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Araştırma Makalesi / Research Article

Generating a Matlab Code with Parameter Optimization in Gearbox

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Abstract

One of the most important engineering problems today is the optimization of systems and process parameters. Optimization is one of the longest and most costly steps to conclude for many multidisciplinary studies. Numerical analysis has been a widely applied approach to reduce this cost of time and money. In this study, first of all, a gearbox with geometric dimensions is modeled using Matlab commercial package software. The created model was then subjected to finite element analysis via student version of Ansys commercial package. The strength of the system was examined over the stress and deformation values obtained in those analysis. Considering the equivalent von Mises stress values obtained in the study, a maximum 200 MPa design on the gear wheels and a two-fold safe design according to the yield limit was revealed. In addition, a Matlab software that reveals the welding path for the reducer outer sleeve and jib crane has also been produced in this study..

Keywords: Matlab, Finite Element, Optimization, Welding Path..

Dişli Kutusu Tasarımında Parametre Optimizasyonu İçeren Bir Matlab Kodunun Oluşturulması

Öz

Günümüz mühendislik problemlerinden önemli bir tanesi de sistemlerin optimize edilmesidir. Optimizasyon, birçok multi disipliner çalışma için sonuçlandırılması en uzun ve en maliyetli adımlardan biridir. Bu maliyetin azaltılması amacıyla numerik yöntemlerden faydalanmakta yaygın uygulanan bir yaklaşım olmuştur. Bu çalışmada öncelikle Matlab ticari paket programı kullanılarak geometrik boyutları ortaya koyulan bir redüktör modellenmiştir. Oluşturulan model daha sonra sonlu elemanlar analizlerine tabi tutulmuştur. Analizlerde elde edilen gerilme ve deformasyonlar değerleri üzerinden sistemin mukavemeti incelenmiştir. Çalışmada elde edilen eşdeğer von Mises gerilme değerlerine bakıldığında dişli çarklar üzerinde maksimum 200 MPa düzeyinde ve akma sınırına göre iki kat emniyetli tasarım ortaya konulmuştur.

Ayrıca çalışmada redüktör dış kovanı ve pergel vinç için kaynak yolu ortaya koyan bir Matlab yazılımı da üretilmiştir.
Anahtar Kelimeler: Matlab, Sonlu Elemanlar, Optimizasyon, Kaynak Yolu.

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1. Introduction

Today, an important problem of engineering studies is the optimization of process parameters. Optimization is a multidisciplinary field of study not only in an engineering branch but also in many fields (Güner, 2020; Zenk et al., 2019). Optimization studies, especially on environmental and energy issues, gain an important place in the literature (Coruhlu et al., 2020; Dmitry et al., 2020; Zenk, 2020). With the simplest approach, the effects of efficiency improvement efforts applied in the production and use stages of energy on the environment are examined by scientists in our world where global warming and pandemic are experienced (Baser and Biyik, 2018; Güner et al., 2021).

When the event is viewed only from the perspective of mechanical engineering, increasing electronic support and widespread use of robotics increase the importance of system optimizations (Zenk and Akpinar, 2014). While some of the approaches applied for system optimization are actively involved in our lives, most of them are the planning steps that remain in the background (Rodionov et al., 2020).

On the other hand, many classical equipment in the existing machine design track are being optimized and put into the service of humanity more effectively (Sadeler and Atasoy, 2011; Savaşkan et al., 2015). A certain know-how infrastructure is needed in the optimization studies. This infrastructure can mostly consist of observations and collected data spread over the past years, or it can be a self-learning based artificial intelligence product (Sadeler and Atasoy, 2016; Tan and Savaşkan, 2020). The endpoint in optimization studies are artificial intelligence-based self-developing systems (Yıldırım et al., 2021/6/21).

There are multiple approaches to optimization in engineering disciplines (Baser, 2020). The finite element method is an important example of these approaches (Güner and Güney, 2018). The method can be used successfully in many engineering disciplines. Finite element method is used not only before production but also after production or when experimental studies are costly (Büyükkaya and Güner, 2020; Güner and Sofuoğlu, 2018). Fuzzy logic analysis systems are successful in solving problems involving deterministic chaos. One of the important advantages of the method is that it allows the system components to be optimized (Zenk et al., 2018).

Another heavily used method is Matlab applications. It is possible to optimize production with software codes made in different versions of the Matlab commercial package program (Eremochkin and Dorokhov, 2021). In design applications where, multiple independent parameters are involved, such applications provide an advantage to the manufacturer (Mezaache et al., 2022).

Gearboxes have gained an important place in a wide range of industries, including heavy industrial wastes such as automotive and steel shredders or factories those have smaller productions like elevators, mini robots, cranes, consumer automation systems etc. One of the studies that will provide an advantage to the manufacturer is that Kurt C., who has calculated and designed a special gearbox originally (Kurt C., 2011).

In another work, a new eigenvalue problem solver for Thermo-mechanics with MATLAB Program is the non-local finite element method of innovative vibration of Timoshenko nano-beams (Numanoğlu et al., 2022).

Optimization has an effect on the correct selection of the welding direction and direction, especially in welding metals with different alloys (Dourado da Silva et al., 2022; Rodionov et al., 2020). Besides the necessity of using different alloys of the same metal together, the need for welding different metals is an important problem. After the model is created in a newly designed system, optimizing the body parameters and coding the robotic software suitable for this design are modern applications in the field of industrial engineering (Geng et al., 2022). In this sense, the production efficiency is increased with the software codes that can be produced in the Matlab commercial package program.

Control systems based on this type of artificial intelligence techniques provide an increase in the processing quality of equipment such as welding. For example, a particle swarm optimization algorithm is discussed to examine the width of the head affected zone in gas metal and arc welding processes. A source code in Matlab 8.3 was used in the research made on welding speed, welding voltage, nozzle-plate distance, wire feed speed (Dourado da Silva et al., 2022).

As a requirement of global competition, the efficiency of technical equipment is constantly being improved. Matlab Simulink applications also show beneficial results in the solutions of the new products developed, especially in the field of electricity and electronics. Developed models are simulated on this program and optimized. In another study, which was submitted by Simulink/Matlab, includes a hybrid photovoltaic-thermal (PV/T) sunlight thermodynamic image following a modular strategy approach (R.M. da Silva et. Al., 2010). In another study by Abdullah (YEAR), thermodynamic modeling of the thermal and electrical performance of a hybrid PVT water collector was performed as the basis for the design of a new absorber (double oscillation absorber).[] Hybrid PVT was studied with normal PV technology (without cooling system) through simulation simulation of model based on theoretical data using MATLAB.

In this study, a Matlab code that can be used to calculate and optimize the geometric dimensions needed in the design of a simple gearbox is produced. Stress analyzes of the designed prototype are also given in the study.

2. Materials and Methods

The reducer is described as an industrial gear system. Machines used in all production branches from automotive to ceramics, food, and cosmetics contain reducers. Its job inside the machine is to decrease the speed and increase the momentum. In other words, it is to be able to adjust the power of the machine according to the production.

In the study, first of all, a Matlab code was created to make the necessary calculations for a gearbox design. After this code, the stresses that the gearbox shafts are exposed to were obtained by finite element analysis. According to the results obtained, the optimized dimensions of the reducer were changed. Since different shafts are subjected to different strain patterns, optimizations in the design are carried out similarly. The generated Matlab code is given in Appendix-1.

In the second step, it is aimed to write a Matlab code to be used in the welding process of a developed jib crane. The jib crane source Matlab code given in Appendix -2 explains the prototype production of the system so that it needs minimum optimization. Successful results were obtained from the analyzes made as a result of the modeling of the system.

It is aimed to minimize the cyclical work in writing the codes, thus minimizing the different needs of the system. Finite element analyzes were performed with the Ansys Student version. The solid model of the designed gearbox is given in Figure 1 as an exploded view.

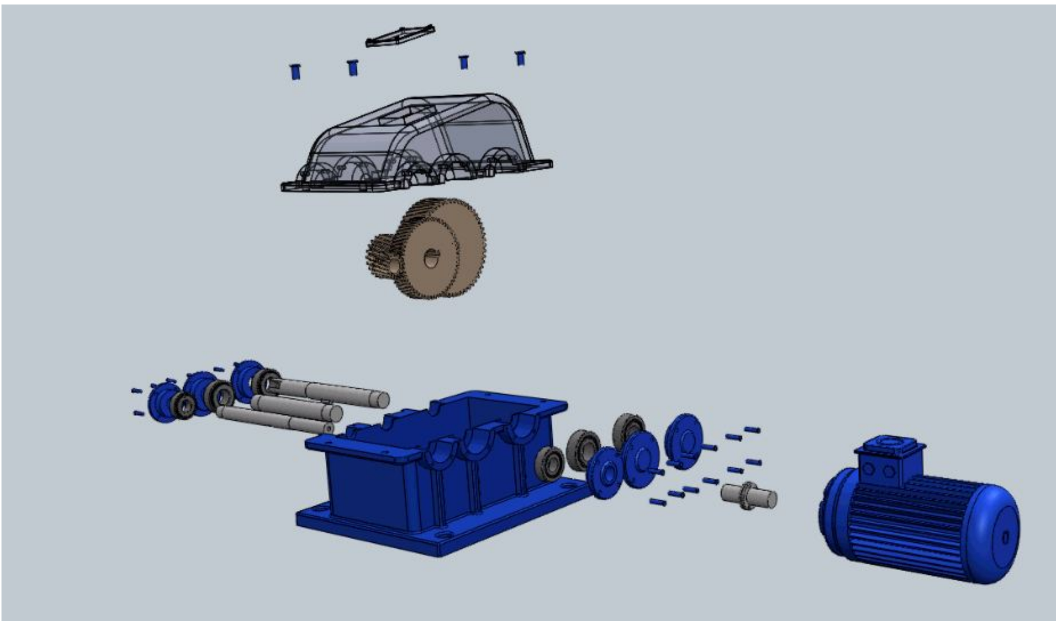

Figure 1. Exploded image of the created reducer solid model.

3. Findings and Discussion

Within the framework of the study, first of all, a gearbox production and stress analysis, followed by a Matlab code to be used in the welding processes of a jib crane was produced. The solid model produced using the generated code was subjected to finite element analysis in Ansys commercial package program. In the analysis, the three shafts of the reducer were examined in terms of stress and strain. The screenshot of the finite element analysis of the first shaft is given in Figure 2. Figure 2 Equivalent von Misses stress distribution on 1st shaft can be seen in Figure 2. It is seen that the largest equivalent von Misses stress on the pinion gear on the shaft is 81MPa. This value is the value on which the yield stress will be taken as a basis in the fracture hypotheses to be applied, whose shaft material is selected.

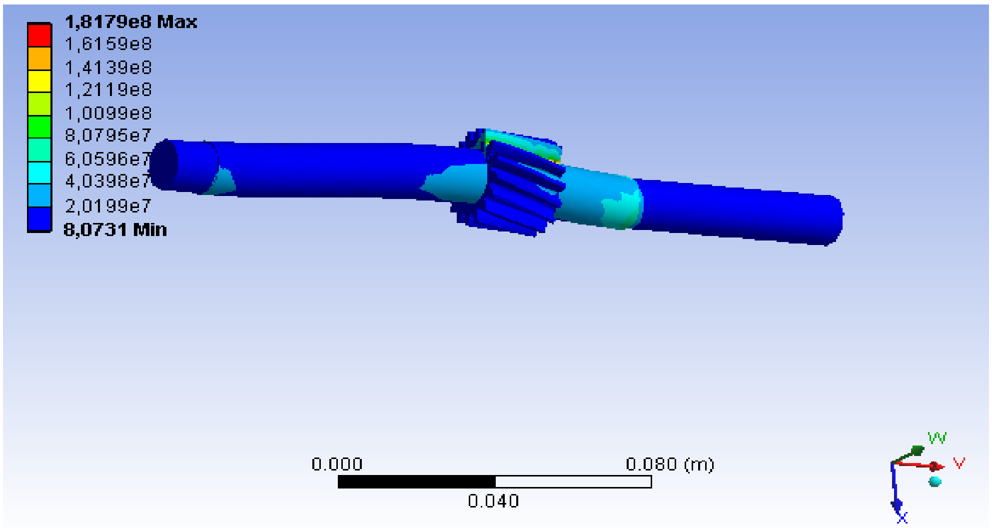

Figure 2. Equivalent von Misses stress distribution of 1st shaft.

In figure 3, total deformation of 1st shaft can be seen. Only in a small pile of the gear teeth exposed to excessive deformation. It is calculated that 2.56e-5m deformation was occurred on the gear teeth as the highest value on the 1st shaft. The minimum deformation was occurred as 2.8e-6m on the bear supports of the shaft.

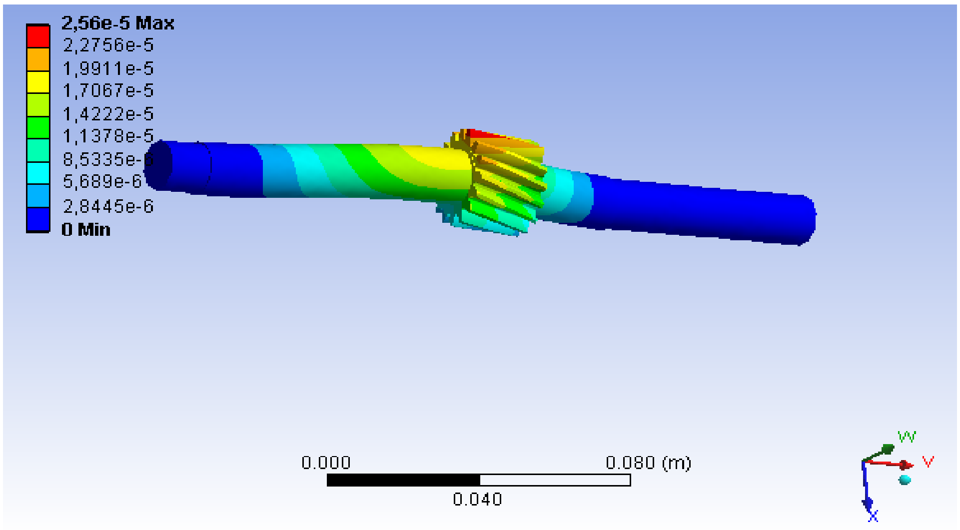

Figure 3. Total deformation of the 1st shaft.

Second shaft is the main part of the reducer. It is the host of two gear, one of them was in touch with first shaft and the other is in touch with the third shaft. The gear tooth were designed counter slope in order to minimize the shear force. this design balanced the shear force with the counter slope of the gears. Because of this reason the excessive equivalent elastic strain was occurred between the gears and the bearer supports of the second shaft. The maximum equivalent elastic strain was calculated lower than 5e-5 which still keeps the shaft in elastic deformation region of stress- strain curve.

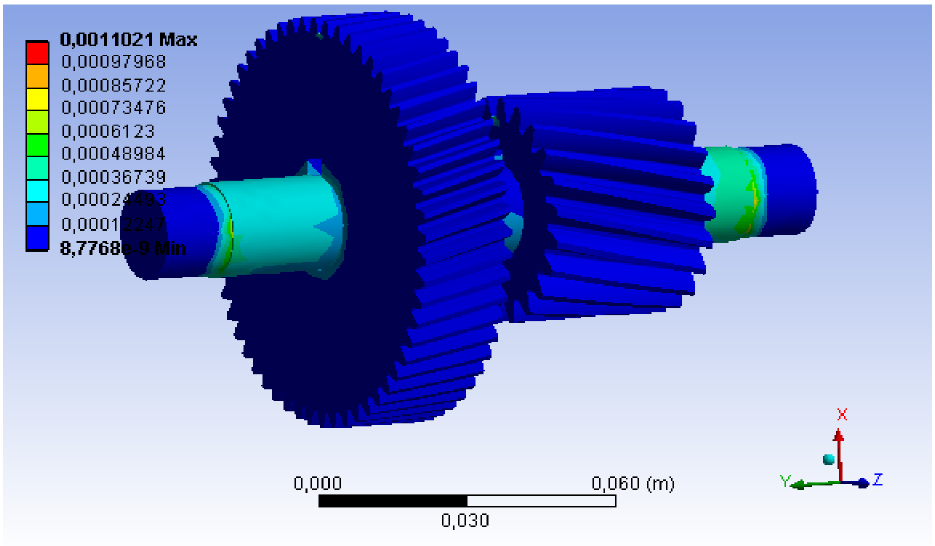

Figure 4. Equivalent elastic strain of second shaft.

The total deformation of the second shaft can be seen in Figure 5. The excessive deformation occurs on the upper part the gear which was in touch with the first shaft. This gear is the biggest gear of the reducer in diameter. Enlarging the diameter causes moment increase in the tooth of the gear.

The biggest gear exposed almost twice deformation of the other gear. The maximum total deformation was calculated as 5.5e-5m on the tooth of the gear.

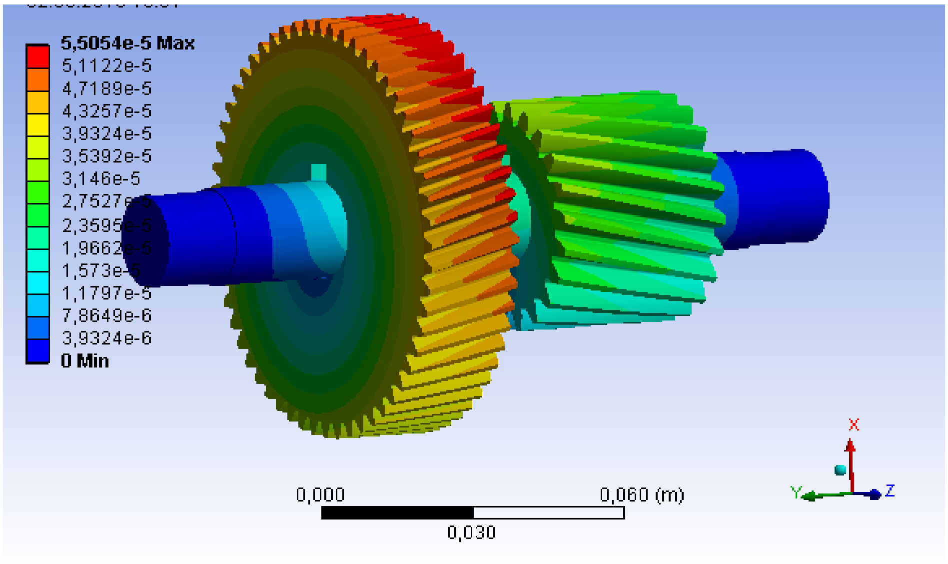

Figure 5. Total deformation of the second shaft.

Figure 6 shows Equivalent stress distribution of the third shaft. This shaft is also called the output shaft. This shaft has the highest torque and the lowest ration in the reducer. Due to the highest torque the shaft is exposed to shear stress. The tooth of the gear shows less normal stress. The maximum equivalent von Mises on this shaft is calculated as 71MPa. This value is similar to the first shaft which is the input shaft of the system. The optimization process worked successfully so that the output and input shaft exposed to similar stress values.

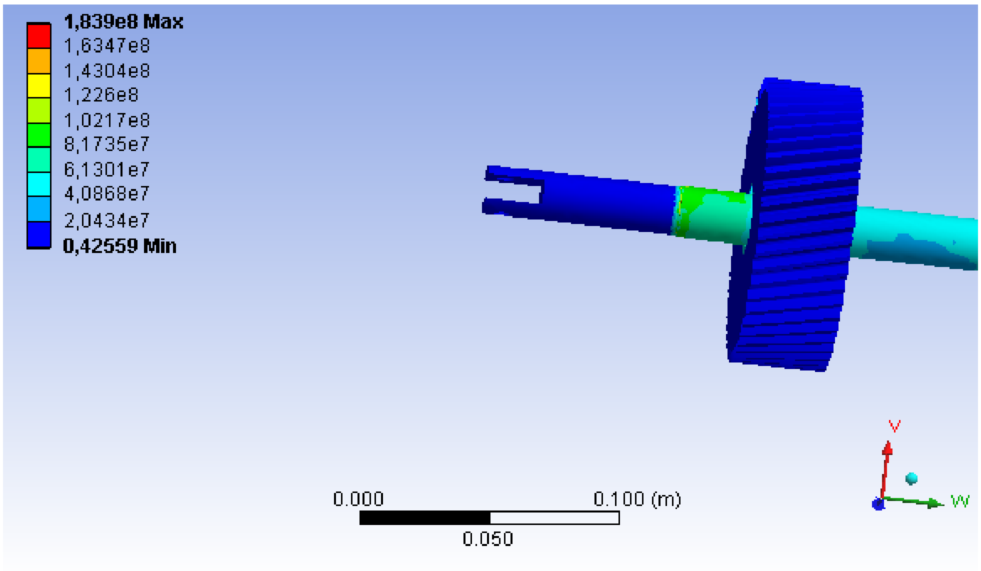

Figure 6. Equivalent Stress distribution of the third shaft.

Similar to the second shaft the highest deformation occurred in the gear tooth. The surface pressure and torsion arise the total deformation. This deformation reaches 0.0001m which the top deformation value obtained in the analyses. The screen shot of the third shaft is given in Figure 7 where the total deformation distribution was also plotted. This shaft is the output shaft of the reducer so that the highest torsion reveals out. This torsion is the main reason for the excessive total deformation.

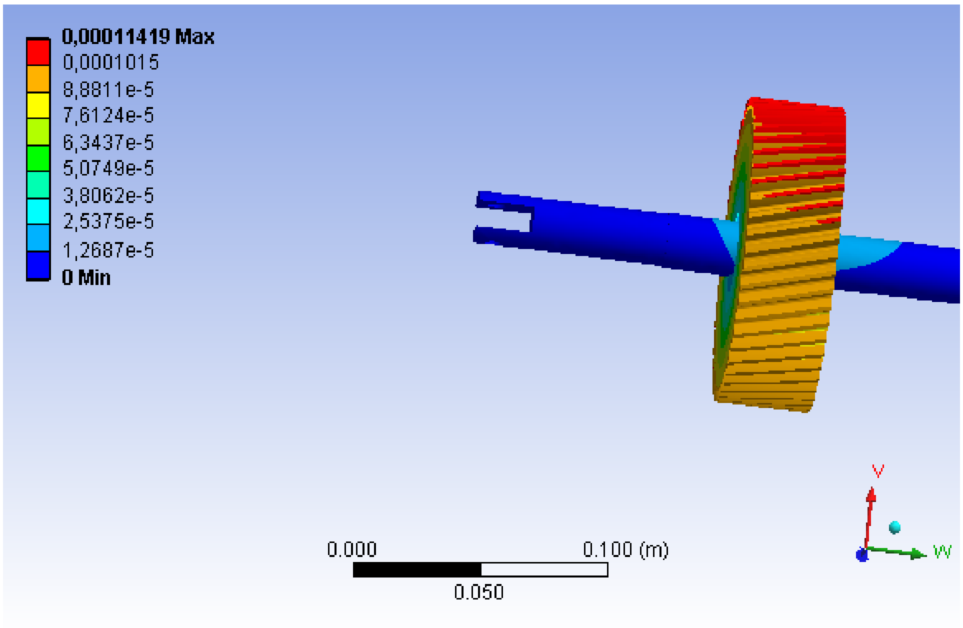

Figure 7. Total deformation on the output shaft of the reducer.

The results of as well as the findings obtained from the research in question are provided in this section. Here, one can compare and contrast the obtained findings with other relevant academic/scientific literature.

4. Conclusions and Recommendations

In this study, two MATLAB codes were constructed. First code aims to optimize modelling process of a reducer. The second code aims to optimize welding process of a jib crane. First of all, the necessary 3D models for the creation of these codes were put forward. Numerical studies were carried out using the codes created on these models. The geometries obtained in the studies were subjected to stress analysis via finite element method. In the analyzes, it was observed that the maximum equivalent von Mises stress values were at the level of 200 MPa, while the amount of total strain remained at the values of 5e-5.

As another result of the study, a great advantage was achieved in high design costs. Many calculation and control steps are minimized with the advantages of numerical analysis. Thanks to the finite element analysis, which is one of the two methods introduced in the study, the stresses that will occur on the model are obtained and the know-how is provided to the pre-production process. Decreasing the risk of unsafe production has been demonstrated at very low costs.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The author declares that this study complies with Research and Publication Ethics.

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