p-ISSN : 2335-1357 e-ISSN : 2437-1122

Mediterranean Journal of Modeling and Simulation

Med. J. Model. Simul. 05 (2016) 046-058

Design and analysis of gasket cutting machine

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ARTICLE INFO

Article history :
Received October 2015
Accepted February 2016

Keywords :
Gasket ;
Fully automated ;
Idealization of system ;
Cost analysis ;
Design for manufacturing and assembly.

ABSTRACT

Paper is about the design and analysis of the optimized gasket cutting machine which can be provide to the companies where there is use of gaskets at a certain interval of time. The paper contain the cost optimized machine which is provide at a much lower cost as compared to the machines presently available in the market. This machine can be specifically used for the boiler and refrigeration companies where the gaskets are used to avoid the leakage due to the joining of two different diametric pipes. Inspite of giving a large order of gaskets, they can prepare the same at small rate whenever needed at the location.

1. Introduction

Gasket is a mechanical seal that is used for filling the space between two surfaces, usually to prevent the leakage between the two objects which is under compression. Gaskets are used to cover irregularities on mating surfaces of machine parts. They are commonly produced by cutting from sheet materials such as paper, rubber, silicon, metal, fiber and asbestos lining material (L. Angrisani et al, 1999).

The use of gaskets in automobiles, chemical plants, power plants, ship building yard, breweries, dye, stuff plants, oil refineries, refrigeration plants, allied industries, assembly lines in refrigeration plants etc (Trelleborg sealing solution,2011). In refrigeration and air conditioning system during assembly of the pipes different diameters pipes are bolted together (David A. Nash et al, 2009 ; Dennis R. Moss et al, 2012). During joining the two different diameters pipe there is a possibility of leakage due to improper contact between them. During assembly there is a major problem of leakage of refrigerant leads to decrees the internal pressure and flow rate of refrigerant. These gaskets get degraded after a specific life time. And for the replacement the companies have to order the same in a bilk. So, rather than buying the gasket the company can have one of the machines so that they can make the gasket whenever needed. But in market the gasket machine

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is available at 30,000-50,000 INR (471- 785 USD). In this paper design of the machine which can cuts gasket rings of different diameters as per requirement.

The machine can be operated manually and can be designed to cut gasket of different diameters and sizes with proper accuracy of +/- 1mm by using this special purpose machine the gasket rings of different diameters can be cut and used in assembly line. The gasket sheets up to 3mm to 5 mm thickness can be cut with proper accuracy. The machine doesn't require any kind of external supply. It doesn't need electric power to run, so it can be used in remote area also. Or otherwise the machine can be operated manually, semi-automated or fully automated depending upon the need. The machine is portable and simple in working.

2. Numerical modeling

Designing is the process of developing a product followed by generation and evaluation of the same. The designing process includes identification, refining, evaluating and then the documentation of the designed product. The design procedure is well depicted in Figure 1.

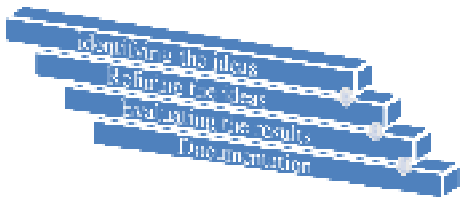

Fig. 1 – Design procedure.

2.1. Design consideration

For the designing of the gasket cutting machine it was necessary to assign some constant parameters for the initial designing procedure (James Walker Moorflex). So, for the same in this paper the diametric range of the gasket ring is considered to be 50mm to 300mm and an accuracy of +/- 1mm. The maximum thickness of the gasket sheet is considered to be 5mm. The length of the guide way is 700mm and height of the machine is 250mm. The main factor of consideration is the ovality ; there should be no ovality error.

2.1.1. Design and description of the different components

The machine consist of base frame subassembly that contains L-angle guide ways on which disk can be slide the supporting panel of the machines that are front supporting plates and L-shaped plates to support the total weight of machine and hold it at proper ground clearance (M.F. Spotts et al, 2011).

Another sub assembly contains the supporting disk with its mountings. On the guide ways the sliding support can be fixed which can slides the disk as per requirement. Above that the disk holder can be placed which holds the disk in proper manner. On which the disk is mounted which both can have sliding as well as rotating motion due to arrangement of bearing. To hold the gasket in proper position above the disk the ovality reducer is placed which can be fitted by screw and thread arrangement.

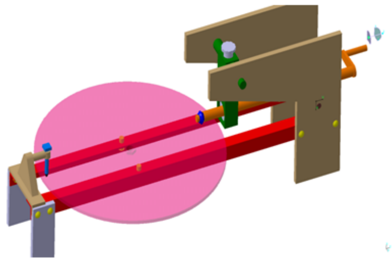

Fig. 2 – Design model of the gasket cutting machine (Catia User Manual).

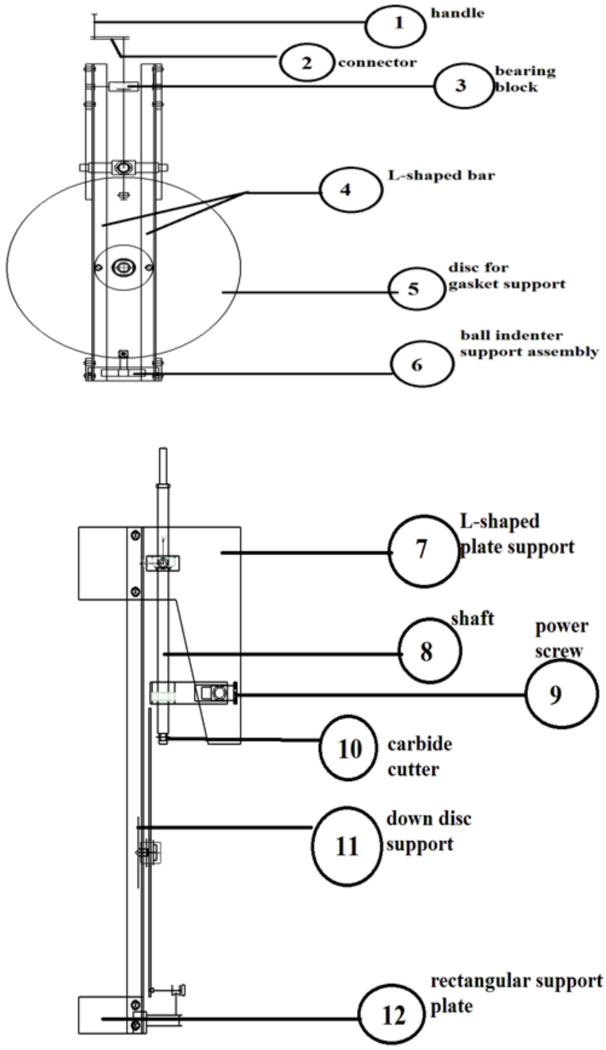

Fig. 3 – Schematic model of gasket cutting machine.

There is another arrangement of roller which can also sides along disk on guide ways with disk. It helps to support the disk at the load side to reduce its tilting effect towards the load side. The cutting operation can be done by carbide tip cutter mounted on the solid shaft at its end. Which can be pressurized by the nut and screw arrangement its head. The shaft is pivoted at one support close to its other end. It consists of handle which can used to rotate the shaft. By simply rotating it the cutting operation can be done. The design model of the gasket cutting machine is shown in Figure 2.

The gasket cuttig machine was modeled taking into consideration, the conventional geomerty of the model. The new characterestics was achieved by introducing an innovative idea of reducing the number of parts and reducing the complexity of the design by using a simple design. The nuber of parts used is less as compared to the previous design. The concepts of design for manufacturing and assembly is been greatly used. The circular base 10 for mounting the raw material is made more dynamically sound by applying necessary constraints.

The constrains can be added or removed according to the work application. To avoid the sagging or bukling of the raw material during cutting a ball indenter support 11 is provided. This innovative design lets the new design to stand out of the crowd because of its uniqueness. FIG. 3 shows the respective view of the gasket cutting machine consist of two L-angle bars 4 which is supported by L shaped plates 7 on one end and rectangular shaped plate 12 on other end. These ensures the stability of the parts above the L-angle bar and provide a good support to the system.

The front frame according to the embodiment includes a ciruclar disc plate 5 on the bars on which the raw materials kept inorder to cut gaskets. These are attached to the bars with the help of the disc support 11 which is tightend with the help of screw. Now a shaft 2 is used in which to the end the carbide tool 10 can be fixed which is useful for cutting the gasket. To the other end of the shaft consist a handel 1 which makes it useful during the period of power cuts. The gasket cand me cut by rotating the handel too.

This shaft is held in a position by using two blocks ; one is bearing block 3 and another one is couple block . These two consists of bearing house which enhances the easy rotation of the shaft. Figure also shows couple block which contains a power screw 9 which provides or which is used to maintain the essential pressure needed to cut the gasket. By rotating the power screw we can change the pressure because as we rotate the screw it pressurises the shaft to bend thus applying pressure on the gasket material.

The assembly consisting of the ball indenter which is used to provide an essential reaction or support to the gasket material to avoid sagging or bending of material due to the application of force by the cutter. To the bottom a shaft or pulley is attached to the disc down support 11 through which a belt is attached which is inturn connected to the motor which can be used to rotate the disc which will appreciate the use of automatic cutting of gasket. The shaft consisting of the tool can be moved linearly to adjust the diameter of the gasket that is to be made.

3. Analysis

The next step after designing is to do the analysis of the product. In earlier days, for analysis one has to actually make a prototype which is actually a very lengthy process and waste of time. But the modern technology has provided the easy way of analyzing the design with the help of software's. Analysis is an essential process as it helps in determining the major failure parts of the system under study. The use of software's has made it easy to check the actual failures same as if the design would have been subjected to the actual working conditions. For the analysis using software's one has to idealize the system geometry, field conditions, boundary conditions etc and the results so obtained from the analysis are next to accuracy and it will or may differ from other software's as the solvers used by the software way differ. The results may differ but the difference in the results will be very less.

3.1. Mesh

The analysis of the system was carried out using Ansys software. For the analysis to start it is very important to mesh the design which has been imported. Meshing is the process of discretizing the model into small distinct parts. Finer the mesh more accurate will be the result. The meshing used is the tetrahedral mesh and the meshing is shown in Figure 4.

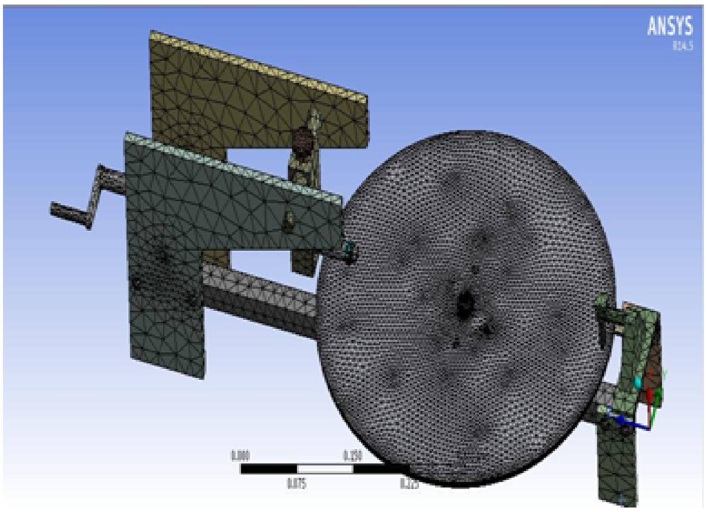

Fig. 4 – Meshing of the designed part (Ansys workbench).

The respective number of nodes and elements generated is shown in Table 1. As the mesh count increases there is an increase in number of nodes and element.

Table 1 – Shows the number of element and node obtained in meshing (Ansys workbench).

Statistics	
Nodes	124043
Element	62990
Mesh metric	None

After doing the meshing it is necessary to give essential boundary conditions such as the end conditions, forces moment etc to get the accurate result (Koji Teramoto et al, 1998 ; Edgar R., 2012). The boundary conditions applied to system are ; a pressure of 398

Pa is applied on the plate due to cutter, a reactant force of 50 N is applied by the ball indenter support, and legs of the system are fixed. The boundary conditions fed to the software is shown in Figure 5.

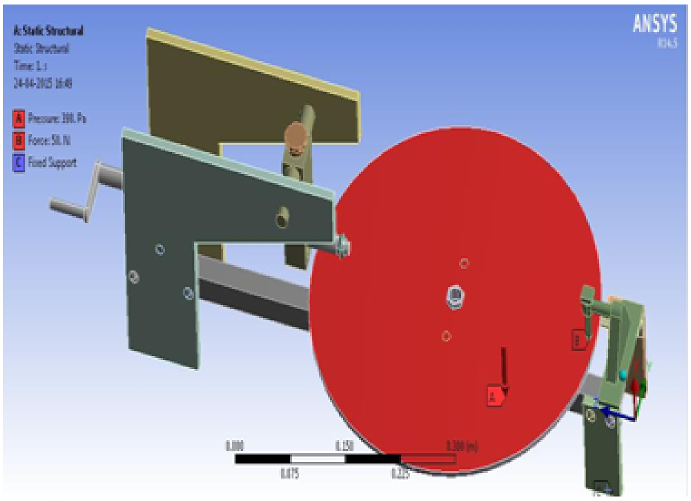

Fig. 5 – Boundary condition given to the design (Ansys workbench).

The values of the forces applied to the model as shown in Figure 5 are given in the Table 2.

Table 2 – Values of the boundary condition applied to the model (Ansys workbench).

Object name	Pressure	Force	Fixed support
State	Fully defined		
Scope			
Scoping method	Geometry selection		
Geometry	1 face	2 face	3 face
Definition			
Type	Pressure	Force	Fixed support
Define by	Component		
Coordinate system	Global coordinate system		
X component	-398 Pa (ramped)	-50 N (ramped)	
Y component	0 Pa (ramped)	0 N (ramped)	
Z component	0 Pa (ramped)	0 N (ramped)	
Suppressed	No		

3.2. Results

After giving the all the essential boundary conditions and running for the results. The first is the deformation result, it is found that the maximum deformation obtained is 0.004 mm which is a very small deflection and can be neglected. The following deflection is shown in Figure 6.

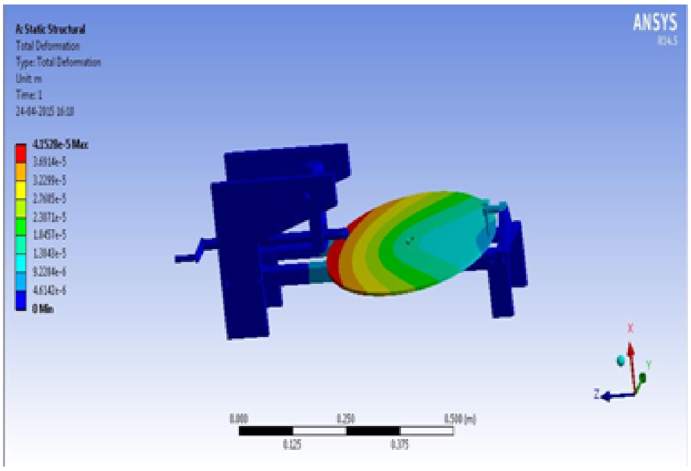

Fig. 6 – Deformation of the designed model (Ansys workbench).

The maximum value of stress induced in the designed model is 1.6765e7 Pa; whereas the maximum allowable stress for the model is 2.5e8 Pa. Thus, the model is safe as per stress point of view and is shown in Figure 7.

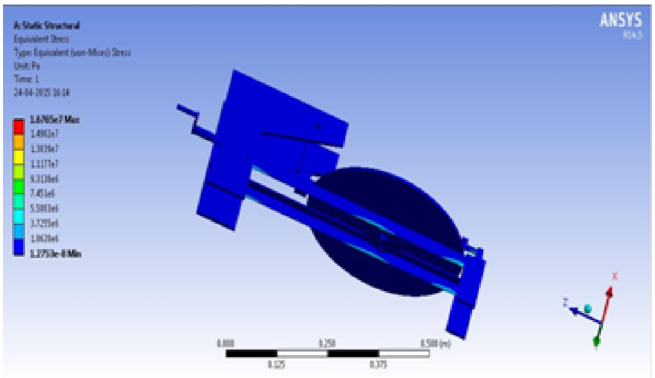

Fig. 7 – Von-Mises stress analysis of the designed model (Ansys workbench).

Similarly, the maximum value of strain subjected to the model is 9.3733e-5 m/m, while the actual value is 4e-6 m/m. Thus the model is safe and is shown in Figure 8.

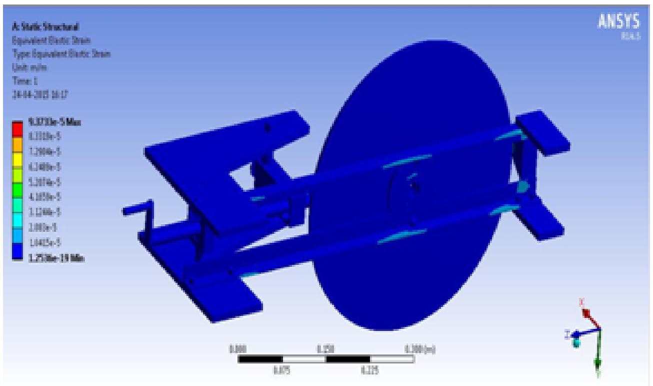

Fig. 8 – Von-Mises strain analysis of the designed model (Ansys workbench).

According to the results obtained from the results, the maximum and the minimum values of the desired parameters and the area of effect is shown in Table 3.

Table 3 – Maximum and minimum values of deformation, equivalent stress and strain (Ansys workbench).

Object name	Equivalent stress	Equivalent strain	Total deformation
State	Solved		
Scope			
Scoping method	Geometric selection		
Geometry	All bodies		
Definition			
Type	Equivalent (von-Mises) stress	Equivalent elastic strain	Total deformation
By	Time		
Display time	Last		
Calculate time history	Yes		
Suppressed	No		
Integration Point Result			
Display option	Averaged		
Results			
Minimum	1.2753e-008 Pa	1.2536e-019 m/m	0 m
Maximum	1.6765e+007 Pa	9.3733e-005 m/m	4.1528e-005 m
Minimum occurs on	Shaft		Down support
Maximum occurs on	Gasket indenter		Circular disc

3.3. Idealization of the results

From the results which were obtained from the analysis of the designed model it is clear that the maximum deformation occurs in the disc. Therefore, analysis for the disc alone was done by using Ansys APDL. Both Ansys classical and workbench are used for the analysis purpose but for more theoretical results Ansys classical are used but work industrial application workbench are used. The same boundary conditions were given for the analysis as it was given during workbench except the fixed support i.e., a pressure of 398 Pa is applied on the plate due to cutter, a reactant force of 50 N is applied by the ball indenter support and the centre of the disc is constrained with all degrees of freedom. The boundary conditions so given are shown in Figure 9.

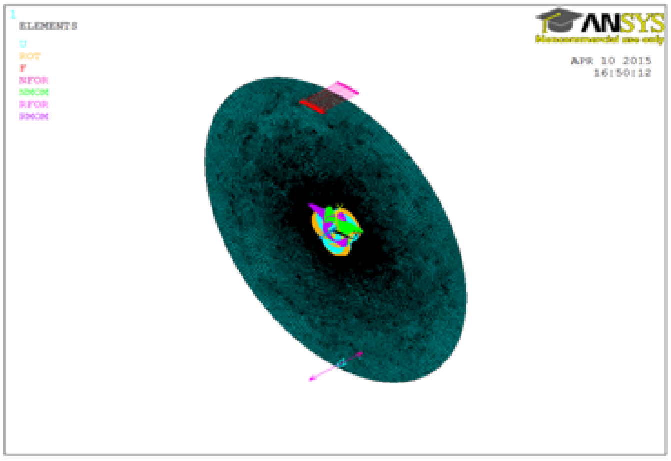

Fig. 9 – Boundary conditions given to the disc (Ansys APDL).

The main concern is with the deformation of the disc. The analysis was carried out and the deformation seemed to be 0.011484 mm which is a negligible value and hence can be neglected. The deformation of the disc is shown in Figure 10.

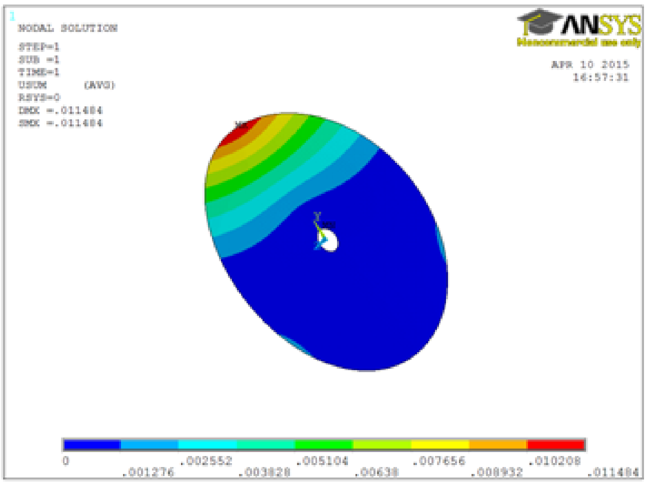

Fig. 10 – Deformation of the disc (Ansys APDL).

The results obtained from both the analysis were satisfying and was well beyond the limits and hence is safe. Thus the structure can be used for the industrial applications.

4. Cost Analysis

In order to sell the product in a market, the product should have enough qualities. One of such factor is the cost (Bryan R. et al, 2011 ; G. Boothroyd et al, 1993). When it comes to the market survival and to compete with the other companies it is necessary that the product should attract the customers and the first factor which attracts the customers is the cost of the product. The products are required to be manufactured at the lower cost and with good qualities.

4.1. Manufacturing methods

The important factor which decides the cost of the part is the cost of machining or different manufacturing process used for manufacturing the respective parts. The manufacturing process of the parts required for the model has been explained in Table 4.

Table 4 – Manufacturing methods of the parts.

Sr.No :	PARTS	PROCESS
1	Shaft	1. Power hacksaw 2. Facing 3. Turning
2	Side plate	1. Gas cutting 2. Grinding 3. Drilling
3	L angle	1. Cutting 2. Grinding 3. Drilling
4	Bearing block	1. Power hacksaw 2. Drilling 3. Boring 4. Turning
5	Nut Block	1. Power hacksaw 2. Drilling 3. Threading 4. Turning
6	Guide way upper plate	1. Power hacksaw 2. Drilling 3.Threading
7	Supporting roller	1. Power hacksaw 2. Drilling 3. Threading 4. Welding
8	Circular disc	1. Gas cutting 2. Drilling

4.2. Cost of manufacturing

The cost analysis of the product is done using DFM software. The calculated cost of the designed model is shown in Table 5.

Table 5 – Cost analysis of the model (DFMA user manual).

Sr. No	PART NAME	MATERIAL	WEIGHT (Kg)	QTY	COST (INR)	COST (USD)
1	M.S Plate	Mild steel	9	2	675	10.6
2	L Angle	Mild steel	2	2	150	2.36
3	Rectangular bar	C45	4	3	300	4.71
4	Nut	Std		23	50	0.78
5	Bolts	Std		25	114	1.79
6	Wicer	Std		1	6	0.09
7	Circlips	Std		5	20	0.31
8	Bearing 6002	Std	0.05	2	305	4.79
9	Bearing	Std	0.025	1	70	1.1
10	Cutter	Std	0.05	1	400	6.28
11	Machining charges				1550	24.33
12	Fabrication charges				1250	19.63
13	Painting				300	4.71
	Total		15.125		5190	81.48

But there is always a scope of reducing the overall cost by eliminating some unnecessary things from the designed model. This can be done by using DFMA software. The assembly reduction analysis result is shown in Table 6.

Thus Table 5 shows that the cost of the designed model can be reduced depending upon the necessity. The weight of the disc can be varied by varying the thickness of the disc. The thickness of the disc will vary upon the type of gasket that has to be cut.

Table 6 – Cost reduction analysis of the assembly (DFMA user manual).

PART NAME	WEIGHT	QTY.	COST	WEIGHT REDUCTION POSSIBLE	COST REDUCTION POSSIBLE
Rectangular bar	4	3	300	2	150
Cutter	0.05	1	400		300
Machining charges			1550		800
Fabrication charges			1250		300
Disc material	4	1	320	3	230
TOTAL	15.125		5190	5 Kg	1780 INR (27.95 USD)

PRODUCT WEIGHT	15.125 - 5 kg	7.7 kg
PRODUCT COST	5190 – 1780	3410/- INR (53.54 USD)

5. Conclusion

As discussed above, the design is fully safe and can be used in the best possible way. Now the industries can create the gasket at the own places without going for other dealers. The designed concluded that the main difference between the existing and the new design model is that the design complexity is reduced so that one can assemble it easily (G. Boothroyd, 2010), the weight of the model is been reduced so thus light in weight and the last but not the least the cost of the product is been reduced to a greater extent. The design can be used manually, semi-automatic or fully automated.

The designed model proves to be much more superior to the existing gasket cutting machine. And by using this system will surely will reduce the dependency of the industry on other gasket producing dealers. The result during the analysis of the project was good which indicate that the product is ready for its application

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