Ten Years Educational Activities Using Electric Vehicles at Kochi University of Technology: 2nd Report of Laboratory Activities in 2000-2006

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Abstract

1st report describes the educational activities using small-sized three-wheels and compact four-wheels vehicles. The latter was converted from gasoline engine to electric. The extracurricular activities using such vehicles were the Eco-power race conducted in Kochi prefecture in 1997 and the Electric Vehicle Rallies in Shikoku Island in 1997-2000. After such extracurricular activities, our laboratory has conducted the design education considering experiences in the real world. One of the most promising experiences as mechanical engineers is a creation of thought to design and produce products such as vehicles. Vehicles produced were small-sized hand-made four-wheels electric vehicles, electric motorcycle, tricycles, and motor-powered tillers. Since design is of great importance to produce products such as vehicles, 3D-CAD learning is firstly recommended in our laboratory before starting the design and manufacturing of products. In this report, the latter half regarding the laboratory activities is described.

Keywords

electric vehicle, electric motorcycle, electric tricycle, electric-powered tiller

1. INTRODUCTION

The Kochi University of Technology was opened in 1997. Since then, new engineering educational curricula such as first year seminars using real products [Sakamoto et al., 1997] experimental courses using vehicles [Sakamoto, 2001], computer assisted English education [Greene, 2001, Hunter, 2001] had been tried to prepare. Among them, the author thinks that the design education is of great importance, as Fargason [Fargason, translated by Fujiwara and Sunada, 1995] mentioned that design is engineering synthesis. As design practices, electric vehicles can be good targets to start. In the 2nd report, laboratory activities such as senior and graduate students graduation projects are described.

Prior to student graduation projects of designing and manufacturing products such as electric vehicles, the author thinks that they need to have knowledge and experience of 3D-CAD. The author has been in charge of a 3D-CAD lesson using ProEngineer for 3rd year grade mechanical engineering students since 2003. The material used for the lesson is the text [Design of manual winch, Power Co. 1991]. After the former half of 3rd year grade, students are assigned to each laboratory. In our laboratory, 3D-CAD lessons are to be continued even in the latter half of 3rd year. Based on such learning, the laboratory requests for each student to consider and perform their graduation project. As well as senior students, graduate students are also requested to consider and perform their advanced projects. The projects that had been conducted include small-sized four-wheels electric, three-wheels motor-assisted, electric motorcycle vehicles, and electric-powered tillers. Such theme was decided by each student or a group, and they perform a project by their own idea. They firstly plan a rough idea, make their idea definite one by 3D-CAD, perform the stress analysis by software such as ProMechanica, prepare the parts, assemble, and finally conduct an experiment on the project.

The second report describes those projects and how students conducted.

2. 3D-CAD EDUCATION

The author has been in charge of teaching 3D-CAD using ProEngineer since 2003, although he has not had any experience in drawing and knowledge of mechanical engineering parts in the graduated university. Receiving the support by teaching assistants, the author has been performing his role of the lecture. The purpose of the 3D-CAD practice is for them to obtain the potentiality of design and production for their own idea. The lesson is a course to draw each part and assemble of a manual winch, consisting of 90 min. x 15 times lesson, and totally students need to spend 22.5 hours at lease in class. They also need two or three times of the lesson in out-of class to fulfill the practice to obtain the 3D-CAD assemble of a manual winch. The manual winch has 37 part drawings. Among the attended student, those who reached to the final goat were 70-80 %.

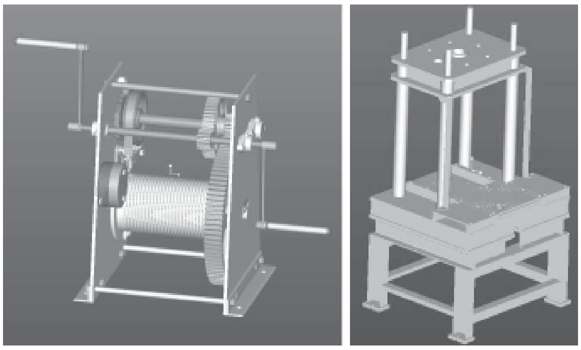

Fig. 1 Manual winch and bearing setting machine

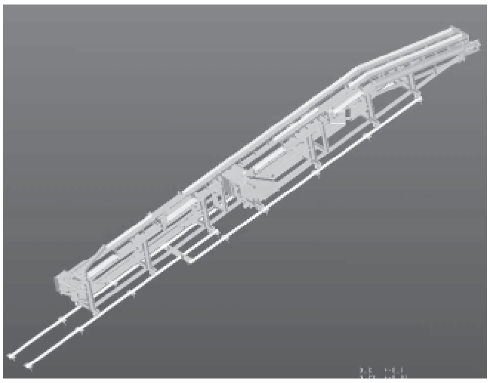

Fig. 2 Conveyer for selecting pipe elbows

The author thinks that they need to have more practices of 3D-CAD in order for them to know the real engineering society, and, therefore, more realistic product examples are requested for 3D-CAD exercise. Asking a private company to let us borrow, some drawing examples were given to students in our laboratory. Figure 1 shows the 3D-CAD of a manual winch (left) and a bearing setting tool (right). Part drawings are 37 for the manual winch and 40 for the bearing setting tool. Figure 2 also shows a conveyer for selecting pipe elbows, whose drawings are more than 100, and 6 students shared the drawings and took about 25 hours per each student. The bearing setting tool and the conveyer are the real products which were designed and fabricated. The bearing setting tool and the conveyer are the ones whose drawings the private company kindly let us borrow.
As is shown, it is thought that 3D-CAD practices are enough for students in our laboratory to perform their graduation projects. The students challenged their work by considering themselves. The projects are divided into mainly two categories. One is the project on material strength and renewable energy such as wind power or water power energies. The other is the project concerning to electric vehicles. The latter is reported in this paper.

3. LABORATORY ACTIVIES (ECOROGY AND MATERIAL STRENGTH RESEARCH LAB.)

The research and project field in our laboratory consists of two categories. They are ecological and material strength research activities. The author used to work with a steel and iron manufacturer and had been engaged in development of railroad vehicle products such as axle, wheel, and bogie truck frame [Sakamoto, 2007a; Sakamoto, 2007b; Sakamoto et al., 2005c; Sakamoto et al., 2003d]. After joining with the university, themes on ecological or renewable energy and design education [Sakamoto et al., 2007e, Sakamoto et al., 2003f, Sakamoto et al., 2003g] have been focused. The main themes on ecological or renewable energy are wind power generators [Sakamoto, 2007h] and electric vehicles [Sakamoto et al., 2006i, 2005j, 2005k, Sakamoto, 2004l, 2007m, Sakamoto et al., 2005n]. In the following, electric vehicles are reported.

3.1 Small-sized four-wheels electric vehicle [Sakamoto H., 2006i, 2005j]

In the first report, the Shikoku electric vehicle rally is described. Among the teams which joined the rally, one group team was highly interested in design and manufacturing of a real electric vehicle not like converted one from the commercially available light weight vehicles. After the team finished the rally, two students became 4th year and then graduate students who were conducting the design and manufacture of the manually-made electric vehicle. After their graduation, other students followed their work. Herein, laboratory activities of small-sized hand-made four-wheels electric vehicle are described.
Figure 3 shows the frame design. Since ordinary electric vehicles are hard to drive in a long distance, they thought that they might need to carry the vehicle by some methods such as a truck. They designed the vehicle in a manner that they can mount it on a light-weight truck.

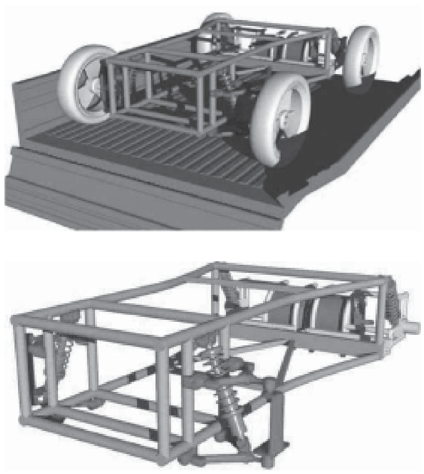

Fig. 3 Frame design for small-sized hand-made four-wheels electric vehicle

Fig. 4 1st product of small-sized hand-made four-wheels electric vehicle

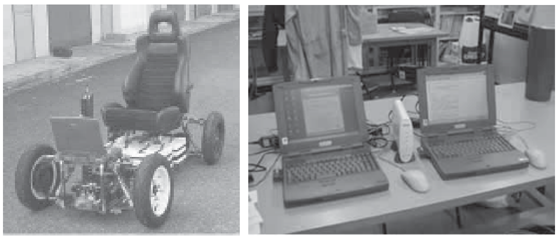

Fig. 5 2nd product of small-sized hand-made four-wheels electric vehicle

Figure 3 left shows the vehicle mounted on a truck, and left is the vehicle frame. Students tried to produce the vehicles several times. Figure 4 is the first product, and Figure 5 shows the second. The first one used a conventional handle and the second used a joystick. The frame is also different. Since the first was hard to get on because the little high double-decked frame, the second

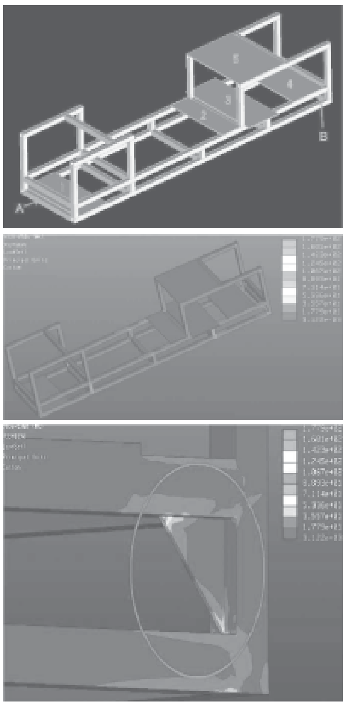

Fig. 6 Low height double-decked frame and stress analysis for the third product

Fig. 7 Completed third electric vehicle

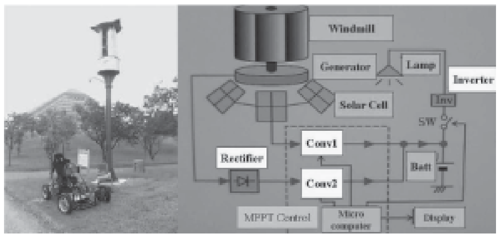

Fig. 8 Small-size electric vehicle and self-powered street light for charging the battery

was changed to one-decked frame. However, since the one-decked frame was not so strong enough, they needed to re-consider the frame design. They designed and changed their double-decked frame to smaller height than the first product. Figure 6 left shows the frame. They conducted the stress analysis using Pro-Mechanica which is a part of 3D-CAD software, ProEngineer. The analytical result shows there is the part of a bit high stress origination in Figure 6 bottom. However, the safety factors for tensile, yielding, and fatigue strength are well below than 1.5, which is the design criterion.

Figure 7 shows the assembled vehicle. It was able to run at the speed of more than 30 km/h and with the distance of 30 km within one-time charged battery. The first and second vehicles were not able to run at such a velocity and with such a distance. However, since the charging is needed, they made a device for charging, using a self-charged street light by a solar panel and a wind power generator. The system is shown in Figure 8.

The aim of the small-size electric vehicle was originally for students to design and manufacture the real product as an engineering exercise for mechanical engineers. However, it gradually changed to the vehicle gentle to elderly drivers. The final goal of the vehicle is ecological (electric), gentle to elderly drivers, and of longer distance and higher speed running.

3.2 Electric-motor cycle and tricycle vehicles [Sakamoto, 2004]

In 2003, one undergraduate student challenged to de-

sign and manufacture an electric-motor cycle. He considered the design by 3D-CAD and manufactured. The welding was conducted by himself. The author requests the students in our laboratory to consider by themselves and conduct the fabrication by themselves. It does not matter whether they conduct by one student or a group. In this case, only one student tried, and he had not reported to the author how he was doing. Right before his graduation, he reported to the author that he fulfilled and let the author took a look. The author was astonished because of the product which he made by himself and of good workmanship. Although it was able only at the speed around 30 km/h because of the motor capacity, it did succeed. Figure 9 shows the CAD and cycle.
In 2004, a student group of three undergraduate wanted to design and manufacture an electric tricycle. The idea is to fabricate the vehicle which can run on the pavement. As the Japanese law, bicycle or tricycle can run when the sign for permission shows. Automobiles and bikes are not allowed to run on the pavement except the motored low-height seat vehicles for elderly people which can run at the speed below 5-6 km/h. By studying the law, the student team found that at the speed below 25 km/h two-wheels or three-wheels cycle can run on the pavement by motor-assisted vehicles when the sign for them to run on the pavement.
The first tricycle is the front two-wheels tricycle, for which the students made an idea, 3D-CAD and manufacturing as is shown in Figure 10. In 2005, a student thought that rear two-wheels tricycle might have been able to drive more smoothly. Figure 11 is the rear two-wheels tricycle. The two tricycles were designed and manufactured, and the function was estimated by some experimental studies. However, they still need some modification in order to complete and put into the market.

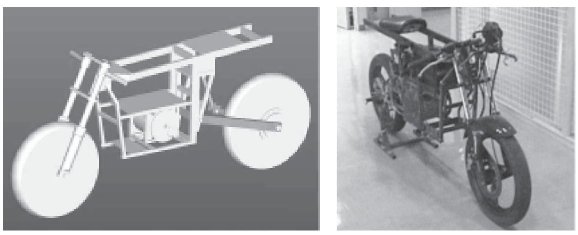

Fig. 9 3D-CAD and fabricated electric-motor cycle

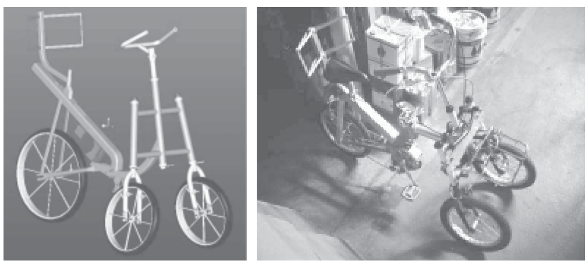

Fig. 10 Motor-assisted front two-wheels tricycle two

Fig. 11 Motor-assisted rear two-wheels tricycle

3.3 Electric tiller [Sakamoto, 2007, 2005]

In 2004, a graduate student started to design and manufacture an electric tiller which is manually operated. The reason he selected the theme is from the recent trend of growing global warming and population of elderly people. In Japan the work force in agricultural industries gradually decreases year by year, and elderly people more than 60 years old among the work force is now 65%. Besides, ecological and global warming consideration is a big concern for agricultural industries as well. The conventional tiller of 60 cc engine displacement with 1 kW power was considered to determine the specification of the electric tiller, which is used for house gardening and whose size is the same as the conventional one. The motor and batteries for electric vehicles produced in the past were used. The power is 400 W, and the weight is 25 kg, which is little lighter than 27 kg for

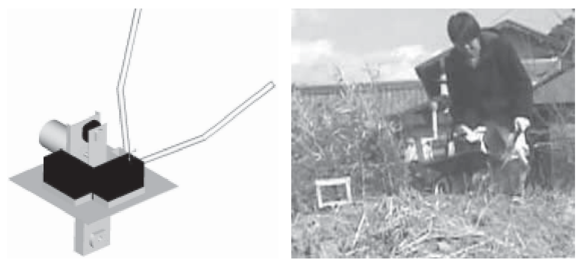

Fig. 12 Hand-made manual electric tiller

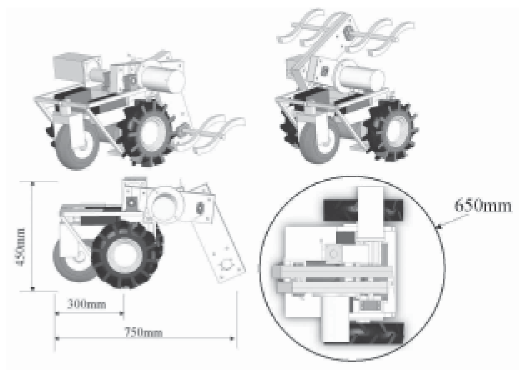

Fig. 13 Electric motor- tiller operated by wired-control device

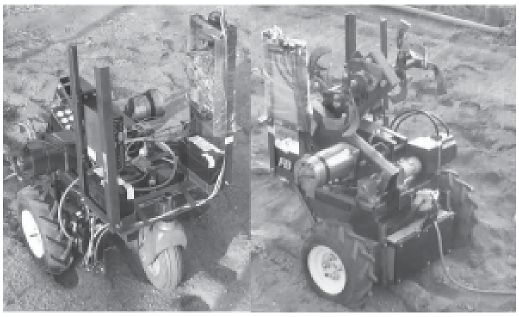

Fig. 14 Produced electric motor-tiller

the conventional. He designed by 3D-CAD, fabricated, and experimented. He found that the tiller can dig up to 50mm depth. Figure 12 shows the 3D-CAD assembly and the tiller operation by the student in his house garden. The technical issue is the control. He used a potentiometer, H8 microprocessor, a rotary encoder, and switches.

The other graduate student challenged the other electric tiller which can be operated by wired signal. Design items to be considered this time are as follows,

(1) Forwardly moving electric tiller by driving motor
(2) Tight turn at the same position and up and down mechanism of rotary parts
(3) The control is conducted by wired signal.
(4) Light-weight frame and designed by 3D-CAD

The specification was decided from the information of the existing engine displacement of 60 cc as is the same for the manual electric tiller. The power is 400 W and the weight is 80 kg. Using the tool to design Solid Works, he was able to consider the kinematics mechanics of the movement for the tiller. Figures 13 and 14 show the 3D-CAD and produced wire controlled electric tiller, respectively.

4. DISCUSSION

In this report, the laboratory activities using electric vehicles are described. The electric vehicles consist of hand-made small-sized four-wheels, bicycle, motor-assisted tricycles, and tillers. These activities were conducted by 4th grade undergraduate and graduated students.

4.1 Theme selection

The author thinks that there are two categories in the student activities in the laboratory. One is the research-oriented one including the author' research, which is in the field of material strength [Sakamoto, 2007; Sakamoto et al., 2005; Sakamoto et al., 2003] and wind power generator [Sakamoto, 2007] in the author' case. The other is the education-oriented one, which includes the internet design collaboration using 3D-CAD. [Sakamoto et al., 2007, 2003. 2003] and electric vehicles [Sakamoto, 2001, Sakamoto et al., 2006, 2005, 2005, Sakamoto, 2005, 2007, 2005].

In the case of electric vehicles, the author is just a consultant. The students select their theme, and fulfill 3D-CAD, manufacture, and estimate the function by experimental work. The student themes regarding electric vehicles were hand-made small-sized four-wheels, bicycle, motor-assisted tricycles, and tillers which were selected by student themselves by one student or two or three student group. Among the activities they had conducted, those of one student theme seem normally successful. Regarding the theme by multi-students group, they are sometimes not successful. This is because some will work hard and some do not. It is hard to distribute the work and get students cooperate together. A good example was the electric motor-cycle, which a undergraduate student conducted everything and he had a responsibility to fulfill. The author started to recommend to determine the project by only one student, although the author has no strong confidence at this moment.

4.2 3D-CAD and software

In our laboratory, five kinds of software for 3D-CAD have been used. They are Solid Edge, Solid Designer, ProEngineer, Solid Works, and I-CAD. The last one, I-CAD, is the domestic, and the others are foreign-made. Although they have different remarks, graduate students evaluate Solid Works, because it enable to study the moving mechanics. In a sense of education, a high range software is recommendable as the first stage of 3D-CAD learning. However, those of middle range software are thought to be appropriate for designing and producing not so complicate products such as electric vehicles for the university education.

5. CONCLUSION

As an engineering education, the design and production activities in the laboratory are reported. The following results are obtained.

(1) As a laboratory education, the author was engaged in graduation research for 4th grade undergraduate and graduate students. Their themes are selected by themselves, and they proceed their design using 3D-CAD software. They conduct the manufacturing and estimation of the product such as electric vehicles. The author plays a role of consultant.
(2) The project themes for electric vehicles are hand-made small-sized four-wheels, bicycle, motor-assisted tricycles, and tillers. Among them, the case which was successful seems to be the one conducted by one student. Those by a multi-members group seem to be difficult to succeed because of communication difficulty and the work to be shared.

(3) The author thinks that the learning environment is of great importance as well as theme selection. Besides the activities of electric vehicles, students in our laboratory use dynamic magnetic field or three-dimensional flow analysis, which is based on 3D-CAD, the base of design and production. The author hopes that they obtain the basis education prior to their social life afterwards.

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