Practical Integrated Learning for Machine Element Design

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Abstract----There are many possible methods to implement the practical-approach-based integrated learning, in which all participants, i.e. lecturer, mentors and students, engage. The selection of a method to use depends on the background and expertise of the lecturer. This academic article is concerned with the courses on Machine Element Design, in which the author has a solid and established background. The following are the minimum requirements for the successful implementation of the practical-approach-based integrated learning, based on the author's viewpoints and experience.

a) *Theoretical and practical knowledge of standard industrial parts*. The theoretical and practical knowledge enables the selection of proper parts and correct dimensions for design work.
b) *Compilation of technical books, teaching aid materials as well as technical academic publications.* Some of the works by the author include textbooks and/or video CDs on the subjects of Machine Element, Manufacturing Process, Engineering Drawing, Engineering Materials, Machine Design, CAD.
c) *Being a resource person in public training courses on the topic of Machine Element*. The courses have been conducted in a theoretical-plus-practical fashion at the Technological Promotion Association (Thai-Japan) and in a number of private organizations. Figs. 1-4 are samples of the presentations and parts used in previous training courses.

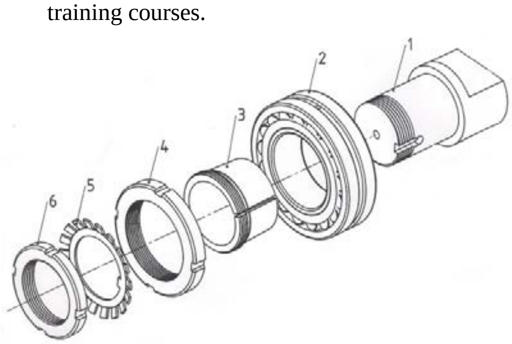

Fig. 1 The exploded view of the training kit on mounting and dismounting of roller bearing onto and from shaft using withdrawal sleeve (part no.3)

Keywords------Integrated learning, Integrated design, Shaft Design, Machine Design, Gear Design

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Fig. 2 An example of authentic standard parts refer to training kit in Fig. 1

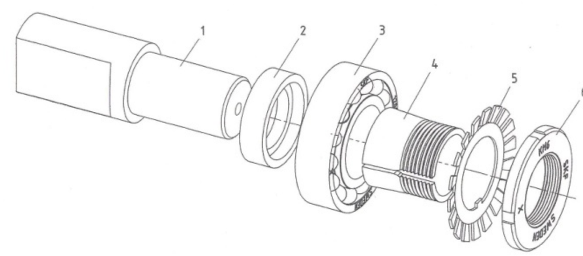

Fig. 3 The exploded view of the training kit on mounting and dismounting of ball bearing onto and from shaft using adapter sleeve (part no.4)

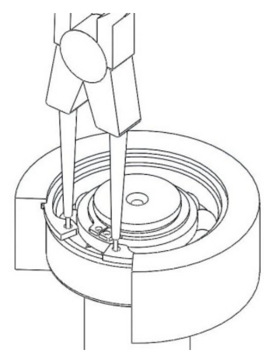

Fig. 4 The 3D drawing of the mounting of a retaining ring into the bore groove to keep the bearing in place.

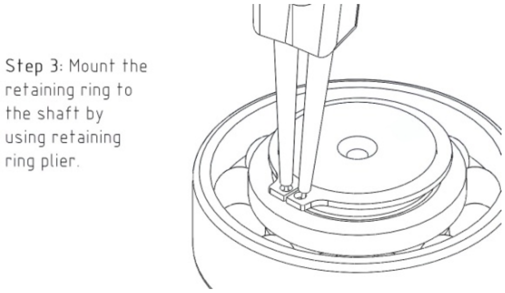

Fig. 5 The 3D drawing of the mounting of a retaining ring onto the shaft end

Fig. 6 Photograph of actual standard parts corresponding to Figs. 4-5.

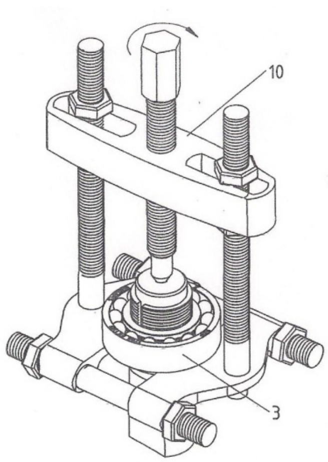

Fig. 7 The 3D drawing of the application of an extractor to pull the bearing out of the shaft end

Fig. 8 The application of a V-Pulley gauge to measure a V-Pulley groove

Fig. 9 The photograph of one of the recent practical training sessions or workshops

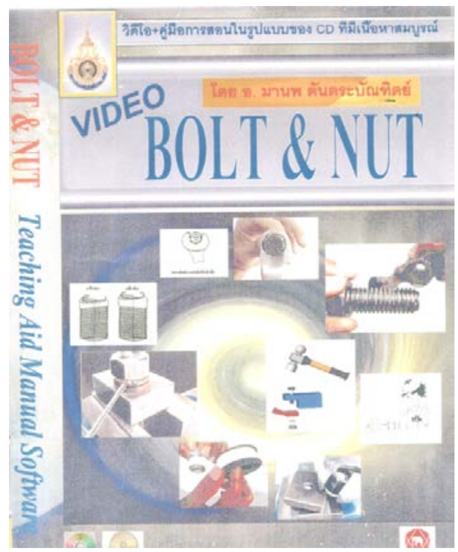

Fig. 10 Teaching aid manual in video CD on bolts and nuts for technical school courses and public training.

Fig. 11 A video CD on engineering drawing for self-learning

d) *Advisor on engineering projects.* The responsibility as a project advisor of fourth year undergraduates provides the opportunities to acquire new technical knowledge as the author is required to help solve the problems, offer suggestions and make comments. These efforts have resulted in the academic works as shown in Figs. 10 and 11.

e) *Collaboration with the suppliers of industrial machinery and parts*. The collaboration takes the form of the suppliers being invited by the author to conduct a workshop and/or seminar at the campus and the participants are technicians and engineers from factories. The author has also been given a chance to learn innovative products and tools.

I. Integrated Learning Components

1.1 Lecturer must possess years of teaching experience in both theoretical and practical parts.

1.2 Mentors: The mentors are required to have good knowledge and skills in CAD, Mechanical Design, animation software programs, and video production.

1.3 Students: The participating students have completed the prerequisite courses.

1.4 Parts: The parts are of standard parts in which the dimensions and surface roughness are measurable as well as in accordance with the industrial standards.

II. Preparation And Planning For Integrated Learning

The integrated learning requires that the theoretical instructions and the practical session be concurrently conducted. In the theoretical session, the participating students are to be given the instructions on empirical equations to enable the speedy completion of design process. In the practical session, the students are familiarized with the standard parts and measuring tools. Examples of the parts are roller bearings, V-Belt pulleys, gears, chain sprockets, springs, pins, bolts and nuts, keys, retaining rings, washers; and those of the tools are V-Belt groove-gauges and vernier calipers. The students are trained to properly measure the parts with the measuring tools and the measurement results are verified against the industrial standards. The participating learners are then given an assignment to design assembly parts using the CAD program and the knowledge of engineering drawing. The requirement of the assignment is that at least one assembly part must be of standard industrial part.

III. Involvement Of Lecturer, Mentors And Students As Well As Suitability Of Facilities

To stimulate the students' interest in the practical-based integrated learning approach, the CAD-CAE program is adopted, besides familiarizing the learners with the program. In addition, the actual works of former students and the previous project works are presented to the participating students. To participate as the mentors, an advanced understanding of the CAD-CAE program is necessary since the mentors are required to offer suggestions and find solutions to the problems of the learners with regard to the CAD-CAE program. Concerning the project procedure, the learners discusses with the lecturer who also supervises the production of video presentation. Furthermore, the training room must be equipped with the required computers, software and hardware.

IV. Theoretical Section And Practical Demonstration Of Authentic Parts

In general, a machine consists of many industrial standard parts, e.g. rollers, ball bearings, V-belt pulleys, couplings, gears, chain sprockets, springs, pins, bolts and nuts, keys, retaining rings and washers. Rollers and ball bearings support the transmission shaft, shaft end and axle, whereas V-belt pulleys, chain sprockets, gears, couplings are the transmission elements at various positions. Bolts, nuts, pins, retaining rings and washers are used to either fix or join parts. In this regard, the standard industrial parts are very essential in the theoretical session as the actual parts are demonstrated to the participating students.

V. Assignment: Different Project Works For Different Work Team

One Machine Element Design course lasts one full semester, i.e. four months. To allow for completion of the project works within the four-month timeframe, the students must be imparted only relevant theories and skills. In addition, the lecturer and the mentors have to work in a cooperative manner with respect to the practical problem solving. The procedures of integrated learning must be concise and clearly defined to enable the participating students the ease of understanding of the course content. The amount and complexity of assignments depend on the number of team members and parts to design. A one-student group is assigned to design one part, a two-student team is to design 2-3 parts, and a three-or-more-student group is to design three to five parts. Some teams are assigned to improve on the works of the former students by following the same procedures but different requirements.

VI. Additional In CAE (Computer Aided Engineering) On Finite Element Analysis (FEA), Animation Program And Conversion To Video

Although the participating students have completed the FEA course, they were taught mostly the principles and theories of the subject. The practical session in which the theories are applied receives little emphasis and thus the students had limited chances to apply what they had acquired to verify the strength of standard industrial parts. As such, the students have encountered the problems of how to simulate the standard industrial parts and how to properly verify them. Both problems nevertheless can be solved with a 2-day training session on a weekend. It is necessary that, prior to the 2-day training session, the lecturer holds a brief training session (1 hour or less) for the participating mentors to familiarize them with the standard parts and impart the proper strength verification procedure [1].

VII. Interaction Among Lecturer, Mentors And The Student Groups

Due to the time constraint (i.e. 4 months), the constant interactions among the three players of the integrated learning, i.e. the lecturer, the mentors and the students, are of paramount importance. It is crucial that they are often accessible for suggestions, solutions to the problems, and comments. Prior to tasking any team with an assignment, the lecturer must take into consideration the students' performance as well as the amount and complexity of the work as these factors affects the final work quality.

In addition, a minimum of two or three mentors are required. The lecturer must possess the fundamental knowledge of manufacturing drawing, such as machining drawing, Machine Element Design, and industrial element standard design. Besides, the participating students must be encouraged to use the CAD-CAE program in design of their works.

VIII. Strengths And Weaknesses Of The Practical-Based Integrated Learning

Strengths:

The participating students are given a plenty of opportunities to apply the acquired knowledge to the design of actual standard industrial parts. In addition, they are provided with an opportunity to acquire a new skill relating to the CAD-CAE software program.

Weaknesses:

The nature of this integrated learning approach requires the participating students to be skillful in many subjects. Thus, the students need to be trained or re-trained with regard to engineering drawing, machine element, material selection, CAD-CAE, and video production so that they have a good understanding and then apply what are taught to the fulfill the course requirement. This entire process takes a long time to fulfill but all the participants have to complete it prior to the end of the four-month time limit.

IX. Cooperative Learning Among The Lecturer, The Mentors And The Students

Although the lecturer, the mentors and the students are working in a cooperative manner, most of the students are unfamiliar with the integrated learning process. To solve this problem, the lecturer and the mentors have to spend more time than in the traditional method of teaching on giving suggestions to the participating students. The outcome following the adoption of the integrated learning approach show that the students have benefited greatly from applying the relevant knowledge to working as a team; and from the mutual collaboration between themselves, the mentors and the lecturer. During the implementation of the integrated learning, it is normal for the students to encounter problems or difficulties. However, the problems or difficulties can be solved either alone by the lecturer, the mentors or the students; or collectively by the team. This practice increases the likelihood of success of the project as all the participants contribute. In addition, experiences have shown that the participating students gain more skills in the CAD-CAE program than those in the conventional learning method. Since the integrated learning project involves many procedures and thus possible mistakes, it is vital that open and constant communication among the lecturer, the mentors and the students be promoted [2].

X. Simulation Works And Actual Parts Of Students

After the design step with the CAD-CAE program is complete, the teams who have been assigned to design two or more standard parts are required to assemble or mate the parts on the computer using the CAD program. The assembly or mating process is recorded by a video program and future use as a teaching aid. Examples of the mating of the parts are the mounting and dismounting of V-pulley to and from the shaft, the mounting and dismounting of chain sprocket to and from the shaft, and the mounting and dismounting of roller bearing to and from the shaft. On the other hand, the single-member teams are only required to perform the calculation of the parts to design, create the manufacture drawing and to carry out FEA.

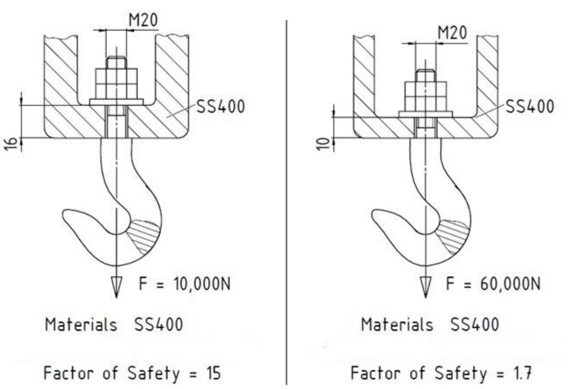

Fig. 12 Example of a project work in which the support thickness analyzed by FEA method is reduced from (a) 16 mm with FOS = 15 to (b) 10 mm with FOS = 1.7 (for static load)

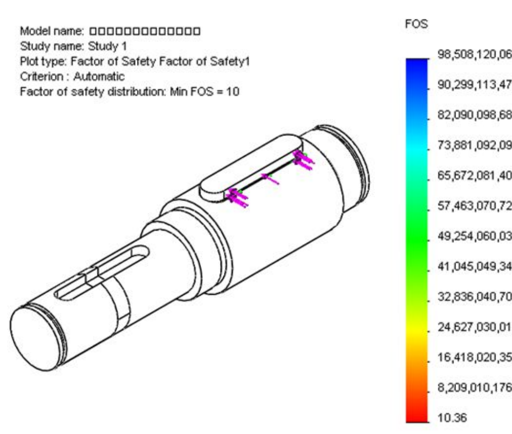

Fig.13 An example of first analysis by FEA applying force F on the upper surface of parallel key with the shaft fixed, giving an FOS of 10.36

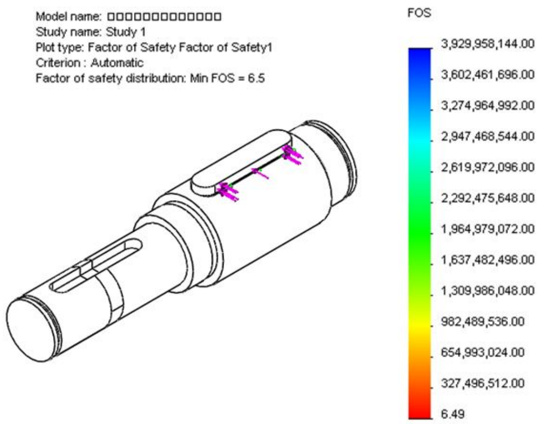

Fig. 14 An example of final analysis by FEA applying force F on the upper surface of the shortened parallel key and the shaft stationary, resulting in FOS = 6.5

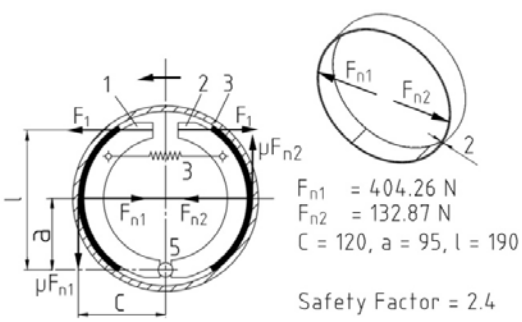

Fig. 15 An example of final analysis by FEA applying force F on the inner surface of brake drum, resulting in FOS = 2.4

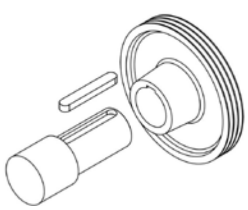

Fig.16 Three parts of an assembly: Shaft end (left), Parallel key (middle), V-Pulley (right)

INSTRUCTION MANUAL OF NUT LOCKING WITH SCREW

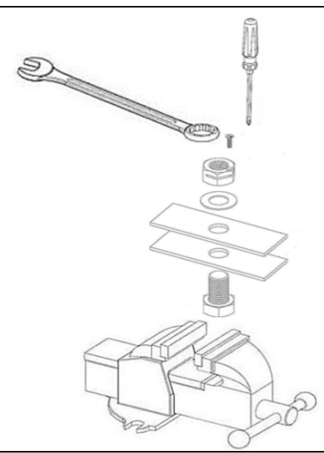

Fig. 17 The cover page of the instruction manual of nut locking with screw

XI. SUMMARY

As the practical-approach integrated learning entails many procedures, all the players (i.e. the lecturer, mentors and learners) are required to invest a great amount of time and effort for its implementation to bear fruit. The lecturer must regularly and personally supervise and monitor the progress of the students' works; and then give advice as well as make comments when mistakes are found, particularly during the animation process and video production. By the same token, the participating students must give full attention to their works and exchange knowledge with other participating students and with mentors. To guarantee a good outcome following the implementation of the technique, the lecturer must be aware beforehand of having to take more responsibility and the participating students must be highly self-disciplined and willing to work in a team setting.

REFERENCES

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[2] Manop Tantrabandit, *Integrated Learning In Machine Element Design: A Case Study Of Chain Sprocket Design* , International Conference Data Mining, Civil and Mechanical Engineering (ICDMCME'2014), Feb. 4-5, 2014.