



## A New Sofa Bed Mechanism System For Furniture Industry

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### ABSTRACT

Today, the works that improve ergonomics and human comfort in the furniture sector are consistently increasing. In addition to this, improving the current situation of the mechanism systems, which are used in the widely produced seating and bed groups, is gaining momentum every day. The design of the mechanisms that provide the desired function is considered within the kinematic synthesis of the mechanisms. The kinematic synthesis of mechanisms is examined in three main categories as function, trajectory and motion synthesis. It is expected that while following the desired trajectory the configuration of the mechanical systems, throughout their movement as well as their area-volume usage will be optimum. Thanks to the mechanisms that provide these requirements, quality of the machine, tools, etc. will increase. In this study, in order to improve the opening and closing systems used in the furniture sector, a mechanism system has been designed and virtual prototypes have been realized in order to ensure optimum use of area and volume during the movement of these parts.

**Keywords:** Sofa Bed Mechanism, Virtual Prototyping, Kinematic Analysis.

## Mobilya Endüstrisi İçin Yeni Bir Çekyat Mekanizması Sistemi

### ÖZET

Mobilya sektöründe bugün ergonomiyi ve insan konforunu geliştiren çalışmalar giderek artıyor. Buna ek olarak, yaygın olarak üretilen oturma ve yatak gruplarında kullanılan mekanizma sistemlerinin mevcut durumunun geliştirilmesi, her geçen gün güçlenmektedir. Arzulanan fonksiyonu sağlayan mekanizmaların tasarımı, mekanizmaların kinematik sentezi

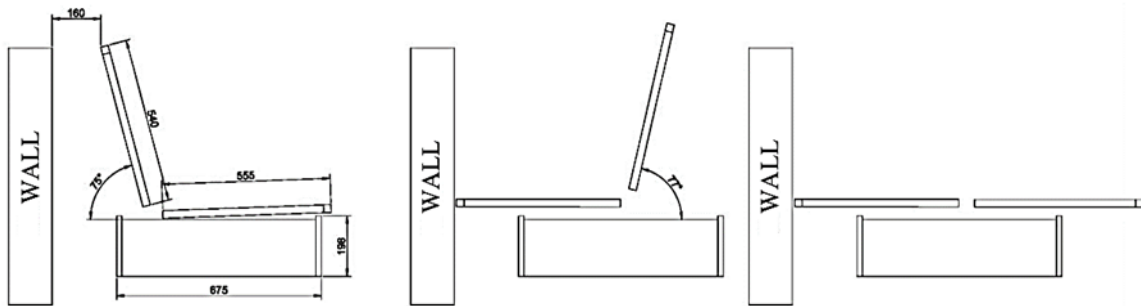
içerisinde değerlendirilir. Mekanizmaların kinematik sentezi, fonksiyon, yörünge ve hareket sentezi olmak üzere üç ana kategoride incelenmektedir. Mekanik sistemleri hareket ettiren istenen yörüngeyi takip etmesi, mekanik sistemlerin hareketi sırasında arzu edilen konum ve alan-hacim kullanımı optimum olması beklenmektedir. Bu gereksinimleri sağlayan mekanizmalar sayesinde, makine, alet vb. kaliteleri artacaktır. Bu çalışmada, mobilya sektöründe kullanılan açma ve kapama sistemlerinin iyileştirilmesi amacıyla, bu parçaların hareketi sırasında alanın ve hacmin en uygun şekilde kullanılmasını sağlamak için bir mekanizma sistemi tasarlanmış ve sanal prototipleri gerçekleştirilmiştir.

**Anahtar Kelimeler:** Çekyat Mekanizması, Sanal Prototip, Kinematik Analiz.

## 1. INTRODUCTION

The home furniture, which can be used for seating and bedding, is called a sofa-bed. The sitting part of the sofa-bed can be used for both lying and sitting by mounting on the connecting rod of a four-bar mechanism. The majority of the sofa-bed mechanisms do not open when they are based on the wall. For this mechanism, the movement is existent only the result of the rotation of the connecting rod of one of the four-bar mechanisms. For this reason, the sofa-bed can only be opened after pulling some distance from the wall. Due to the heavyweight of the system, it is difficult to pull. This reduces the quality of use of the existing system. In this study, a sofa-bed mechanism is designed which is to open up without touching the wall. The designed system can be easily adapted to the needs of small-scale industry.

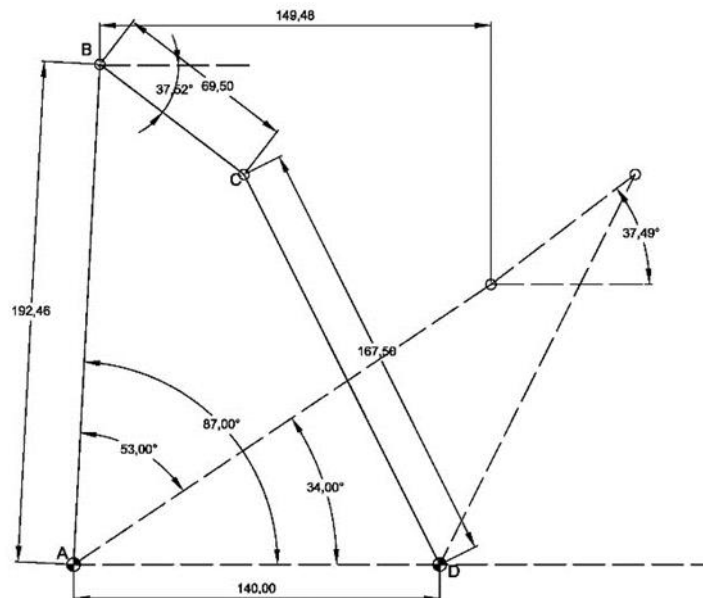
The design dimensions of the mechanism system are based on the characteristic measurements as the seating, rotation and bearing positions of an existing sofa as shown in Figure 1.



**Figure 1.** Typical sofa-bed measurements and opening positions

## 2. DESIGN NEW MECHANISM

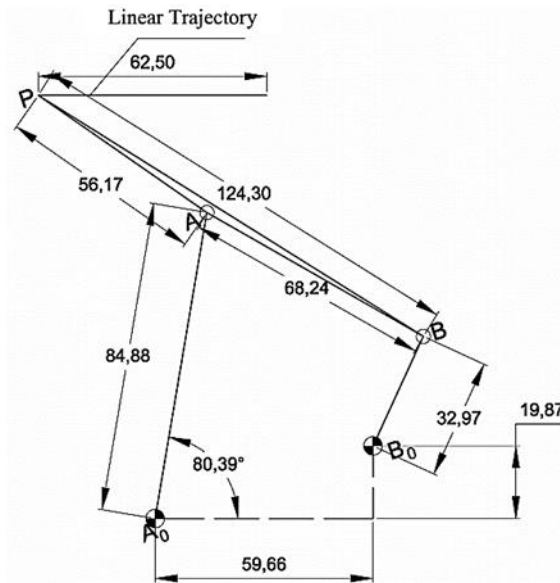
Designed mechanism has two degrees of freedom, it consists of six-bar and four-bar mechanism. In here four-bar mechanism is settled on connecting rod of six-bar mechanism which supplies straight line motion. While rotation is ensured by four-bar mechanism, moving away from wall horizontally is allowed by the six-bar mechanism. The four-bar mechanism dimensions that generate functions have been obtained by developed computer software based on references (Mutlu, 2004; Mutlu, 1994). In the design, the freely selected parameters were systematically changed to select the most suitable one. In the selection, the characteristic lengths of the sofa-bed, the aspect ratios of the resulting mechanism and the volumetric limitations are taken into consideration. The kinematic dimensions of the four-bar mechanism and the kinematic diagram showing the initial and final positions are shown in Figure 2.



**Figure 2.** Kinematic dimensions of four-bar function-generating mechanism

In Figure 2, if the BC connecting rod mounts on seating group, the first position shows the sitting position and the last position shows the lying position. Secondly, there is a need to design a carrier mechanism for moving the AD joint in the Figure 2 horizontally. It is necessary to design a mechanism to obtain linear path and it has to be appropriate for the dimension of the sofa-bed. The design of this mechanism can also be realized within the scope of path synthesis of the mechanisms. For this purpose, previously developed computer software is used. Mathematical model methods based on implicit solutions are used as in the synthesis of functions (Mutlu, 2004; Mutlu, 1994; Akçali and Mutlu, 1994)

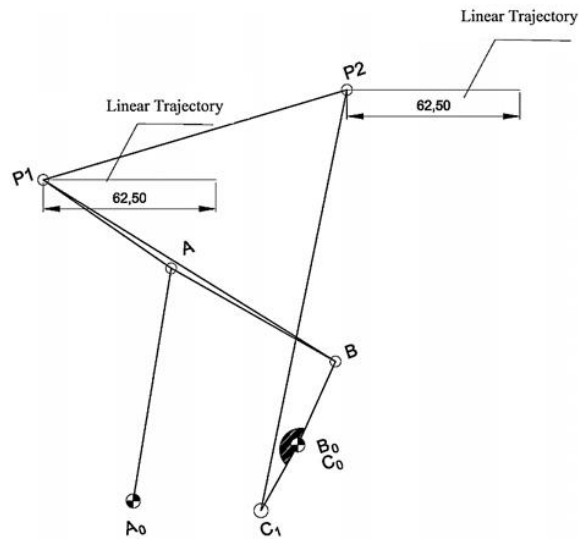
To design the four-bar mechanism based on path synthesis, the free parameters (input bar rotation amount, trajectory parameters etc.) have been systematically changed and a lot of kinematic dimensions have been obtained. Among these dimensions, optimum dimensions have been determined according to the structural error (the difference between the given path and the path generated by the mechanism) and manufacturing suitability. The kinematic dimensions of the designed mechanism are shown in Figure 3.



**Figure 3.** Kinematic dimensions of four-bar mechanism generating trajectory

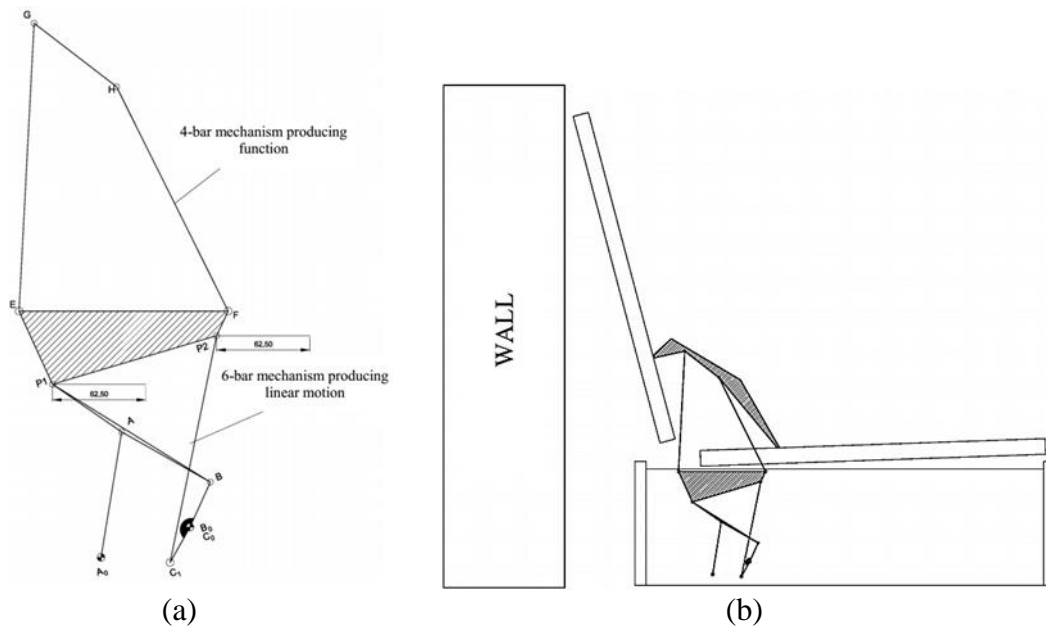
It is not enough to use the mechanism in Figure 3 for the horizontal movement. There is a need for a solid object that does not rotate on a linear path. It is possible to find a different dimensions 4-bar mechanism with different dimensions which draws the same curve based on the mechanism in Figure 3. The four-bar mechanisms with different dimensions the four bar mechanisms which draw the same curve are referred to as conjugate four-bar. Robert-Chebyshev Theorem is used to find these conjugates (Söylemez, 2007). According to the Robert-Chebyshev Theorem, other conjugate mechanisms having different dimensions are obtained.

When mechanisms, which are obtained according to Robert- Chebyshev Theorem, are rearranged and combined, six-bar mechanism which moves horizontally can be obtained. Resulting six-bar mechanism is shown in Figure 4.



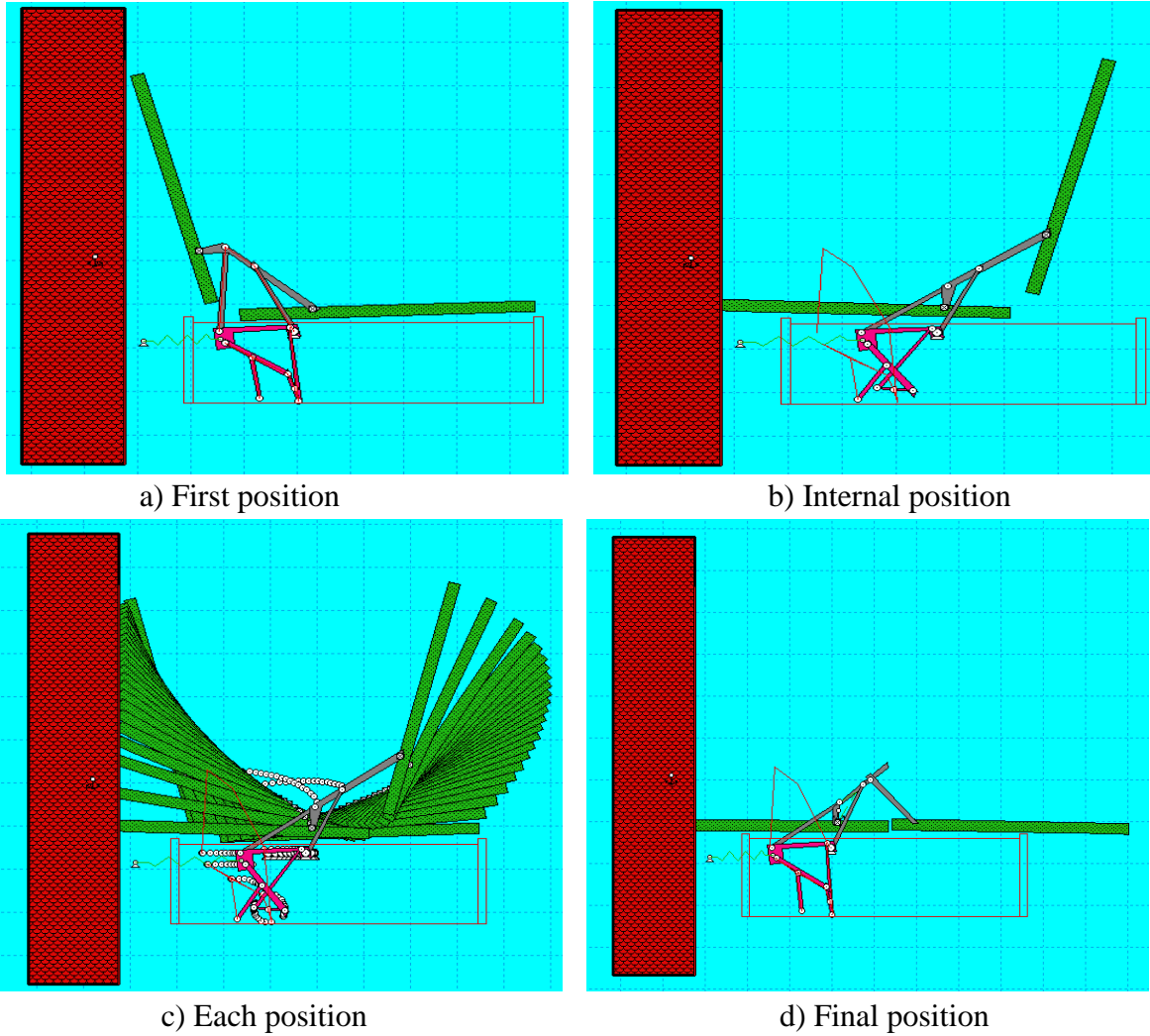
**Figure 4.** Six-bar mechanism generating line

If the four-bar mechanism that generates function and six-bar mechanism that generates straight-line trajectory are combined, new 2 DOF mechanism can be obtained. In this way sofa-bed can be opened without moving away from the wall. 2 DOF mechanism is shown in Figure 5 (a) and assembly viewing of the 2 DOF mechanism on sofa-bed is shown in Figure 5 (b).



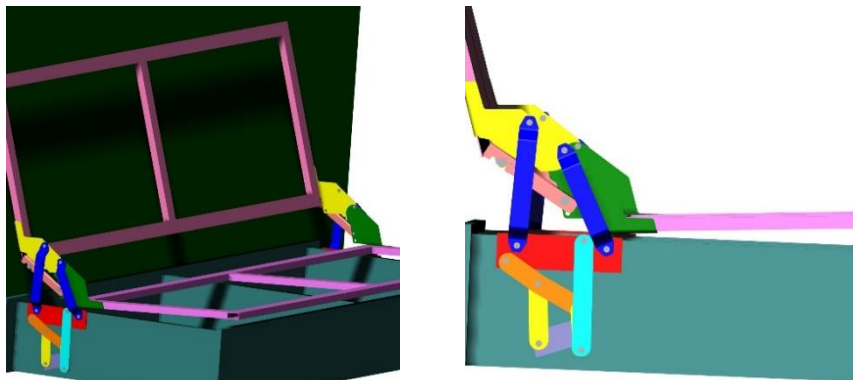
**Figure 5.** a) Resulting 2 DOF mechanism, b) 2 DOF mechanism on sofa-bed mechanism

Some virtual results obtained by computer simulation of the new sofa-bed mechanism are shown in Figure 6. In Figure 6, section (a) shows the initial position of the sofa-bed, section (b) shows sofa-bed position without pulling from the wall, section (c) shows each position of sofa-bed system when it opened, section (d) shows the final position of the sofa.



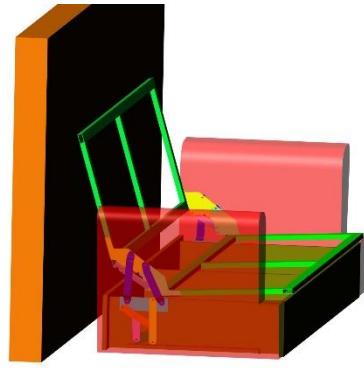
**Figure 6.** Computer simulation position of the new sofa-bed mechanism

The virtual model of design sofa-bed mechanism which is appropriate for real life is shown in Figure 7. 3 Dimensional models of new sofa-bed mechanism of every step while it is opening are shown in Figure 8.

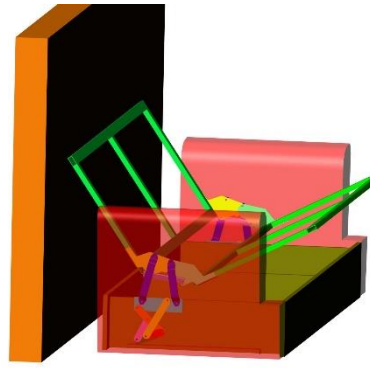


a) Perspective view of sofa-bed      b) Detail picture of mechanism

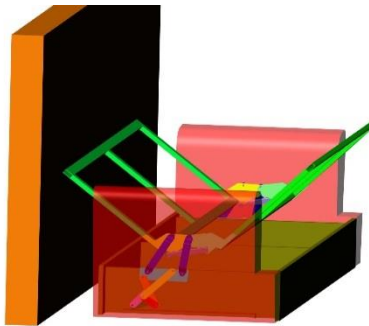
**Figure 7.** Virtual model of designed sofa-bed mechanism



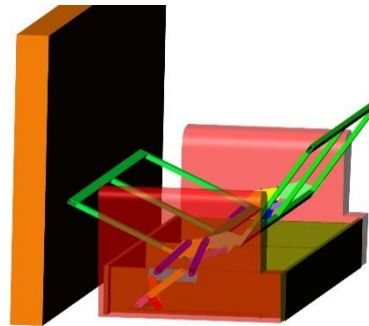
a)



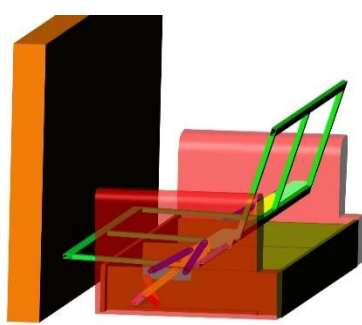
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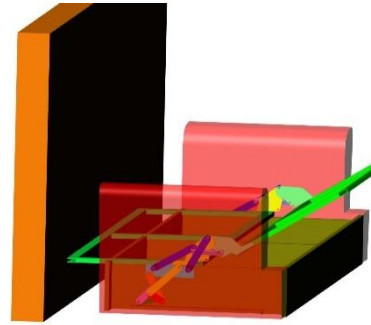
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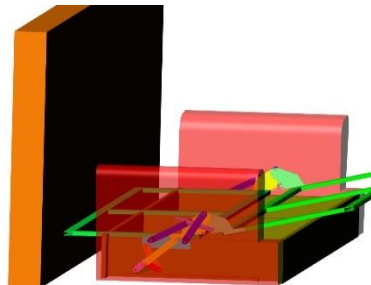
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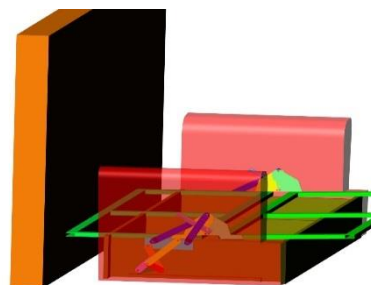
e)



f)



g)



h)

**Figure 8.** New sofa-bed mechanism

### **3. CONCLUSION**

In this work, a study was carried out on the kinematic synthesis of the mechanisms and a new mechanism has been developed. Mechanism synthesis methods are used based on the analytic solutions to reveal the original designs and a new computer software is developed to that end. It is thought that it will be very helpful to realize the dimensional synthesis of new type of mechanisms with the new software developed and to convert them into real products and to increase the quality of the mechanisms. Thanks to the new mechanism designed, the sofa bed is opened easily without any need to remove it from the wall.

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