle engineering department of Guangxi University which is an important content of “centralizing practical teaching”. The course usually start at the sixth or seventh semester and last for three weeks. Before the reform, the design content of this course is arranged at the sequence as followsings: clutch, transmission, universal transmission shaft, drive axle, brake, and suspension. Tutors assign each student one design assignment based on syllabus, but the design parameters is too idealistic to concern about the overall performance of car, which has negative effects for student’s scientific attitude. This monotony design is not attractive to curious students. At the same time it also results in some students relying on others and copying others to hand out the paper. Obviously, the traditional teaching method is not helpful for the students and can not reach to the goal of professional development and practical teaching reform under the new situation.

Virtual simulation experiment technology play an important role in the field of education and is an important part of education informatization [5]. With the development of computer and network technology, virtual simulation has been widely applied in the experimental teaching [6]. But there is not much practice teaching reform with this virtual simulation technology to assistant students to finish course design. To achieve this goal and break the single design task tradition, establishing design work to meet the performance as the guiding principle for design goal is important [7-8]. After years of practice teaching, the task group gradually formed a suitable mode for virtual simulation experimental teaching, which promoted the reform of practice teaching and formed professional characteristics [9-11].

Function of CRUISE Software

CRUISE is a powerful software focus on system dynamics and virtual simulation of vehicle which could make simulation analysis for vehicle power transmission system. Through its general model elements it can quickly build all kinds of complicated model of power transmission systems. According to the preset performance, fuel economy or emission indicators, it will undertake rapid optimization of model’s parameters. Also conducting power transmission system matching
optimization (DOE parametric studies and powertrain matching study) by using CRUISE built-in
Matrix Calculation and Component Variation function.

There is seven basic computing tasks build in CRUISE which covers the vehicle performance
(performance, fuel economy and emission index) as followings. (1) Circulation Mode (Cycle Run):
calculation circulation conditions of fuel consumption and emissions; (2) Climbing Performance
Analysis (Climbing Performance): calculate maximum gradability; (3) Steady State Riding
Performance Analysis (Constant Drive): calculate the consumption and emission values value when
the car is driving stability; Calculation of the theory highest speed and actual speed. (4) Full Load
Acceleration Calculation (the Full Load Acceleration): calculate the maximum acceleration, starting
performance and accelerating performance; (5) Maximum Traction Calculation (Maximum Traction
Force): drawing the balance of driving force-running resistance chart; (6) Calculating the Cruise
Condition (Cruising): calculate the value in cruising speed for the fuel consumption and emissions;
(7) Brake/Slide/Reverse Drag Performance Analysis (Brake/Group/Thrust): calculate the vehicle
braking performance [12].

Steps of Building CRUISE Simulation Platform

CRUISE simulation platform building process is divided into the following steps [13].

Step 1: Establishing the vehicle model. According to the need of models to select components from
the component library after that drag it into the modeling window to establish vehicle physical model;
Step 2: Input parameters of assembly unit. Input the basic parameters of each element, including
performance parameters and structure parameters;
Step 3: Establishing a mechanical and signal connection. According to the power transmission and
signal transmission system to establish mechanical connection and signal connections;
Step 4: Setting computing tasks. Choose require task from seven computing tasks and settings
related parameters;
Step 5: According to the requirements to check the results. After simulation calculation the results
can be viewed in the form of text and graphics.
Step 6: Optimization design. Though adjusting parameters and recalculation to make the
performance achieve the optimal value.

New Organized Teaching Mode for Course Design

Based on the function of CRUISE virtual simulation, there are two problems needed to be solved. At
macro level, it involves the organization of teaching mode. At micro level, it involves the specific
implementation steps. This section is to discuss teaching organization methods and next section to
introduce the details of implementation steps.

Process diagram of course design teaching mode organization is shown in figure 1. Each team is a
whole vehicle development team, team leader is responsible for the overall design and members are
responsible for each assembly car transmission system design. Each team must follow their design
goal to choose the design parameters and using CRUISE to build their own transmission system
simulation platform. The task generally includes CRUISE built-in seven basic computing tasks,
which specific indicators can be seen on the previous section.

Students build their own CRUISE simulation platform, which makes the new changes in the
teaching organization mode: teaching center usually occupied by teachers has been replaced by
students. Teaching task has been changed into “no specification” design from a single target. From
start to the end during the course design, the students participated spontaneously rather than
command. Only through their cooperation and exploration, the task can be finished.

Students participate the design in the form of group, in some extent all students’ design is both
independent and interrelated. Only though the cooperation the students can reach the design
requirements. Students should not only understand the importance of teamwork but also learn
practical knowledge and the way to operate with each other during the design. It is really an effective way to practice students’ better understanding and calculation ability.

![Diagram](image)

Figure 1. Teaching Mode Organization of Course Design.

**The Application of CRUISE Simulation Platform**

As an example, Adopt, the whole vehicle transmission system model is built, matched and optimized using one group’s design data.

**Establishing Vehicle Transmission System Model**

Firstly, determine the vehicle market position after the preliminary market research and access to relevant model data. Secondly, take a benchmarking model for reference to determine the basic parameters of vehicle and each assembly. Finally, though a group discussion, team leader establish vehicle transmission system model according to the basic modules of team members. Parameters of the design vehicle are shown in table 1.

These model includes: vehicle module (Vehicles), engine module (Engines), clutch module (Clutches), transmission module (Gear Box), the main reducer module (Single ratio transmission), Differential module (Differential), the Wheel module (Wheel), Cockpit module (Cockpit), drive torque Control module (Anti-Slip Control), Monitor module (Monitor).

Mechanical and signal connections are connected after establishing basic modules. Figure 2 is the structure model of vehicle transmission system simulation platform.

<table>
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<th>Project name</th>
<th>Technical parameters</th>
<th>Project name</th>
<th>Technical parameters</th>
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<tr>
<td>Length X width X height(mm)</td>
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<td>Curb weight(kg)</td>
<td>1210</td>
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<tr>
<td>Wheel base(mm)</td>
<td>2680</td>
<td>Half load weight(kg)</td>
<td>1435</td>
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<tr>
<td>Tread(mm)</td>
<td>1527/1533</td>
<td>Full load weight(kg)</td>
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<td>Rolling radius(m)</td>
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<td>Windward area(m²)</td>
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<tr>
<td>Final driver ratio</td>
<td>3.8</td>
<td>Drag coefficient</td>
<td>0.32</td>
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</tbody>
</table>
Vehicle Performance Analysis

Results of Vehicle Dynamic Analysis

Under full load condition the car could reach top speed of 198.69 km/h when corresponding rotational speed is 5080.19 r/min. Each gear’s maximum acceleration is shown in figure 3. Figure 4 shows the start acceleration time curve. The red curve represents the displacement of the car, speed is shown in blue and instantaneous change of the acceleration shown in green curve. As speed increased to 180 km/h, it took about 42 s, displacement is 1560.62 miles.

Second top gear (40-100 - km/h) overtaking acceleration time and maximum block (50-120 km/h) overtaking acceleration time respectively as shown in figure 5 and figure 6.
Fuel Economy Simulation Analysis

Under the condition of Chinese GB18352.5-2013, the car fuel consumption is computed. When car runs for 11078.19 miles, the fuel consumption is 5.34 L / 100 km.

Simulation curve of constant hundred kilometers fuel consumption is shown in figure 7. It can be seen the changes of the engine speed and fuel consumption at a certain speed. Fuel consumption is higher when the transmission is in 4th, 5th, 6th gear. While speed reach 40 km/h, the fuel consumption value of first gear is 8.48 L / 100 km, fuel consumption value of second gear is 4.29 L / 100 km, fuel consumption value of third gear is 3.55 L / 100 km, fuel consumption value of forth gear is 3.12 L / 100 km, fuel consumption value of fifth gear is 2.92 L / 100 km. When at speed of 180 km/h, fuel consumption of forth gear is 12.96 L / 100 km, fifth gear is 12.56 L / 100 km and sixth gear is 12.42 L / 100 km. These results indicate that higher the gear, lower the fuel consumed, but with the increase of speed, fuel consumption is increased. By the way, the engine speed is decreased as the gears goes higher at the same speed.

The whole working conditions contain the idle speed, acceleration, constant speed and decelerate in GB18352.5-2013. Simulation of various stages of fuel consumption rate curve as shown in figure 8. Fuel consumption of acceleration condition is highest followed by constant speed condition when decelerating working condition consume least. At the time of 1180s, fuel consumption is highest. The fuel consumption of different working condition is shown as followings: 0.214kg in accelerate condition, 0.198kg in constant speed condition, 0.023kg in idle speed condition, 0.017kg in deceleration condition. The overall fuel consumption is 0.50kg.

Transmission System Matching Optimization

Selected Matching and Optimization Parameters

The parameters for optimization is wind resistance coefficient and the main reduction ratio. The wind resistance coefficient is 0.26, 0.28, 0.30, 0.32 and 0.34. The numerical range of main reduction ratio is 3, 3.2, 3.4, 3.6 and 3.8. Taking wind resistance coefficient and main reduction ratio as consideration, there is total 25 possible calculation modules.

Performance Comparison of Before and After Optimization

The fuel consumption of bottom row is lowest as showed in Figure 9. There is only small influence of wind resistance coefficient when main reduction ratio is 3. In the case of constant wind resistance coefficient unchanged, the fuel consumption is less as reduction ratio goes smaller. As the main reduction ratio drops from 51.49% to 38.34%, the fuel consumption decreased gradually.

It can be seen in figure 10, the fuel consumption of right side is lowest which indicated the larger wind resistance coefficient the better fuel economy. It can be seen that the top speed and the fuel consumption is declined although the wind resistance coefficient is increased.
Comparison of fuel economy before and after optimization

Generally, the lower fuel consumption is better on the premise of power performance is ensured [14 -15]. Figure 11 shows that the bottom consumes the lowest fuel. So choose the module at LOWER LEFT, which wind resistance coefficient is 0.26 and main reduction ratio is 3. Through optimizing Fuel consumption is decreased from 5.34 L / 100 km to 4.83 L / 100 km through optimization.

Figure 9. Climbable gradient. Figure 10. Top speed. Figure 11. Isokinetic 100 kilometers fuel consumption.

Summary

Students’ engineering ability is cultivated by using virtual simulation technology CRUISE software in the course design. Students could do better than traditional teaching mode by establishing the simulation platform which combine the analysis and design ability.

Teaching practice showed that the “car design curriculum design” course based on CRUISE software has obtained good results. During three weeks of courses design, students are active to make course design with high enthusiasm. Establishment of the platform effectively assisted the course design and students’ design ability and engineering quality were being trained. Difficulty of virtual simulation technology CRUISE software is moderate, which can completely meet the requirements of car course design for undergraduate students teaching.

Acknowledgement

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References


