Simulation Software Enhanced Student Understanding

Article

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Abstract:

This paper illustrates the usages of modern educational tools like multimedia and simulation software to understand the engineering aspect of mechanical engineering courses.

Keywords:

Engineering Education, Simulation Software, Learning Strategy.

1. Introduction

Engineering technology is skill based rather than theory based. In order to understand complex theory and illustrate its concept, the education must move from teaching to learning and from passivity to activity. Teaching engineering courses follow the traditional pattern: Math-theory-analysis-modeling-design, this is followed by laboratory exercise in order to highlights the particular theoretical concept. Bissell [1], suggests to move to *design of courses according of what we want students to be able to do rather that what we want them to do*. Furthermore, the courses must develop new concept and practices to improve the quality, efficiency and effectiveness of their teaching. This must be done in a comfortable class environment.

Current text books of mechanical engineering provide an excellent source of teaching the theory of different sciences. These theory-oriented books are designed to teach the student the problem solution techniques, which make them to fall in a passive learning pattern and increase the gap between the concept and theory. Most mechanical engineering topics depend on geometric and physical observation, and teaching methods must enhance this ability.

The use of modern teaching method to simplify the theory like multimedia, internet, simulation software and visualization will enhance the conceptual understanding. Incorporating simulation within engineering curriculum will motivate the student by positive contributions during the learning process, which develop innovation and design as stated by Morgan [2].

2. Educational Strategy

Bloom [3] suggests that in order to provide better understanding of conceptual theory, the engineering course must include the following objectives:

1- knowledge: By presenting basic principal and theory.
2- Comprehension: By problem solving.
3- Application: By presenting real world problems.
4- Synthesis: By presenting small deign problems.

In the lecture the theoretical concept of a real engineering problems are presented and simulation software is used to clarify the problem. The main objective is to teach the student how to approach the problem and to analyze the result. In order to understand the engineering aspect of the theoretical concept, the example must be a real world problem, with emphasis on design.

3. Subjects and Software

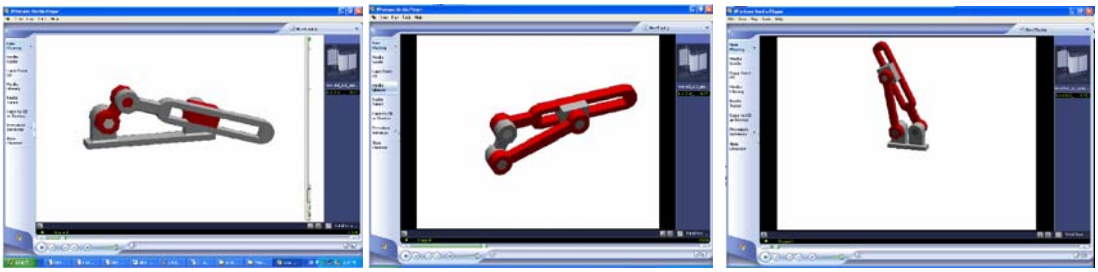
Teaching subjects like dynamics, theory of machines with emphasis on the theoretical concept only is trivial. In order to understand the function of a special mechanism, students are previously asked to build their own model in the workshop, or a laboratory setup is required to visualize and demonstrate

the mechanism motion. A more viable option is to use the computer simulation to replace the workshop and Lab.
Because of its extensive mathematical, simulation and graphical capabilities, Matlab was selected to do the numeric and graphical job. Also, Matlab has a wide number of toolboxes, like Simulink which provide a graphical modeling environment. The ability of Matlab to be interfaced with other dynamic simulation programs, makes it a powerful tool for mechanical engineering educational. In the other hand, Working Model (WM) and Visual Nastrand (VN) are becoming popular tools in education institutes. They are simulation packages that allow one to quickly build and analyze a dynamic mechanical system. These packages are easily interfaced with Matlab, which make it easier for the student to get the numeric data required for the simulation.

4. Illustrative examples

At Birzeit University a new teaching method has been adopted to teach courses like dynamic and theory of machines. Following Bloom`s strategy, The knowledge is achieved in the theoretical lecture with emphasis on practical examples. In order to enhance student comprehension Multimedia, Matlab, Excel sheet, Working Model and Visual Nastand are used for demonstration and visualization of the problem presented in the theoretical lecture.

Multimedia
As previously mentioned by many authors, Wankat [4], students learn better when acting and contributing, rather than watching or listening. For example, the kinematics of rigid body is difficult to visualize. The concepts of rigid body motion are usually taught in by developing the mathematical model and then employing them to solve practical problems. Multimedia has the ability to integrate motion within the class presentation, which is an efficient method to address difficult topics like kinematics of rigid bodies. In the course of theory of machines, in order to explain the inversions of the slider-crank mechanism, different configurations of the mechanism are pre-built by using Visual Nastrand software was introduced in the presentation of the theoretical class, as shown in Figure 1. Since it is difficult to explain the motion of the mechanism by traditional way (*chalk* and *talk*), multimedia will make the student to reflect as they realize the effect of simulation of the mechanism and the problem associated to it. This method substituted the previous method which required building a prototype for each mechanism in the workshop.



(a) (b) (c)

Figure 1. Inversion of Slider-crank mechanism

Mathematical and Simulation

Cam design is a subject taught in theory of machines and machine design courses. The theoretical concept of cam design which includes selection of displacement curves of the follower and the parametric equations of the cam profile is presented in the class. In many students mind, the subject is a collection of mathematical manipulation, in order to provide the student with the engineering ability and a better understanding of the theory, each student is asked to design his own cam. After selecting the suitable displacement curves as function of cam rotation angle as shown in the Figure 2. The student must find the cam intervals (β) to match velocities and accelerations at inflection points, the minimum cam radius to avoid cusps (R_o), the roller radius (R_r) and the maximum pressure angle of the cam profile ($\propto_{max}$). Then he must derive the equation of cam profile as follows:

$$R = R_o + f(\theta) \quad (1)$$

Where:

R= Radial follower displacement, $f(\theta)$=follower displacement function.

$$x = R\cos(\theta) + Rr\cos(\pi - \theta - \propto) \quad (2)$$

$$y = R\sin(\theta) - Rr\sin(\pi - \theta - \propto) \quad (3)$$

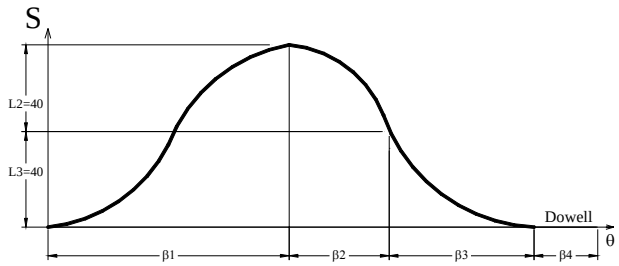
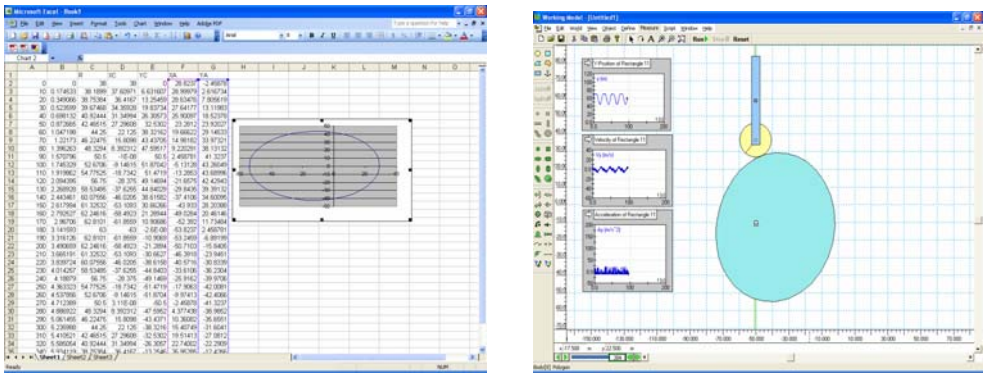


Figure 2. Displacement curve of a radial follower.

Since it is a tedious job to solve the equation of cam profile by hand calculation, the solution is performed by Matlab or spread sheet in order to get the numeric values of the cam coordinates at any cam rotation angle. This will force the student to spend more time in understanding the problem and less time to perform the calculations. Figure 3(a), shows an excel spread sheet used to calculate the coordinates of cam profile. Then, the data is exported to Working Model to model the cam geometry using the geometry window. The rest of linkages are easily modeled and the mechanism is animated to analyze its motions. The motions parameters can be easily changed to visualize the output motion like displacement, velocity and acceleration in a form of easily to read and understand graphs as shown in figure 3(b). The student can compare the output results obtained from the simulation and the theoretical values.



(a) (b)

Figure3. Data of cam profile from Excel sheet and WM simulation.

Since we did not want students to get constrained with mathematical manipulation, but learn the subject matter, the use of mathematical software was encouraged. Matlab is one of the most widely used software in engineering applications. This package has symbolic, numeric and graphical capabilities, but it requires more programming ability. Matlab is suitable software to analyze the motion of a mechanism at any time. Most traditional methods used for motion analysis can find the required values at a given instant, to analyze the system at any time is a tedious job. For example, in order to find the dynamic analysis of an offset slider-crank system at any instant as shown in the Figure 4, first the equation of motion is developed as function of crank angle using the loop closure equation as follows:

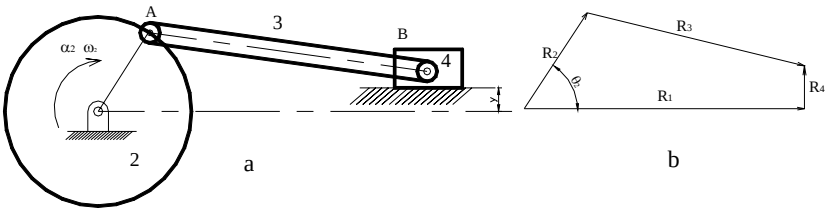


Figure 4 Slider Crank-mechanism and Loop closure equation.

$$R_y+R_B=R_2+R_3 \quad (4)$$

$$ye^{\pi/2}+r_B=r_2e^{i\theta 2}+ r_3e^{i\theta 3} \quad (5)$$

where r_B represents the slider displacement

A simple code is build by Matlab to model the displacement of the slider. The derivatives of the displacement equation to obtain velocity and acceleration are handled by Matlab. The program asks the user to specify the input parameters ω_2 and $\propto_2$ and the time interval, then Matlab displays the output in a simple to read graphs, see Figure 5.

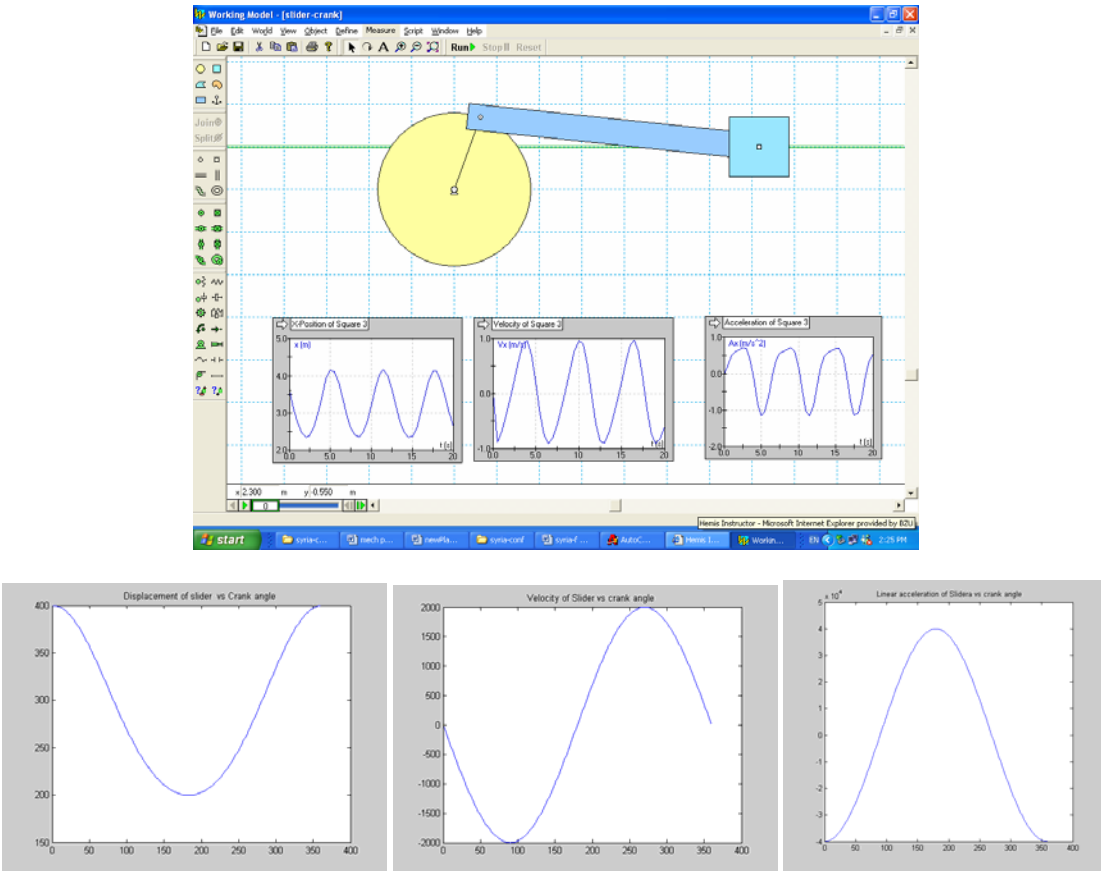


Figure 5. Slider crank analysis using Working Model and Matlab.

5. Conclusion

Using multimedia enables the student to visualize problems that are difficult to be explained in books or theoretical class, which provides them with better understanding of the theoretical concept. Design problems are selected for homeworks assignment in order to encourage the student to think like engineers. Hence, incorporating computer software into teaching and learning strategy was done to enhance paper based case studies.

Using of simulation software can change the way the engineer approach problems, also student find pleasure by making him active in the computer exercise. To get the best benefit of the selected package, it must be easy to learn and can be used for more than one course. Furthermore, it must be widely used in the market in order to provide the student with a vital skill at graduation.

Finally, we should be aware of the danger of using computers in problem analysis. As the simulation becomes complex, the student may have difficulty in understanding what computer is doing or detect what wrong in the simulation. There is also a risk of students developing a bad habit by trying to formulate while at the computer rather than formulating the problem and using computer as a tool to solve it.

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