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Optimization of Basket Oven Oil Seal Design For Quality, Productivity and Material Handling

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A B S T R A C T

In the oil seal production process, one of them is the post-cure oven process as a heat treatment to engineer the rubber material so that it has resistance to friction and has high heat resistance. The post-cure oven process itself uses equipment in the form of an oven basket made of heat-resistant steel material to place the oil seal. However, the Basket oven itself has a maximum limit for placing the oil seal in the oven, so calculations are needed to find the optimization value to find out the maximum value obtained so as to increase work productivity. From the problems found, the existing oven baskets were unable to accommodate 1,442 pcs/lot of products, but were only able to accommodate 1,344 pcs of products. so it is necessary to design a new basket oven to get the optimal value so that the basket oven can accommodate as many as 1,442 pcs/lot of products. From the research results it is known that to save material the most optimum cutting value is if the value of x = 8.5. Meanwhile, to get the maximum volume value, it is cut with a value of x = 11. By using the new oven basket, the product volume that can be accommodated is 1,568 pcs when compared to the use of the old basket which was previously able to accommodate 1,344 pcs of product. The use of a new basket oven can increase basket volume by 16.7%.

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1. INTRODUCTION

The machine operates using the concept of energy conversion. Generally convert chemical energy or electrical energy into motion. This process often causes heat and friction between each component. Therefore, every machine is usually equipped with a lubrication system. Which functions as a lubricating medium to reduce friction between components that touch each other. At the same time it is also used as a heat-conducting medium to reduce engine working heat. The lubricating substance commonly used today uses oil. Manufacturing companies with oil seal products require a heat treatment process in one of their processes, this process requires high productivity for optimal production (Sarjono et al., 2023). To improve efficiency and product integrity, process optimization is mandatory (Ozule et al., 2022). To achieve this, optimization of quality and productivity must be achieved simultaneously (Bamidele et al., 2023).

The properties of oil which has viscosity and anti-rust are very suitable for use as a lubricating medium. However, engine components made of metal cannot be impermeable and oil leaks often occur in interconnected components. Because of this, a non-metallic part with elastic properties is needed to maintain the density of each machine connection to prevent leakage, which is called an oil seal (Sarjono, 2021). Oil Seals in their use require materials that are resistant to heat and friction with high durability.

In order to have good material resistance, oil seals must go through an oven process as a heat treatment to engineer the rubber material so that it has resistance to friction and has high heat resistance. Process failure often occurs because the product stack exceeds the maximum limit in the basket during the heat treatment process, this causes some problem with oil seal, such as; sticky, easy to break and fragile. Not only the oven temperature that must be maintained, the density of the parts in the oven also needs to be regulated so that heat can be distributed evenly throughout the material. In research (Swilam et al., 2022), heat treated rubber product withstand temperatures of 200°C for two hours. For that to happen the company needs to engineer the oven process storage arrangements. This research focuses on the purpose of making a combustion oven basket design to produce productivity based on material handling with the appropriate quality with the highest capacity. From the problems found, the existing oven baskets were unable to accommodate 1,442 pcs/lot of products, but were only able to accommodate 1,344 pcs of products. so it is necessary to design a new basket oven to get the optimal value so that the basket oven can accommodate as many as 1,442 pcs/lot of products.

2. LITERATURE REVIEW

Optimization can be defined as the process of selecting the best action or decision from a set of available options, taking into account certain desired or expected criteria. In the context of mathematics, optimization can be formulated as a mathematical programming problem that seeks the maximum or minimum value of an objective function, taking into account the limitations or limitations that exist. The goal of optimization is to achieve the best possible result by considering all relevant and possible factors.

Nonlinear variable optimization is a branch of mathematical optimization that studies methods for finding the minimum or maximum value of an objective function involving one or more variables, where the relationship between these variables cannot be represented linearly. In optimizing non-linear variables, the desired objective function often has complex properties, such as having several optimal locales or complex constraints. The goal of variable non-linear optimization is to find a solution that satisfies the desired optimization criteria, such as minimizing costs or maximizing profits, taking into account the existing limitations. The methods used in the optimization of non-linear variables include the gradient method, the Newton-Raphson method, the quasi-Newton method, and the line search method.

Previous studies discussing non-linear variable optimization namely using three different approaches in the optimal placement and size of several Distributed Generation (DG) in the distribution system. The aim of this research is to reduce active and reactive energy losses in the distribution system (Sultana et al., 2017), The data analysis used is a linear program through the simplex method (Finšgar & Rajh, 2023), two responses (removal efficiency (RE,%) and adsorbent yield (Y,%) were tested using two quadratic models. The results showed that the optimum conditions for making ACPKS were activation temperature of 829.4°C, ratio of KOH to precursor 3.01 w% and activation time of 85 minutes with 94.41% RE response and 39.4% ACPKS yield (Habeeb et al., 2017), this study found that the optimization that best fits the real situation of the BjLS manufacturing industry is multivariate NLP with limits on production volume, production time, raw material inventory, and raw material purchase budget (Ats-Tsauri et al., 2022), line loss interval calculation method based on power flow calculation and linear optimization (Liang et al., 2022), lean method is used to optimize the number of work stations, a new Taguchi-based method for optimizing worker safety compliance in equipment and non-equipment related activities in bottling plants (Martins & Oke, 2021), profit

optimization using the simplex linear programming method can be applied to UMKM Dongkal Awug Kang Cakes which in actual conditions produce 24 portions of Traditional Dongkal Cakes (x1) and 37 portions of Contemporary Dongkal Cakes (x2). After optimization, an increase in production is obtained by 7 portions at optimal conditions (Cahyono et al., 2023), gray wolf optimization (GWO) approach to optimize machining parameters of AISI 4340 alloy to increase cutting force, surface roughness and tool wear (Ozule et al., 2022), optimizing the cost of submitting product claims processed by LINGO results in a shipping fee withdrawal of 5% of the budget (Paduloh & Mayana, 2023), Establishment of a diet menu problem model based on a Boolean Linear Programming approach to cover a variety of daily diet menu settings and meet daily nutritional needs while minimizing costs (Harahap et al., 2023), the SVM algorithm method with the Radial Basis Function (RBF) kernel produces the best accuracy of 71.2%. Algorithm method combination SVM with the RBF kernel algorithm and the PSO algorithm obtained an accuracy of 68.84%, and the combination of the RBF kernel SVM algorithm and the GA algorithm obtained an accuracy of 69.52% (Mustamu & Sibaroni, 2023), the application of the simplex method aims to find out and be able to optimize the long-term profit costs of XYZ company, the results of its application XYZ company can get a maximum profit of 27.5, if it produces X1 goods, namely 5/6 tons of strawberry bread and 5 tons of chocolate flavor X2 (Pratama, 2023).

3. RESEARCH METHOD

The focus of this research is how to design heattreatment baskets using variable optimization methods without research constrains to improve quality, productivity and material handling. In optimizing this design, the height dimensions of the basket are limited by the maximum number of piles of oil seals in the basket so that the combustion products don't stick. The length of the basket is taken from the average maximum value of the operator's elbow length. While the width of the basket is measured based on the average maximum cubits length of the operator. This refers to ergonomics studies to facilitate material handling, so that operators can manually load the basket and easily add it to the trolley. The first step of this research is to calculate the average operator's shoulder width. Next calculate the average cubits length. The last step is to calculate the dimensions of the basket based on shoulder width, cubits length and the maximum height of the oil seal stack.

Calculate the volume with the volume equation V = x (average length of the operator's elbow - 2x)(average length of the elbow to the fingertips -2x), Then do the first derivative test to find out the maximum value $\frac{dv}{dx}$ and second derivative test to find out critical value $\frac{d^2v}{dx^2}$.

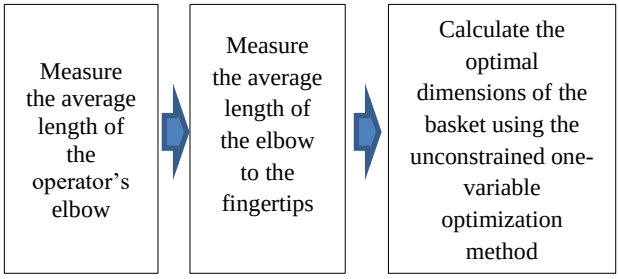

Fig. 1. Study framework

4. RESULT AND DISCUSSION

After the measurements were taken, the results showed that the average length of the elbow = 69cm and the average distance of the finger to the operator's elbow = 42cm. then the data that has been collected is analyzed using the one-variable calculus method without constraints.

Table 1. Elbow length measurement data

Elbow Length Measurement (cm)		
72	66	64
67	64	72
77	62	74
67	63	77
64	64	64
72	70	75
75	74	73
74	72	71
65	68	66
66	65	72
Average		**69**

The elbow length at Table 1. is used as the data for the length of the basket.

Table 2. Cubits measurement data

Cubits Measurement (cm)		
40	42	42
41	42	41
40	44	43
43	41	40
41	40	44
41	42	42
43	43	41
44	43	42
40	42	40
41	40	40
Average		**42**

The cubits measurement at Table 2. is used as the data for the wide of the basket.

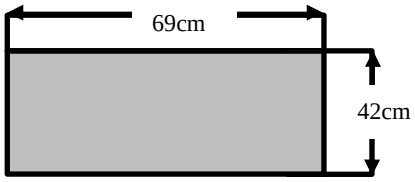

Fig. 1. Basket raw material plate base size

Using the calculus method, the volume of the oven basket is expressed as follows:

$V = x\,(69-2x)(42-2x) = 2\,(1449x-111x^2+2x^3)$

The formula above is the volume equation function x. The next step is to perform the first derivation test on x to find out the maximum or minimum value. as in the calculation below.

$$\frac{dv}{dx} = 2\,(1449 - 222x + 6x^2)$$
$$= 5\,(483 - 74x + 2x^2)$$
$$= 5\,(2x - 57)\,(8{,}5 - x)$$

From the calculation results above, the value of x 57/8.5 might be an extreme value. For this reason, the value of x used is 8.5 and then a second derivation test is carried out.

$$\frac{d^2v}{dx^2} = 2\,(-222 + 12x) = 8\,(2x - 37)$$

Substitute the value x = 8.5 into the equation:

$$8(2x\text{-}37) = 8\,(17\text{-}37) = -160 < 0$$

$$V = 2\,(1449x\text{-}111x^2\text{+}2x^3)$$
$$0 \leq x \leq 21$$

Table 3. Maximum value search table

X	(1449	-111X²		2X³)		Nilai V
0	1449	111	0	2	0	0
1	1449	111	1	2	1	2680
2	1449	111	4	2	8	4940
3	1449	111	9	2	27	6804
4	1449	111	16	2	64	8296
5	1449	111	25	2	125	9440
6	1449	111	36	2	216	10260
7	1449	111	49	2	343	10780
8	1449	111	64	2	512	11024
9	1449	111	81	2	729	11016
10	1449	111	100	2	1000	10780
11	1449	111	121	2	1331	10340
12	1449	111	144	2	1728	9720
13	1449	111	169	2	2197	8944
14	1449	111	196	2	2744	8036
15	1449	111	225	2	3375	7020
16	1449	111	256	2	4096	5920
17	1449	111	289	2	4913	4760
18	1449	111	324	2	5832	3564
19	1449	111	361	2	6859	2356
20	1449	111	400	2	8000	1160
21	1449	111	441	2	9261	0

Then V has a maximum value for the value
x = 8.5
After that, it must be checked whether it is the maximum value of the x value. it can be concluded that 0 < x < 21 because the value x = 0 and the value x = 21 the value V = 0. it can be concluded that the maximum value does not occur in the boundary area, look at Fig. 3.

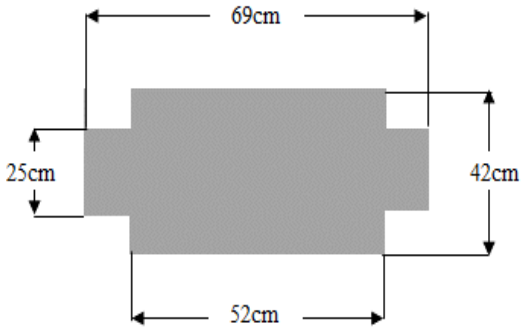

Fig. 2. V maximum heat treatment basket

The implications for the industrial world of this research are to improve the quality of oil seals produced because having the right density in the oven basket arrangement makes the level of maturity of the heat treatment results more perfect. This has an impact on the high service life of the oilseal because it has higher heat and friction resistance. A good heat treatment basket design makes the basket able to accommodate the maximum number of oil seals and allows operators to move more freely in handling materials.

5. CONCLUSION

From the research results it can be concluded that, to save material the most optimum and to get the maximum volume, the cutting is done with a value of x = 8.5cm. Using the new basket oven, the volume of products that can be accommodated is 1,568 pcs when compared to the use of the old basket which was previously able to accommodate 1.344 pcs of products. So it can be concluded that the use of a new basket oven can increase the volume of the basket by 16.7%.

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