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Digital Mock-Up Kinematic Analysis of Various Mechanisms to Obtain Trace

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Abstract*— Engineering students need to practice and carry out experiments in laboratories to complement their learning process. However, instructors and equipment are not always available. Additionally, there may be risk and trouble using some equipment that may hurt students or damage the equipment. Computer aided modeling and simulation of various mechanism based on models to combine virtual laboratories with intelligent tutoring systems had been developed, and applied it in some domains like CATIA. Trying something different, the models of Theory of Machines practical used for this software that creates a "virtual lab" environment for the students. This lab consists of experiments dealing with study of Mechanisms such as four bar chain or quadric cyclic chain, Single slider crank chain and Double slider crank chain. Also dealing with Inversion of the above mentioned chain. The labs can be run on any PC running CATIA V5 R20 software and tutorials could be made available through Internet or college website. With the ability to vary different parameters in the experiments, students can develop an intuitive sense of cause-and-effect. All students are required to conduct the lab exercises and submit lab reports. No longer do students have idle time waiting for lab benches to become available.

***Index Terms*—Engineering, Intuitive, Mechanisms, Simulation, Virtual Lab.**

I. INTRODUCTION

Traditionally, the only way to study such motion was to design and manufacture a physical prototype and run it in the lab. In this setting, the displacements, velocities, accelerations and forces had to be measured. This physical simulation is inflexible in terms of mechanisms parameters and more importantly, due to costs and space limitations, the variety of mechanisms available for the study is limited. In addition, the study of mechanisms in a physical lab is usually done in groups, which limits a student's personal experience due to time constraints. To overcome this problem it is desired to use the modern available tools and resources. Computer in terms of tool and design software as resources will give a solution to above mentioned problem.[1][2]

A. DMU DIGITAL MOCK-UP KINEMATIC ANALYSIS

DMU digital mock-up kinematic analysis is an independent CAD product dedicated to simulating assembly motions. It addresses the design review environment of digital mock-ups (DMU) and can handle a wide range of products from consumer goods to very large automotive or aerospace projects as well as plants, ships and heavy machinery.

B. THE VIRTUAL LAB

The virtual lab is designed to retain the general topical areas of the traditional lab assignments. The content areas are related to Theory of Machine consisting of twelve mechanisms. Individual mechanism is solved separately from modeling to assembly and assembly to simulation to obtain trace. An assignment consists of tutorials containing a brief description of each mechanism. A series of steps activities in which the students are required to solve and analyze a variety of results. The data (pictorial) is typically available on the screen. The main focus of paper is the concept of obtaining trace for any desired point of the mechanism with the help of simulation tool. In several design software concepts are being pursued in different procedures, and also from simple mechanisms to complex one. This paper describes few mechanisms of such concept. Virtual mechanical lab offers a tutorial based system to simulate and optimize the performance of mechanical student. It provides computer based techniques to interface the students with the physical world, with suitable front end design to provide increasing sophistication and increased flexibility.

II. PROBLEM STATEMENT

Instead of each school/college spending time and effort creating and maintaining dozen different labs, we build one (or a few) elaborate experiments and share it with a dozen different schools/colleges. A traditional laboratory would require the students to come in at specified time slots and either work in very large groups using one piece of equipment or in smaller groups with numerous pieces of identical equipment. The former solution does not allow for more individual access to the laboratory equipment and the latter does not efficiently use space or financial resources. However, a Virtual Lab can be accessible twenty-four hours a day, seven days a week. Thus, student usage can be spread over more time requiring less laboratory setups.

III. PROJECT DESIGN

A project design comprises modeling, assembly and simulation of various mechanisms to obtain trace at desired point on the mechanism. Trace is a shape created by the set of points whose position satisfies a given set of rules. Different mechanisms from subject of "Theory of Machine" are

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selected for this paper. Mechanism selected are classified as Four bar chain, Inversion of four bar chain, Single slider chain, Inversion of single slider chain and Inversion of double slider chain. The important characteristic of a project assigned to students is that it is formulated in terms of functional requirements for the mechanism without giving any other velocities, forces, etc. In this approach the project becomes open-ended and the students have to achieve the required functional performance step by step. The use of software allows accomplishing this in a short time [4].

IV. AIM AND OBJECTIVES

The new teaching techniques motivates students towards self learning, So the paper is a steps in form of tutorials which gives students a tool to performs on their own the modeling, assembly, simulation and trace of conventional mechanisms related to syllabus. Tutorials provide a self learning material and are independent in teaching learning process. The objective of the paper is to design a platform for easy creation of remotely operated mechanical structures experiments. It is created to allow better access to and improved quality of mechanical structures experiments. To accomplish this task several key goals were decided upon

• The user experience should be as close as possible to actually being at the laboratory.
• The user should have access at any time from any computer with a commonly available web browser.
• The laboratory should be flexible enough to allow for different levels of mechanisms to utilize it.
• No special dimensional adjustments should be needed for the normal operation of the system.
• New tutorials for laboratory realization should be easily deployed within the platform.

A. NEED FOR VIRTUAL MECHANICAL LAB

Limitation of finite resource in the provision of laboratory hardware and infrastructure.

- Many experiments are dangerous to perform in labs.
- Some experiments are expensive, so we can't repeat in lab many times.

Using GUI (Graphical user interface) makes a better way to understand it.(spatial communication or way of understanding)[2]

B.DMU KINEMATIC ANALYSIS

DMU is the process of building and using a computer-based digital 3D representation of a product – a mock up – to conduct tests that will predict product function and performance in the real world. An obvious advantage of DMU is the ability to reduce or even eliminate the need for physical prototypes – one of the most expensive aspects of product development. DMU Kinematics Simulator defines mechanisms for digital mock-ups of all sizes using a wide variety of joint types, or by generating them automatically from mechanical assembly constraints. DMU Kinematics Simulator also simulates mechanism motion easily with mouse-based manipulation in order to validate mechanisms. DMU Kinematics Simulator analyzes mechanism motion by checking interferences and computing minimal distances. It generates the trace and swept volume of a moving part to drive further design. It allows combined simulations through the integration with other DMU products. Addressing people involved in activities ranging from the design of mechanisms to the functional verification of mechanisms, DMU Kinematics Simulator is targeted for all types of industries. [5]

C.DMU KINEMATICS WORKBENCH

1. Assembly constraints conversion
2. DMU Kinematics Simulator
3. Simulating with Laws
4. Simulating with Commands
5. Simulating On Request
6. Sensors
7. Speed and Acceleration
8. Clash and distance
9. Joint limit
10. Reviewing Simulations
11. Recording Positions
12. Replaying Simulations
13. Product overview
14. Trace
15. Swept Volume
16. Save Management[6]

V. STEPS USED IN DIGITAL MOCK-UP KINEMATICS USING SIMULATION WITH LAW

1. Assembly
2. Enter DMU workbench
3. Auto Constraints conversion (n/n to 0/n)
4. Convert joint into Angle driven and Length driven
5. Simulation
6. Simulation with law
7. Formula ∫(x)
8. Speed and acceleration
9. Trace
10. Save all[6]

VI.DIFFERENT MECHANISMS OF WHICH TRACE IS TO BE DETERMINED ARE LISTED BELOW.

1) Four Bar Chain / Quadric cycle chain
2) Inversion of FOUR BAR chain MECHNAINSM
   a. Beam Engine / Crank and lever mechanism
   b. Coupling rod of a locomotive / Double crank mechanism
   c. Watt`s Indicator Mechanism / Double lever mechanism
3) Single slider crank chain
4) Inversion of Single Slider CHAIN
   a. Pendulum Pump / Bull engine
   b. Oscillating Cylinder Engine

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c. Crank and Slotted Lever Quick Return Mechanism
d. Whitworth Quick Return Mechanism

5) Inversion of Double Slider
a. Elliptical Trammels
b. Scotch Yoke Mechanism
c. Oldham`s Coupling[7]

I. TRACE OBTAINED FOR VARIOUS MECHANISMS

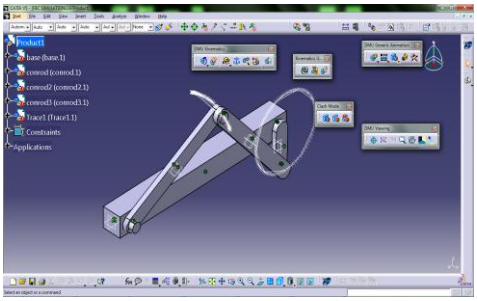

Fig 1 Trace of Four bar Chain.

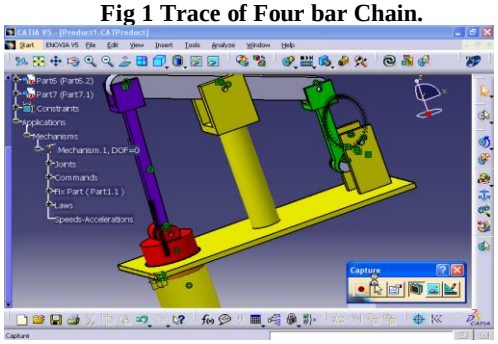

Fig 2 Trace Of Beam Engine.

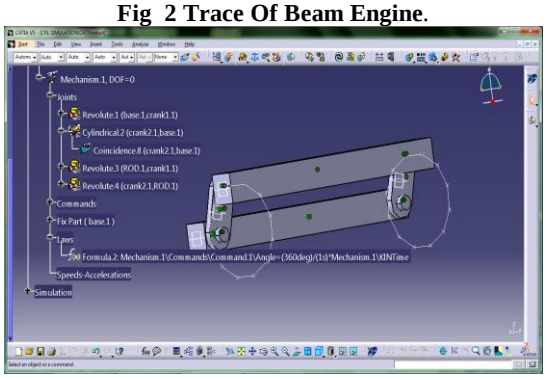

Fig 3 Trace Of Coupling Rod Of Locomotive.

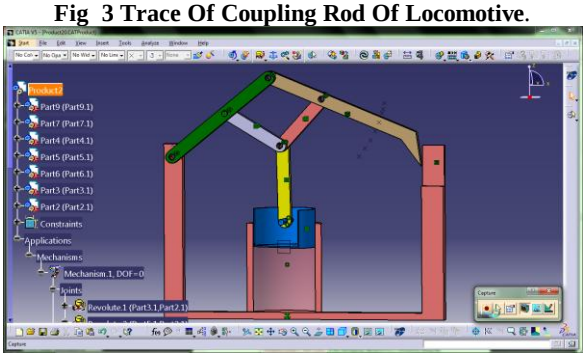

Fig 4 Trace of Watt`S Mechanism.

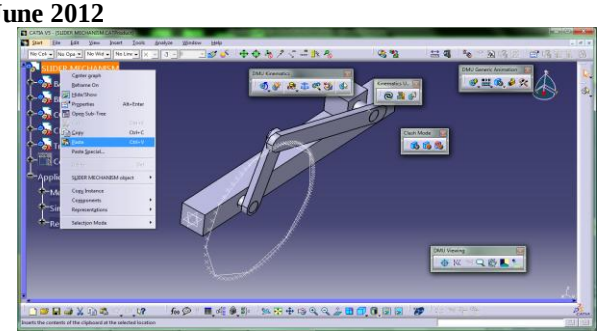

Fig 5 Trace of Slider Crank Mechanism

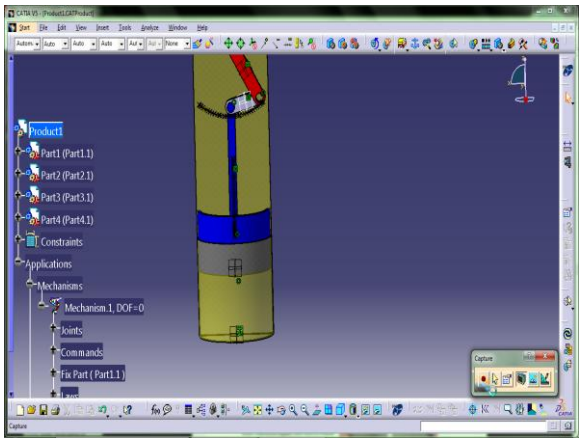

Fig 6 Trace of Pendulum Pump.

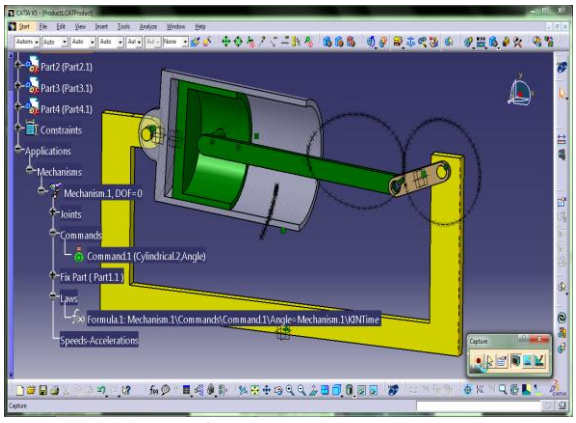

Fig 7 Trace of Oscillating Cylinder Engine.

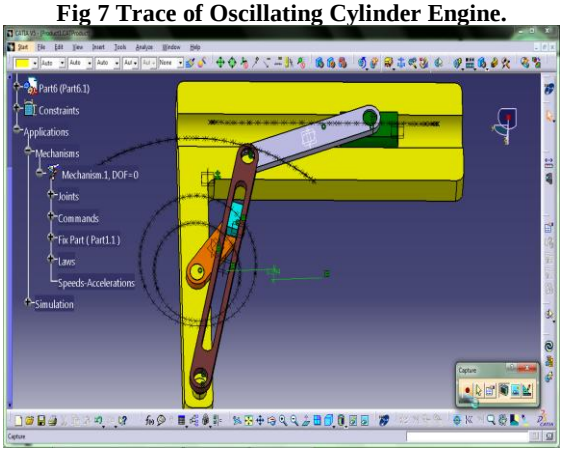

Fig 8 Trace of Crank and Slotted Lever Quick Return Mechanism

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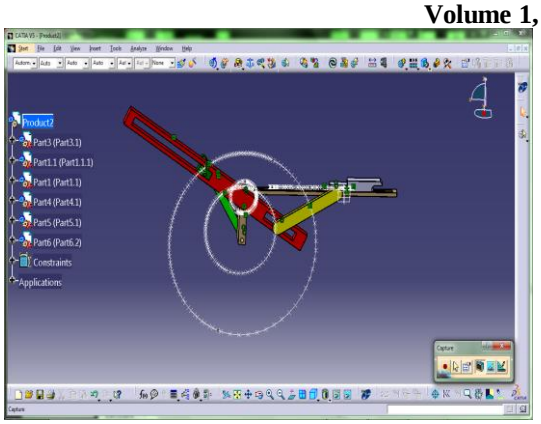

Fig 9 Trace of Whit Worth Quick Return Mechanism.

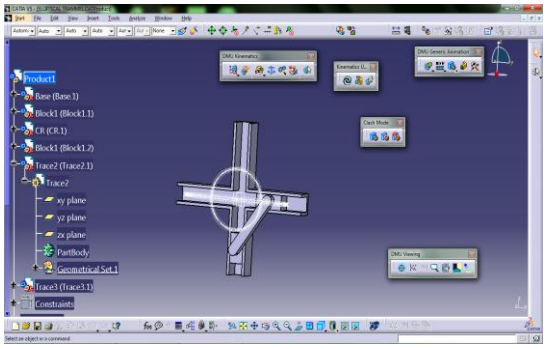

Fig 10 Trace of Elliptical Trammel.

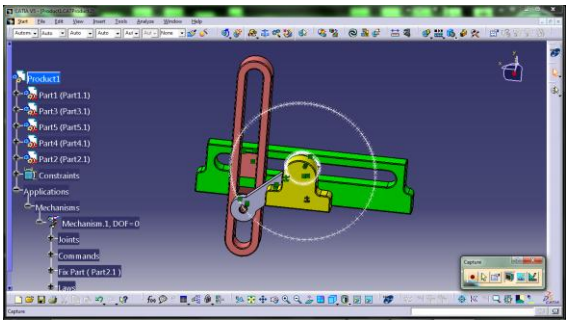

Fig 11 Trace of Scotch Yoke Mechanism.

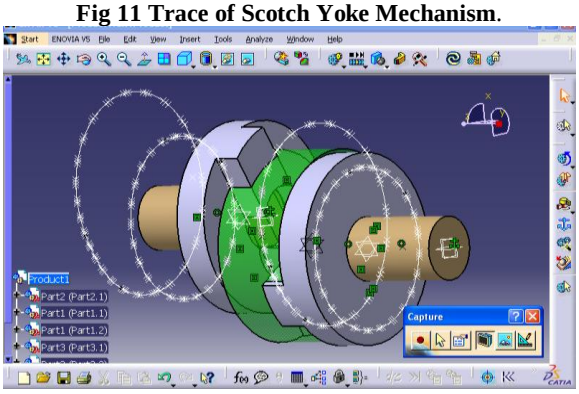

Fig 12 Trace of Oldham's coupling.

VII. RESULTS

In this paper twelve different mechanisms are modeled, assembled and simulation is done to obtain trace and is presented in form of tutorials to the students. The motivation of such tutorials is that the students would see the limits of the analytical models they had developed in class. By using a virtual laboratory, it was expected that the students would perform the experiments shortly after performing the analytical analysis. Perhaps they would have had both results on their computer screens at the same time and will be to make rapid evaluations of the results. If they had done everything as expected, the students would have found that the analytical results consistently over estimated the trace of the mechanism. While there are numerous possibilities for the discrepancies, the details are not important. What is really crucial is that the students might have begun to think about these possibilities. The laboratory assignment also make students to explore areas for new mechanisms that are difficult to analytically model, such as more complex mechanism. It also gave them experience of GUI [4]. However, the benefits of DMU extend far beyond reducing the number of physical prototypes. By providing a mechanism for sharing product information and allowing design reviews to be quickly and easily conducted among multiple team members and across multiple companies and geographies, DMU provides the critical time and data needed to explore design alternatives and increase product innovation.

VIII. CONCLUSION

For students earning a degree in mechanical engineering, these black-box commercial software packages are suitable for explaining some basic principles and concepts with traditional graphic methods. However, In order to fully comprehend the subject matter, students must utilize numerical and analytical methods to solve complicated mechanisms. DMU Kinematics Simulator provides users the ability to define a point in a moving part and generate it trace for the mechanisms. During mock-up design review, users do not only need to view simulated kinematics but also analyze the mechanism's consistency with the functional specifications. DMU Kinematics Simulator performs interference and clearance checking as well as computing the minimum distance. A 'stop on collision' option freezes the motion for detailed analysis. A virtual lab "provides advantages in terms of pedagogical approach, cost, and access." Additionally, in the current economic environment where technology changes rapidly, virtual lab software saves money by not having to invest in expensive equipment that may be outdated in only a few years. This study provided confidence that incorporating virtual lab activities into several classes in the engineering course would improve learning and assist in meeting good outcomes. A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. [3]

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IX. FUTURE SCOPE

This paper deal with the conventional simulation and analysis conventional mechanisms but for future studies non conventional and complex mechanisms from the real world can be used for analysis. Force analysis and Torque analysis may be done for the same mechanisms depending upon the input parameter by the user. Relationship between number of links and number of joints can be explored further. Paper has generated a trace and builds the trajectory with the development from the point in the mechanism in the design software but the exact values for the trace from point to point need to be tabulated. Similar to the trace, swept volume can be generated of moving parts for various mechanisms. The next generation of virtual lab will deal with Virtual Work.

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