

DESIGN AND ANALYSIS OF A NOVEL SEALING UNIT FOR PACKING MACHINES

M.Eng. Numan Irmak¹, M.Sc. Onur Cimen¹, Prof. I.Etem Saklakoglu PhD.²

¹Kansan Wetwipe Machinery R&D Center, Izmir, Turkey

²Ege University Faculty of Engineering Mechanical Engineering Department, Izmir, Turkey

numanirmak@kansanmak.com

Abstract: Packaging machines using for wet wipes operate at high speeds and the demand for speed in the relevant market is constantly increasing. The most important difficulty to faster operation of these machines is the relative slowness of the units used for sealing the packages. In this study, it is aimed to design a unique mechanism that can work at 160 packages per min instead of sealing unit which is still operating at 120 packages per min, and to verify the design by mechanical analysis. For this purpose; instead of the existing sealing unit driven by a single servo motor, the horizontal and vertical movements are separated and driven by two servo motors to achieve %33 more speed.

Keywords: PACKAGING MACHINES, WET WIPES, SEALING

1. Introduction

Nowadays, the standard application for sealing the packages in packaging machines is provided for a fixed time, at a constant temperature, with spring compression and due to the standard cam geometry, adhesive bonding under variable pressure forces during the application period. This results in higher energy consumption on the one hand, while limiting the type of material that can be bonded on the same machine.

There is no automatic adjustable machine both in our company and in the global market. In this study, it is aimed to develop a user friendly and energy efficient machine which can work with all kinds of polymer packaging materials at high speed and efficiency.

2. Definition of Problem

The jaw unit in our standard packaging machine is capable of bonding at a constant time and pressure. This causes problems in the adhesion of some of the packaging materials developed recently and slows down the speed of the machine. Therefore D-Cam movement obtained by single servo motor in the jaw module of our standard packaging machine was improved. D-Cam movement will be provided by using 2 different cam movements by means of 2 independent servo motors. One motor will be control the vertical movement of the jaws, while the other motor will control the horizontal movement, ie the synchronous movement with the package. To do this, it have been worked on formulating the jaw movement that was occur by using 2 different mechanisms on the automation side and added into the equation. Therefor an easily adjustable adjustment screen that can be understood by the operator was designed.

Horizontal movement of the sealing jaws (movement in the direction of the flow of the package) was provided by separation of the horizontal and vertical movement.

While the horizontal movement is limited to 60mm fixed value in the current system, it is planned to increase this movement up to 100mm in the system to be developed and be able to change it from the operator panel without any mechanical adjustment.

It is also aimed to increase the contact time of the sealing jaws to the package by increasing the horizontal movement and to achieve better adhesion quality at lower temperatures.

In the design of the movement mechanism of the jaw unit, the choice of cam bearing according to the loads to be formed, determination and design of the closed cam form, dimensioning the connecting mechanism to be designed according to the jaw stroke movement were studied.

Both mechanical and automation measures was taken to protect the jaw unit against mechanical jams. When driving the horizontal

movement of the jaw unit, torque limiter coupling was used in the system.

Automation measures was taken in order to detect the phase misalignment that may occur in the system. So that the sealing jaws do not press on the wet wipes which do not center the package.

A graphical image of the movements that can be obtained with standard D-Cam and adjustable D-CAM mechanisms is given in figure 1.

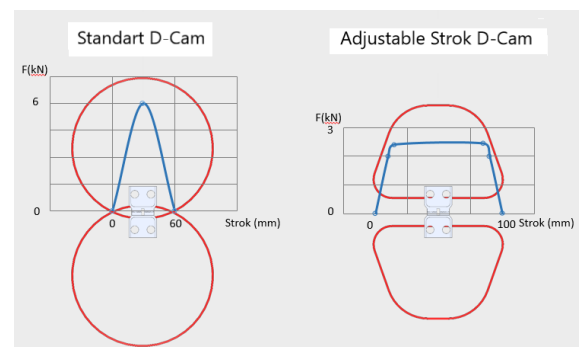


Fig. 1 Standard and Adjustable Strok D-Cam

The design of the movement obtained with a single servo motor in the jaw module of our standard packaging machine is shown in figure 2.

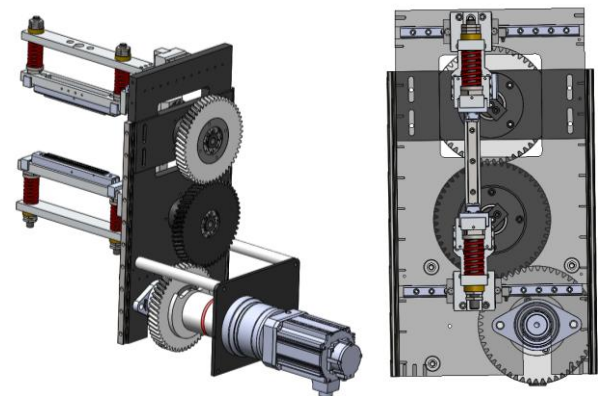


Fig. 2 Isometric and front view of single servo motor in the jaw module

3. Variable Stroke Jaw Design

While the horizontal movement is limited to 60mm fixed value in the current system, it is planned to increase this movement up to 100mm in the system to be developed and be able to change it from the operator panel without any mechanical adjustment.

It is aimed to increase the contact time of the sealing jaws to the package by increasing the horizontal movement and to achieve better adhesion quality at lower temperatures.

In the design of the movement mechanism of the jaw unit, the choice of cam bearing according to the loads to be formed, determination and design of the closed cam form, dimensioning the connecting mechanism to be designed according to the jaw stroke movement were studied. Figure 3 shows the variable stroke jaw mechanism designed by us

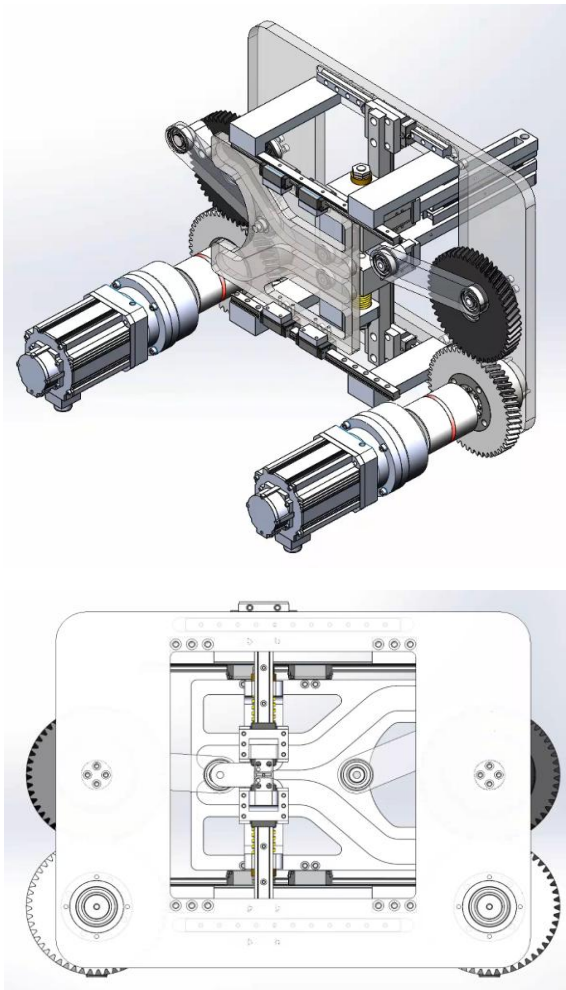


Fig. 3 Isometric and front view of single servo motor in the jaw module

4. Variable Stroke Jaw Position Equations

In order to provide axis movements in the two-motor design, the geometric positions formed during the movement of the mechanism must be calculated and formulated so that the automation system can control the positions.

Figure 4 shows the initial state of the closed cam positions.

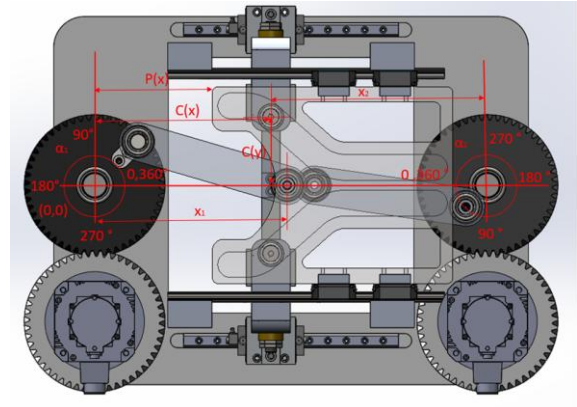


Fig 4. Initial state of the closed cam positions.

The calculations related to the location analyzes performed below are given.

x_1

$$l_1 = 100mm$$

$$l_2 = 253mm$$

$$\cos \alpha_1 (0,360)$$

$$x_1 = \frac{l_1^2 - l_2^2 + x_1^2}{2 \times l_1 \times \cos \alpha_1}$$

$$x_1 = \frac{100^2 - 253^2 + x_1^2}{2 \times 100 \times \cos \alpha_1}$$

$$x_1^2 - (200 \cos \alpha_1)x_1 - 54009 = 0$$

$$\Delta = b^2 - 4ac, \quad a = 1, b = -200 \cos \alpha_1, c = -54099$$

$$x_1 = \frac{-b + \sqrt{\Delta}}{2a}$$

x_2

$$l_3 = 50mm$$

$$l_4 = 249mm$$

$$\cos \alpha_2 (0,360)$$

$$x_2 = \frac{l_3^2 - l_4^2 + x_2^2}{2 \times l_3 \times \cos \alpha_2}$$

$$x_2 = \frac{50^2 - 249^2 + x_2^2}{2 \times 50 \times \cos \alpha_2}$$

$$x_2^2 - (100 \cos \alpha_2)x_2 - 59501 = 0$$

$$\Delta = b^2 - 4ac, \quad a = 1, b = -100 \cos \alpha_2, c = -59501$$

$$x_2 = \frac{-b + \sqrt{\Delta}}{2a} + 71mm$$

(+71 mm; added length of part connected to 14)

$C(x_2)$;

Position of the jaw on the x axis relative to the center a1

$$C(x_2) = 640 - x_2$$

$$100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122))>91,8;(640-(((100*\text{COS}(\text{RADYAN}(\text{B1}))+\text{SQUAREROOT}((-100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122))<167,3);(167,3-(640-(((100*\text{COS}(\text{RADYAN}(\text{B1}))+\text{SQUAREROOT}((-100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122)))*\text{TAN}(\text{RADYAN}(41,33)))+18,93+29;\text{IF}(\text{VE}(((640-(((100*\text{COS}(\text{RADYAN}(\text{B1}))+\text{SQUAREROOT}((-100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122))>167,3;(640-(((100*\text{COS}(\text{RADYAN}(\text{B1}))+\text{SQUAREROOT}((-100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122))<217,48);76-\text{SQUAREROOT}(5776-((640-(((100*\text{COS}(\text{RADYAN}(\text{B1}))+\text{SQUAREROOT}((-100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122))-217,48)^2)+29;\text{IF}(((640-(((100*\text{COS}(\text{RADYAN}(\text{B1}))+\text{SQUAREROOT}((-100*\text{COS}(\text{RADYAN}(\text{B1}))^2-4*(-59501))/2)+71)-(((200*\text{COS}(\text{RADYAN}(\$A309))+\text{SQUAREROOT}((-200*\text{COS}(\text{RADYAN}(\$A309)))^2-4*(-54009))/2)-122))>217,48;29;0)))));2)&"))$$

As a result of all the location analyzes and calculations performed in excel, point cloud showing the position status in excel environment was created. Figure 7 shows a graphical representation of these points.

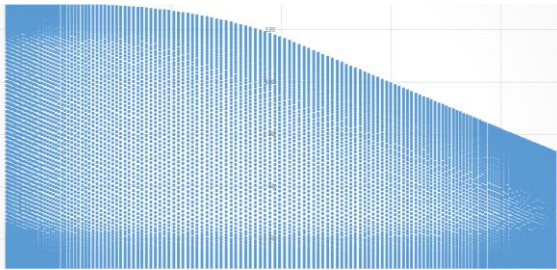


Fig 7. A graphical representation of cloud showing the position status

5. FEM Analysis

In the study, mechanical analysis of the critical loads was performed. This ensures safe operation of the machine parts. Figure 8 shows examples of analysis of the selected carrier pin and pin socket.

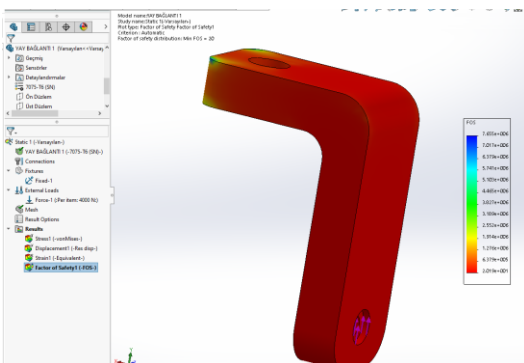


Fig 8. a. Carrier pin socket

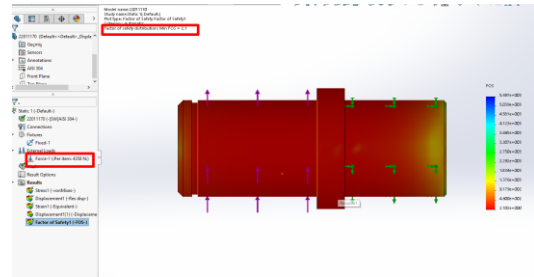


Fig 8. a. Carrier pin

Fig 8. Examples of analysis of the selected carrier pin and pin socket

6. Conclusion

In this study, instead of the existing sealing unit driven by a single servo motor, the horizontal and vertical movements were separated and driven by two servo motors. To have position control it has been analyzed the geometric positions and to have stiffness mechanical analyses were performed for critical parts of machine. It is designed a unique mechanism for sealing unit that can work at 160 packages per min instead of 120 packages per min.

7. Acknowledgment

Some of the applications presented in this study were supported by TUBITAK-TEYDEB (The Scientific and Technological Research Council of Turkey-Technology and Innovation Support Programs) with project number 3181073.

8. References

[1] Prab Bhatt, Programming the Dynamic Analysis of Structures, CRC Press Published June 13, 2002, ISBN 9780419156109

[2] Doyle, J.F. Static and Dynamic Analysis of Structures with An Emphasis on Mechanics and Computer Matrix Methods, ISBN 978-94-011-3420-0, Springer Netherlands

[3] Sondipon Adhikari, Structural Dynamic Analysis with Generalized Damping Models: Analysis, ISBN:9781848215214, 2014 by John Wiley & Sons, Inc.

[4] Bucalem M.L., Bathe KJ. (2011) Mathematical models used in engineering structural analysis. In: The Mechanics of Solids and Structures - Hierarchical Modeling and the Finite Element Solution. Computational Fluid and Solid Mechanics. Springer, Berlin, Heidelberg

[5] Mathematical Modelling in Solid Mechanics, Editors: dell'Isola, Francesco, Sofonea, Mircea, Steigmann, David (Eds.) ISBN 978-981-10-3764-1, Springer Singapore

[6] K. F. Riley, M. P. Hobson, S. J. Bence Mathematical Methods for Physics and Engineering: A Comprehensive Guide, Cambridge University Press

[7] John W. Dettman, Mathematical Methods in Physics and Engineering, Dover Pup. Inc

[8] Bernard Liengme, Keith Hekman, Liengme's Guide to Excel 2016 for Scientists and Engineers, Academic Press, Elsevier