USBTU
INTERNATIONAL JOURNAL OF SIVAS UNIVERSITY OF SCIENCE AND TECHNOLOGY
ULUSLARARASI SİVAS BİLİM VE TEKNOLOJİ ÜNİVERSİTESİ DERGİSİ
ISSN:
dergipark.org.tr
DOI:
Araştırma Makalesi / Research Article

Design Automation of Four Bar Mechanism Using Msc Adams

Ufuk DEMİRCİOĞLU[1*] (Orcid ID: 0000-0002-9707-8271)

[1] Sivas University of Science and Technology, Faculty of Engineering and Natural Sciences, Mechanical Engineering Department, Sivas

*Sorumlu yazar (Corresponding author): udemircioglu@sivas.edu.tr

Geliş Tarihi (Received): 17.06.2022 **Kabul Tarihi (Accepted)**: 18.07.2022

Abstract

Design is highly iterative process. As a result of these iterations it takes time, money and considerable amount of labor force to complete it. It is also essential to redesign an existing product in order to modify its features based on what customers look for in the product. Therefore, it is always considered to be necessary to automate or parametrized design process to speed up the product development. In this particular study design automation is implemented by using MSC Adams customization properties. Design is automated such that a useful product can be obtained at the end of design process quickly. A customized menu is created in MSC Adams view environment. Using this menu, one can build, test, review the results and improve product by optimizing. From simulation it was observed that the entire product can be designed and optimized as desired. It was also found out that time takes to redesign is reduced from hours to a few minutes using this method.

Keywords: MSC Adams, four bar mechanisms, design automation

INTRODUCTION

A mechanism is in most general term explained as a system that transforms motion and forces from one direction to another. The mechanism can also be determined as a system that is combination of rigid bodies that are brought together with kinematic pairs. Mechanisms are brought together to establish bigger device. Consequently, mechanisms can be used in a great variety machines and devices. The simplest mechanisms are the four-bar mechanisms that is also known as four-bar linkage that possess three moving links (crank, coupler and output link), one fixed link (ground link) and four revolute joints.

These days there is a firmly huge competition in the market between companies to maintain their existence and position in the market and also to widen their market and increase the customer satisfaction. To achieve that they must provide effective and efficient product agilely in order to meet customer expectations. Satisfying customer requirements with good quality products they asked in the shortest time is a major role in production world. Market is driven by customer desires. Those who satisfies that desires have better chance to remain in the market and in completion to other companies. One way to do that is by automation design process in order to quickly respond to clients. Design automation is the perfect way to increase productivity. Almost all the companies in the world have been using CAD/CAM/CAE as a tool for two decades nearly to reduce the time span of design and manufacturing and completing these tasks. These tools have gained importance especially in last two decades to avoid the repetitive tasks and thousands of mouse clicking.

A lot of researchers have put effort in the field of design process to automate design process and productivity, subsequently to increase customer satisfaction to get better market share. Researchers studied the design automation process at different level, namely, at part, assembly and simulation or analysis levels. For example, researchers tried to automate part generation by employing parametric design and macro generation (Babu and Abubacker, 2018; Aamani and Valaramathi, 2018; Brahmbhatt, Patel and Sanchapara, 2014; Reddy and Rangadu, 2018; Rathod et al., 2011). They automated the parts generation by creating relationship among dimensions and geometric characteristic of parts. And also creating macros and building graphical user interface is used by designers to automate design process at part level. When reducing the time and avoiding repeated tasks are considered these methods has done well job. However, as mentioned above any mechanism or machines are consisted of more than one part. As a result, one can say automation of part design on its own is not enough to automate design process of any product. So therefore, other researchers investigated the possibility of automating design process of a product at assembly level in order to overcome the deficiency of previously mentioned part automation (Mokhede et al., 2017; Trivedi et al., 2013; Mitrache et al., 2011; Sundar, Shankar et al., 2014, Sawant and Kadam, 2016; Shah, 2014; Ali et al., 2018; Sawant and Nimbalkar, 2015). Not only they automated parts design but also they automate the entire product. Nevertheless, the attempt was still insufficient because current manufacturing system require analysis or tests to be able to pursue production right after design process. Therefore, some researchers investigated the automation of analysis process in order to fill gab between design and analysis (Zheng, 2018; Li, 2019; Wang et al., 2009; Lin et al., 2013; Bin and Tang, 2015). They automated the simulation process at both part and assembly level. However, simplification was done to perform finite element analysis or analysis and design process are done in separate software which makes it harder and expensive.

When the literature is considered one can see that the efforts have been put to automate design process by designers. They have tried to automate design process as mentioned above at part, assembly and at analysis levels. These attempts have done well job so far. However, parts and assemblies should be modeled and simulation or finite element analysis should be performed automatically one after another more specifically in the same software if possible. Considering this deficiency in the literature, the objective of this study is to automate design process of four-bar mechanism and also to automate simulation to get desired results. In fact, automation all alone might not work. Automated or parametrized design may be used different designer. Therefore, automation should be done such that every designer can understand it. So the objective of this study is to automate the four bar mechanism so that everybody could use it with little knowledge. To do so graphical user interface is implemented.

MATERIALS AND METHODS

MSC Adams is one of the most commonly used dynamic simulation software in the world. Actually Adams stand for (Automatic Dynamic Analysis of Mechanical Systems). MSC Adams possess several sub-modules to be able to study different systems such as Flex, Car, Chassis, Driveline, Insight, and Vibration. This software is widely used in auto and train designs, as considerably as in many other industries. The software enables us to create dynamic, kinematic and static analysis of the desired mechanical systems and give opportunities designers to optimize and improve the properties. It clearly helps designer how the loads and forces are distributed throughout the mechanical system. More specifically, it helps to designer to calculate how loads and forces change with time. Also it gives more insight about the mechanisms being studied before real structure is manufactured. In conclusion the software MSC Adams enables us to model, analyze and optimize virtual prototype even before the actual implementation of the production of the prototype. One of the unique properties of the software is it allows us to customize user interface.

In this study, modeling, analysis and optimization of for bar mechanisms is customized using the software. Firstly, Adams menu is customized than modeling, simulation and optimization menus are added step by step.

RESULTS AND CASE STUDY

In this study, the steps shown in figure 1 is used to achieve the design automation for four bar mechanisms. Menu named four bar mechanism is created and later on under this created menu build, simulate and optimize sub-menus are created.

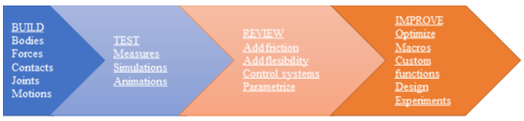

Figure 1. Schematic of how this study is organized

At the beginning of design process, four bar mechanism is modeled manually. As shown in figure 2 point 1, point 2, point 3 and point 4 are created. Later on member of four bar mechanism is modeled. Point 1 is fixed to ground whereas other points are mobile. Crank, connecting rod and output link are modeled using these constructions points. Crank connecting rod and output link are modeled as follows from point 1 to point 2, from point 2 to point 3 and from point 3 to point 4 respectively. Once these tree members are modeled fourth link between point 1 and point 4 is created which is determined as ground in this software.

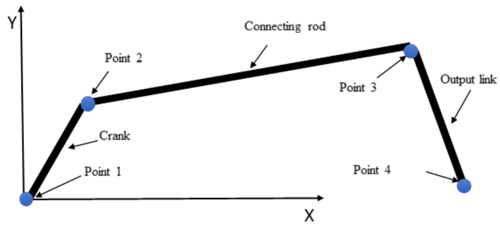

Figure 2. Four bar mechanism used in this study

Building Four Bar Mechanisms

In order to automate modeling of four bar mechanism, customized menu is created using MSC Adams view. As can been seen in figure 3 a menu is added to ribbon bar whose name is Fourbar. Later on a submenu called 'Build' under this menu is created. When Build menu is clicked a dialog box will appear as shown figure 4. As soon as designer enters the points shown in figure 4, four bar mechanics will be modeled immediately. Developing the customization process is hard and time consuming.

However, once the customization is done design the four bar mechanisms take less than a second. From design process that has been done so far one can conclude that developing the menu reduces time required. It is clearly seen from simulation designing the mechanism using customization menu so fast that it is unnecessary to compare it with conventional modeling.

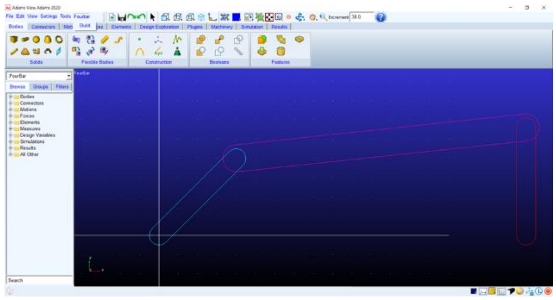

Figure 3. Customization of four bar mechanisms

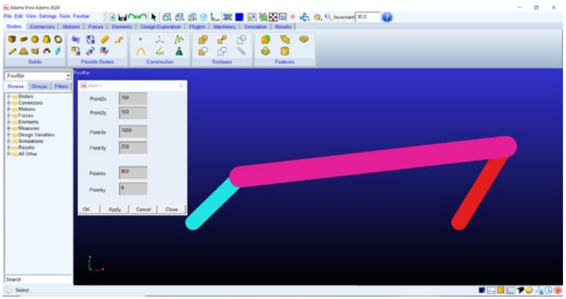

Figure 4. Performing build menu

Testing and Reviewing

In this part of the study a submenu called 'simulation' is added under customized menu Fourbar as shown in figure 5. When simulation button is clicked, the user interface menu is showed up as show figure 6. The user interface allows users to give desired rotational speed and also to simulate the system instantly when simulate button is clicked. Desired output can be obtained using this menu. The objective function in this study is to find the transmission angle as the crank rotates. Every design needs more or less optimization to perform better. Therefore, next stage of this study to optimize for bar mechanism to improve transmission angle.

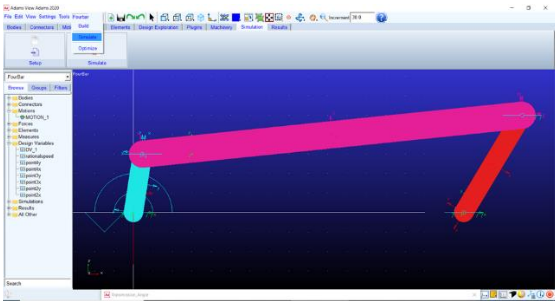

Figure 5. Customization simulation menu of four bar mechanisms

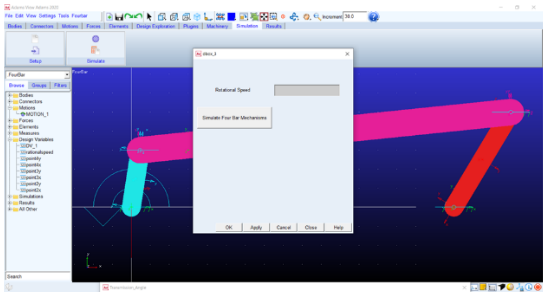

Figure 6. Performing simulation menu of four bar mechanisms

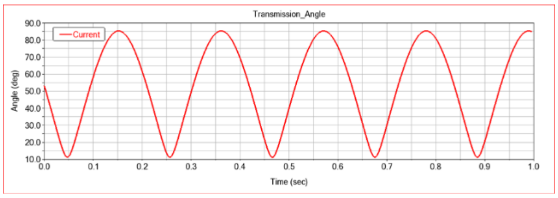

Figure 7. Design objective (transmission angle) of four bar mechanisms

Improving the Design

As mentioned previously automation design process does not work on its own. Design automation and analyzing is brought together in previous section. However, this is still insufficient since the mechanism built up to now could not ensure a useful product. Therefore, in order to improve design process such that useful product can be modeled at the end of design automation process. To that end, an optimization submenu is created as shown in figure 8. When this button clicked customized optimization interface pops up as shown in figure 9. Design variables and design objective should be given in design variables and design objective section. When optimize menu is clicked optimization stars immediately.

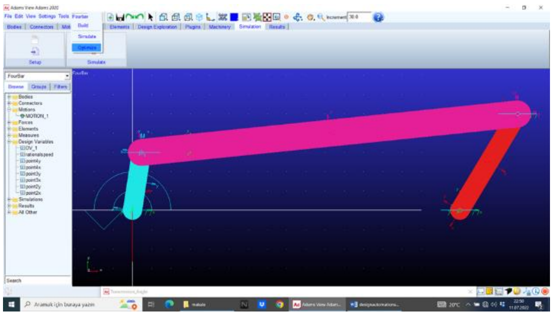

Figure 8. Customization optimization menu of four bar mechanisms

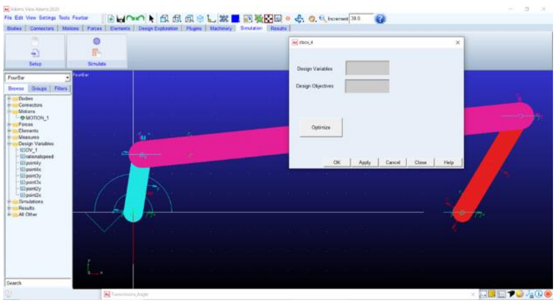

Figure 9. Performing optimization menu of four bar mechanisms

CONCLUSION

Design is locomotive of product development process. Once design is completed production and marketing come after them so easily. So one can say the faster the design is the earlier a company can go into the market. In this study design is automated by implementing customization menu using MSC Adams. Customization menu is created such that it has submenus namely, build, simulate, review and improve in MSC Adams view environment. Thanks to customized menu one can design the whole product at once. Consequently, time that takes to design is reduced from hours to a few seconds with this method. Along with time reduction this method provides the simulation of results. Also using this menu one can perform optimization if desired. Summing up all it was observed from study that one can design a ready-to-produce product.

ACKNOWLEDGE

I thank to reviewers and editors for their valuable time they spent evaluating our article.

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest between the authors.

STATEMENT OF RESEARCH AND PUBLICATION ETHICS

The study is not complied with research and publication ethics

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