Solution for stainless steel jar crack beading while usage time

Ashwanth Srinath.G
Department of Mechanical engineering
Sri Sairam Engineering College
Chennai,India
ashwanthsrinathg@gmail.com

Athithan.E
Department of Mechanical engineering
Sri Sairam Engineering College
Chennai,India
e.athithan@gmail.com

Bhanu Prasanna.A
Department of Mechanical engineering
Sri Sairam Engineering College
Chennai,India
look4prasana@gmail.com

Annamalai.V
Department of mechanical engineering
Sri Sairam Engineering college
Chennai,India
annamalaikohli123@gmail.com

Krishnaraj. S
Assitant Professor – Grade II
Department of Mechanical engineering
Sri Sairam Engineering College
Chennai,India
krishnaraj.mech@sairam.edu.in

***Abstract*- Preethi Home Appliances Pvt. Ltd., is India's largest mixer grinder brand and a leading Kitchen Appliances company.**

With presence in over 10 million households across India and abroad, and having such a reputation, there are few problems faced by the firm, and by rectifying them they can keep up with the industrial competition. Hence considering one such problem, stainless steel jar beading crack, design and analysis for the existing design is made to identify the problem and to eliminate them or suggesting a feasible design for the rectification of the problem.

Keywords— Beading, crack, design, analysis

I-INTRODUCTION

A modern kitchen is never complete without a mixer-grinder. But at the same time, it has no place for run of the mill products. More than many homemakers like to run their kitchen with a Preethi mixer-grinder. And the numbers are the proof to this. With presence in over 10 million households' across India and abroad, Preethi is India's largest mixer grinder brand and a leading Kitchen Appliances company.

Preethi, now seen as a giant in the industry, had a humble beginning in 1978. From a small mixer-grinder brand, it has grown into a nationally reputed kitchen appliances company. Auto-Cooker/ Warmers, Induction Cook Tops, Electric Pressure Cookers and Coffee Makers are just a few among our products to enter the hearts and kitchens of many families across the world. And these are the families that inspire us to innovate. Every Preethi appliance is efficient, contemporary and easy to use. And it keeps evolving to support and often improve the lifestyle of many a people.

Started in early 1990's.Various steels with different Ni content from 6% to 0.2%.The development was initiated to cater the domestic market of utensils, with low cost stainless steel. The technical theme behind development of these grades was mainly to substitute the costly nickel with manganese and nitrogen to achieve the austenitic structure. With the growing popularity and increased knowledge on the in-service properties of such steel across India, this steel could also find high-end applications in the field of consumer durables, catering and food processing industry, architecture, transport, building and construction. Role of alloying elements, Manganese is added to steel to improve hot working properties and increase strength, toughness and hardenability. Manganese has THREE main effects to aid the stability of stainless steel promotes the formation of austenite combines with the sulphur to form manganese sulphides increases the solubility of nitrogen. Nickel, The reason for Nickel addition is to promote an austenitic structure. Nickel generally increases ductility and toughness. It also reduces the corrosion rate and is thus advantageous in acid environments. Chromium, Most important alloying element in stainless steels, it provides stainless steels basic corrosion resistance. It also increases the resistance to oxidation at high temperatures. Nitrogen, Nitrogen is a very strong austenite former. It also substantially increases the mechanical strength. Moreover, Nitrogen improves the resistance to pitting. Copper, Copper enhances the corrosion resistance and stress corrosion cracking resistance in certain acids and promotes an austenitic structure. Presence of copper also increases ductility.

II-ALTERNATE MATERIAL SUGGESTION

As machinability depends on the strength and hardness of the work material, tensile strength and Brinell hardness data are included in Table 9 to Table 11. If the material strength or hardness differs from the values given, the recommended machining parameter determined by the machinability index will need to be interpolated or extrapolated accordingly.

The values quoted in Table are estimated to be valid in about 70 % of cases. They are based on a flank wear land width of VB ≈ 0.6 mm at the end of the tool's life, and a tool life of T = 30–60 min for carbide cutting tools in group N10 (N20), or T = 45–90 min for HSS cutting tools (HS10-4-3-10).

When machining copper materials with a strain hardened skin, the machinability of the material is determined by the machinability of the skin, which is itself dependent on the hardness of the skin layer.

Machinability rating	**HSS**	***Solid carbide D=3–20 [mm]***	***Carbide inserts***
60	58	205	290
50	52	194	263
40	46	183	235
30	41	171	208

TABLE 2.1 MACHINABILITY

Copper is a good conductor of heat. This means that if you heat one end of a piece of copper, the other end will quickly reach the same temperature. Most metals are pretty good conductors however, apart from silver, copper is the best.

Thermal conductivity of common metals. When you heat one side of a material, the other side will warm up. The values above are a measure of how quickly the other side gets as hot as the heated side.

It is used in many heating applications because it doesn't corrode and has a high melting point. The only other material that has similar resistance to corrosion is stainless steel. However, its thermal conductivity is 30 times worse than that of copper.

Metal	Relative Conductivity
Copper	394
Silver	418
Aluminum	238
Stainless steel	13

TABLE 2.2 RELATIVE CONDUCTIVITY

Copper is a ductile metal. This means that it can easily be shaped into pipes and drawn into wires. Copper pipes are lightweight because they can have thin walls. They don't corrode and they can be bent to fit around corners. The pipes can be joined by soldering and they are safe in fires because they don't burn or support combustion.

Copper and copper alloys are tough. This means that they were well suited to being used for tools and weapons. Imagine the joy of ancient man when he discovered that his carefully formed arrowheads no longer shattered on impact.

Copper is low in the reactivity series. This means that it doesn't tend to corrode. This is important for its use for pipes, electrical cables, saucepans and radiators.

It also means that it is well suited to decorative use. Jewelry, statues and parts of buildings can be made from copper, brass or bronze and remain attractive for thousands of years.

Copper is inherently antimicrobial, meaning it will rapidly kill bacteria, viruses and fungi that settle on its surface. This property is seeing the installation of surfaces made from copper and copper alloys in hospitals and other areas where hygiene is a key concern.

	Brass	Bronze
Composition	Alloy of copper and zinc. Commonly contains lead. May include iron, manganese, aluminum, silicon, or other elements.	Alloy of copper, usually with tin, but sometimes other elements, including manganese, phosphorus, silicon, and aluminum.
Colour	Golden yellow, reddish gold, or silver	Usually reddish brown and not as bright as brass
Properties	More malleable than copper or zinc. Not as hard as steel. Corrosion resistant. Exposure to ammonia may produce stress cracking. Low melting point.	Better conductor of heat and electricity than many steels. Corrosion resistant. Brittle, hard, resists fatigue. Usually a slightly higher melting point than brass.

TABLE 2.3 PROPERTIES COMPARISON

Brass often has a bright gold appearance; however, it can also be reddish-gold or silvery-white. A higher percentage of copper yields a rosy tone, while more zinc makes the alloy appear silver. Brass has a higher malleability than either bronze or zinc. Brass has desirable acoustic properties appropriate for use in musical instruments. The metal exhibits low friction. Brass is a soft metal that may be used in cases when a low chance of sparking is necessary. The alloy has a relatively low melting point. It's a good conductor of heat. Brass resists corrosion, including galvanic corrosion from salt water. Brass is easy to cast. Brass is not ferromagnetic. Among other things, this makes it easier to separate from other metals for recycling.

While modern living has made a turn towards the more convenient steel, glass and non-stick cookware, old-school utensils are noted to hold therapeutic benefits, whether you use them for cooking, or to eat. While glass and steel are fairly neutral, coated or non-stick pans could even be detrimental to the health of skin. According to a research, the chemicals that leach off these coated pans could cause conditions like chronic acne.

Bronze usually is a golden hard, brittle metal. The properties depend on the specific composition of the alloy as well as how it has been processed. Here are some typical characteristics: Highly ductile. Bronze exhibits low friction against other metals.

Many bronze alloys display the unusual property of expanding a small amount when solidifying from a liquid into a solid. For sculpture casting, this is desirable, as it helps to fill a mold. Brittle, but less so than cast iron.Upon exposure to air, bronze oxidizes, but only on its outer layer. This consists of copper oxide, which eventually becomes copper carbonate. The oxide layer protects the interior metal from further corrosion. However, if chlorides are present (as from sea water), copper chlorides form, which can cause "bronze disease" - a condition in which corrosion works through the metal and destroys it.

Aluminum is a very light metal with a specific weight of 2.7 g/cm^3, about a third that of steel. For example, the use of aluminum in vehicles reduces dead-weight and energy consumption while increasing load capacity. Its strength can be adapted to the application required by modifying the composition of its alloys.

Aluminum naturally generates a protective oxide coating and is highly corrosion resistant. Different types of surface treatment such as anodizing, painting or lacquering can further improve this property. It is particularly useful for applications where protection and conservation are required.

Aluminum is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made aluminum the most commonly used material in major power transmission lines.

Aluminum is ductile and has a low melting point and density. In a molten condition it can be processed in a number of ways. Its ductility allows products of aluminum to be basically formed close to the end of the product's design.

As discussed with the firm the earlier test reports from the lab produced the following data, the chemical analysis for two of the jar specimen was carried out:

TABLE 2.4 PREVIOUS TEST REPORTS

Chemical Analysis :		Test Method : OES - ASTM E1086-14	
S. No.	Characteristic Test	Requirements	Results
1	Carbon, (%)	0.15 Max	0.086
2	Manganese, (%)	5.5 – 7.5 Max	6.160
3	Silicon, (%)	1.00 Max	0.736
4	Sulphur, (%)	0.030 Max	0.024
5	Phosphorus, (%)	0.060 Max	0.050
6	Chromium, (%)	16.0 -18.0	16.854
7	Nickel, (%)	3.5 – 5.5	5.053
Note : The Sample given for test confirms to AISI 201.			

TABLE 2.4 (A) OES-ASTM STANDARD TEST REPORTS

S. No.	Characteristic tests	Findings
01	Carbon, (%)	0.17
02	Tin, (%)	0.22
03	Iron, (%)	0.10
04	Copper, (%)	90.43
05	Others, (%)	0.080
06	Oil Content, (%)	8.20

TABLE 2.4 (B) OES-ASTM STANDARD TEST REPORTS

Email : test@mettexlab.com
Web : www.mettexlab.com
Phone : 044-22323163, 42179490, 91
Fax : 044-22311034

CHENNAI METTEX LAB PRIVATE LIMITED®
Jothi Complex, 83, M.K.N. Road, Guindy, Chennai - 600 032. Certificate No.:TC - 5589

TEST REPORT

Page No. 1of 1

ISSUED TO : M/s.Preethi Kitchen Appliances Pvt. Ltd., (Mixie Plant), Survey No:112/1B,1C,112/2B,Natham, Egattur Road, Thazhambur, Chengalpattu T.K. Kanchipuram.Dt-603103.

T.C Date : 08.03.2019
T.C No : CML/18-19/76175
ULR-TC558919000008333F
Date Of Receipt : 07.03.2019
Completed On : 07.03.2019

Cust. Ref : Letter Dated : 07.03.19
Lab No : 1986679
Sample Description : Jar - Non Ok Part.

Chemical Analysis :		Test Method : OES-ASTM E 1086-14	
S. No	Characteristics Test	Requirements	Findings
1	Carbon, (%)	0.15 Max	0.061
2	Manganese, (%)	5.5 – 7.5 Max	0.540
3	Silicon, (%)	1.00 Max	0.532
4	Sulphur, (%)	0.030 Max	0.007
5	Phosphorus, (%)	0.060 Max	0.030
6	Chromium, (%)	16.0 -18.0	16.299
7	Nickel, (%)	3.5 – 5.5	4.788
Note : The Sample confirms to AISI 201 in respect of items tested.			

End of Report

[redacted]

For Chennai Mettex Lab Private Limited
M. UMAMAHESWARI
Senior Chemist

The lab results for the defective part,

To verify with the above results the same tests were carried out, and the chemical composition of the jar specimen was checked and the lab results produced the following data, the non-defective and defective jars were tested in an authorized laboratory.

Email : test@mettexlab.com
Web : www.mettexlab.com
Phone : 044-22323163, 42179490, 91
Fax : 044-22311034

CHENNAI METTEX LAB PRIVATE LIMITED®
Jothi Complex, 83, M.K.N. Road, Guindy, Chennai - 600 032. Certificate No.:TC - 5589

TEST REPORT

Page No. 1of 1

ISSUED TO : M/s.Preethi Kitchen Appliances Pvt. Ltd., (Mixie Plant), Survey No:112/1B,1C,112/2B,Natham, Egattur Road, Thazhambur, Chengalpattu T.K. Kanchipuram.Dt-603103.

T.C Date : 08.03.2019
T.C No : CML/18-19/76174
ULR-TC558919000008332F
Date Of Receipt : 07.03.2019
Completed On : 07.03.2019

Cust. Ref : Letter Dated : 07.03.19
Lab No : 1986678
Sample Description : Jar - Ok Part.

Chemical Analysis :		Test Method : OES-ASTM E 1086-14	
S. No	Characteristics Test	Requirements	Findings
1	Carbon, (%)	0.15 Max	0.061
2	Manganese, (%)	5.5 – 7.5 Max	6.295
3	Silicon, (%)	1.00 Max	0.345
4	Sulphur, (%)	0.030 Max	0.018
5	Phosphorus, (%)	0.060 Max	0.038
6	Chromium, (%)	16.0 -18.0	16.466
7	Nickel, (%)	3.5 – 5.5	5.276
Note : The Sample confirms to AISI 201 in respect of items tested.			

End of Report

[redacted]

For Chennai Mettex Lab Private Limited
M. UMAMAHESWARI
Senior Chemist

The lab results for the non-defective part,

III - DRAFTED DESIGN

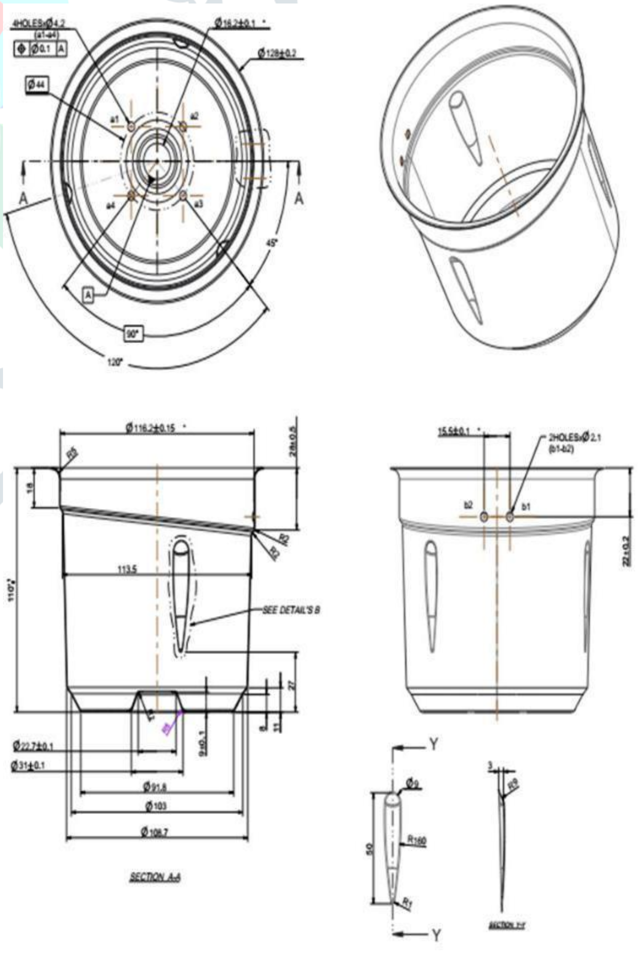


FIG 3.1

3.1 1L JAR DRAFTED DESIGN:

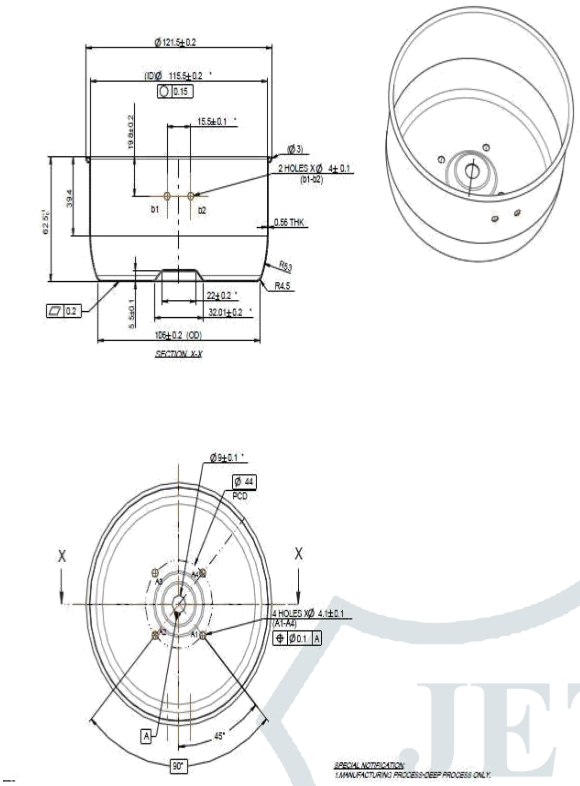


FIG 3.2

3.2 0.5L JAR DRAFTED DESIGN:

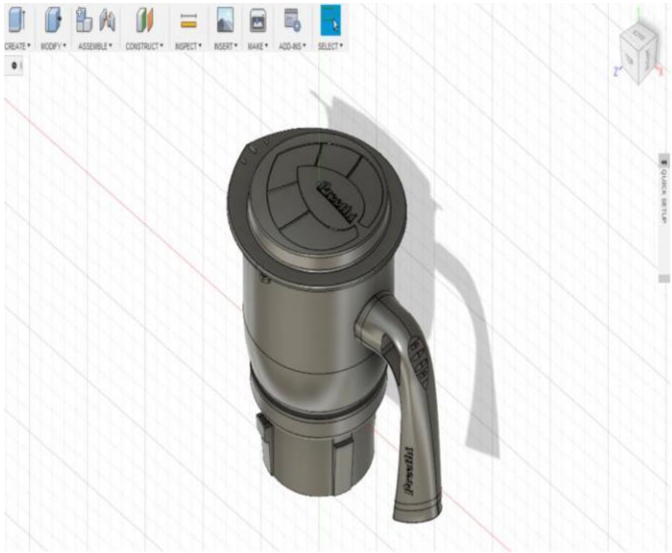


FIG 4.2 1.25 L JAR DESIGN

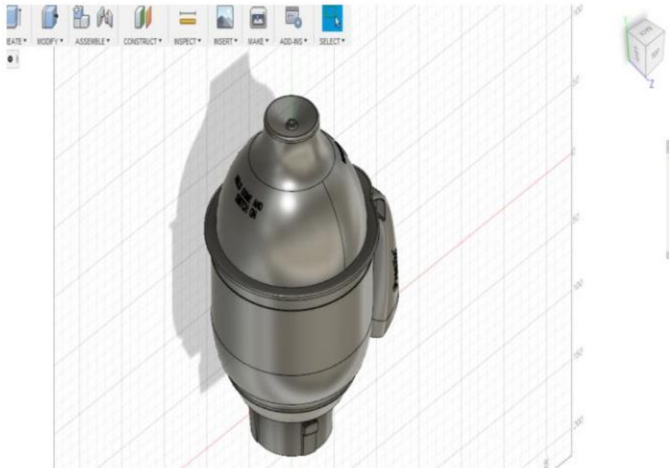


FIG 4.3 1.5 L JAR DESIGN

IV-DESIGN

4.1 EXISTING DESIGN

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius
Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

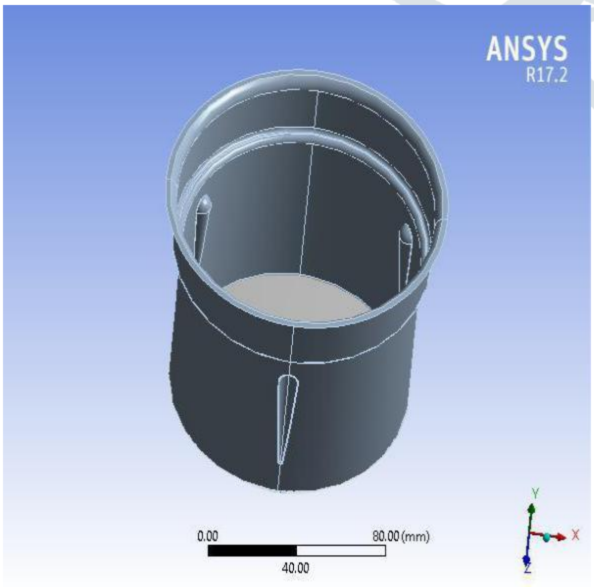


FIG 4.1 EXISITING JAR CAD MODEL

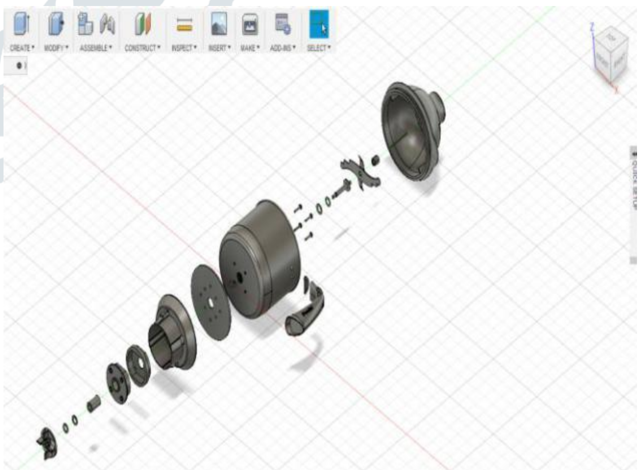
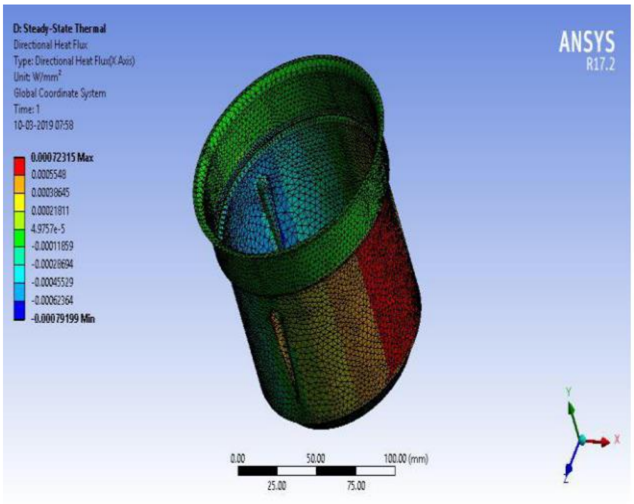
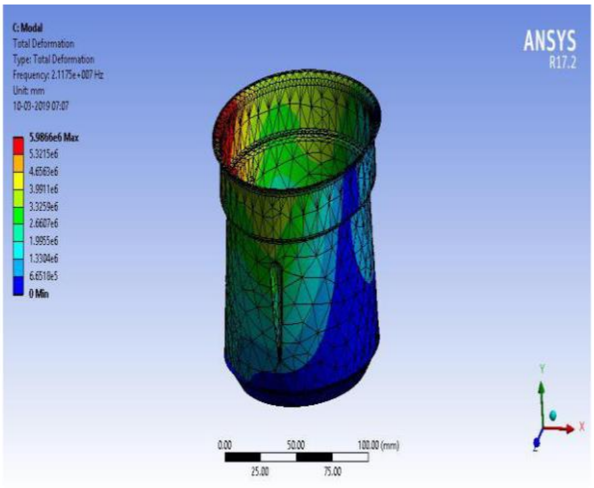
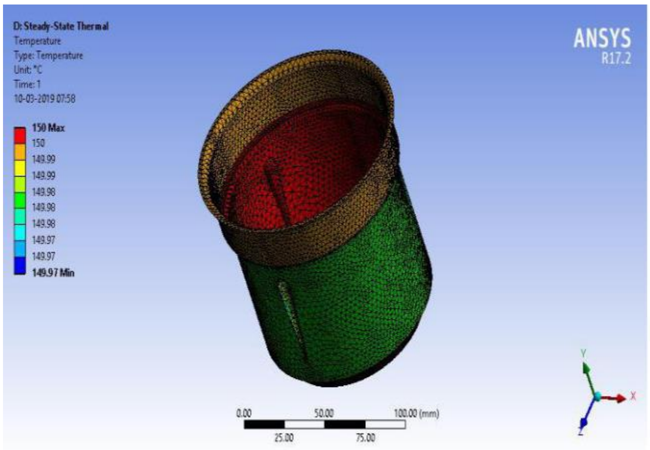


FIG 4.4 EXPLODED VIEW OF THE MIXER JAR

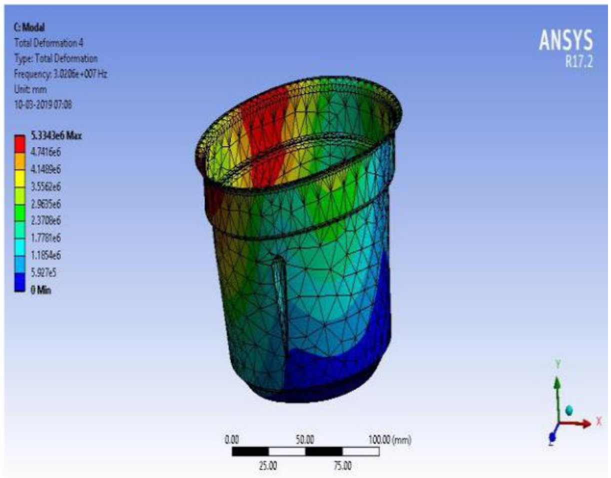




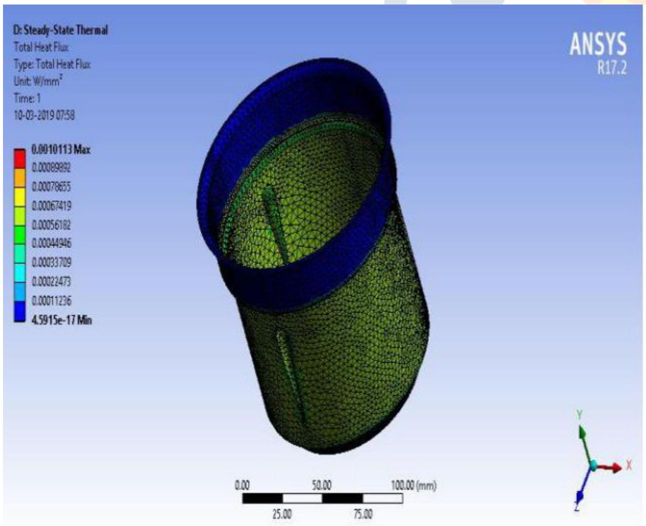
5.7 TOTAL DEFORMATION



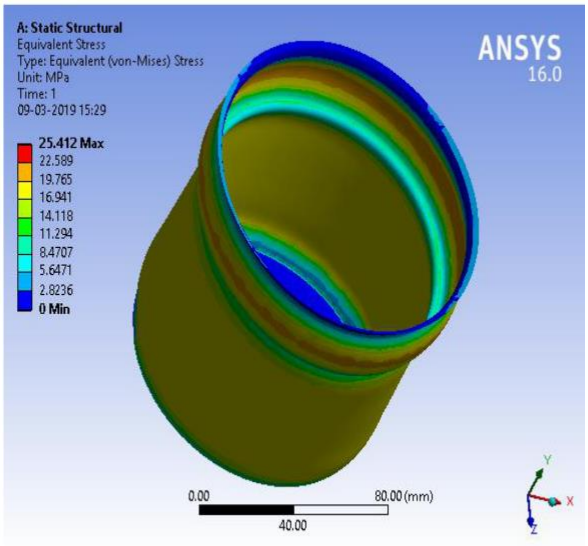
4.5 STEADY STATE THERMAL ANALYSIS



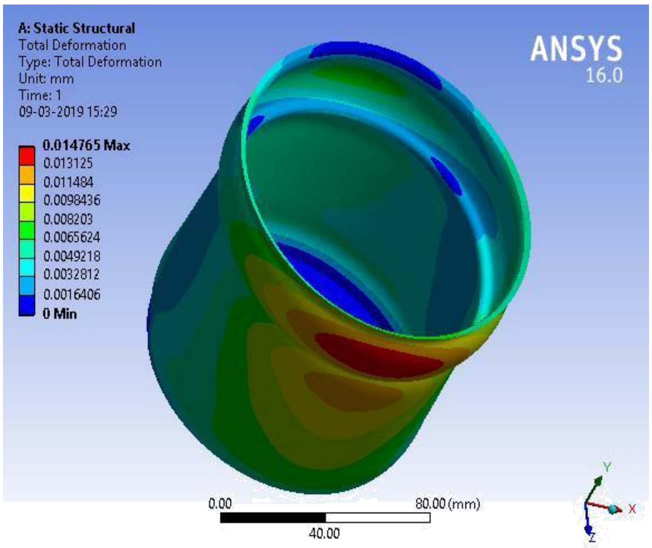
4.8 DIRECTIONAL DEFORMATION



4.6 MODAL STATE ANALYSIS



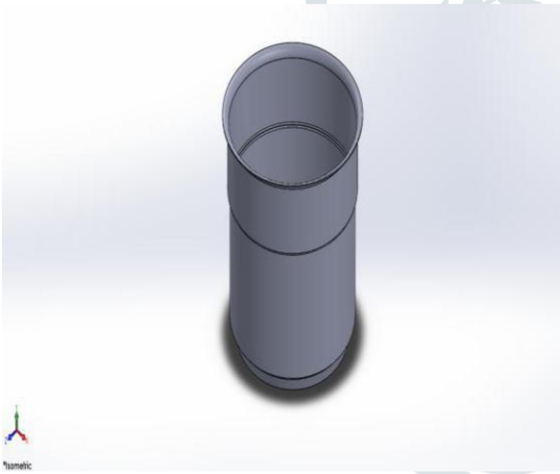
4.9 STRESS ANALYSIS



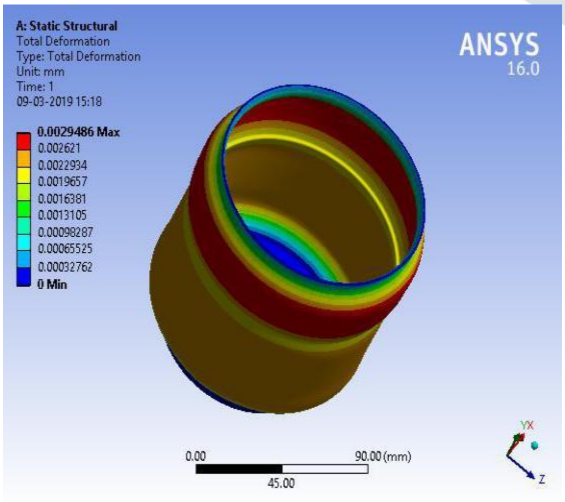
4.10 DEFORMATION ANALYSIS

V- MODIFICATION OF DESIGN

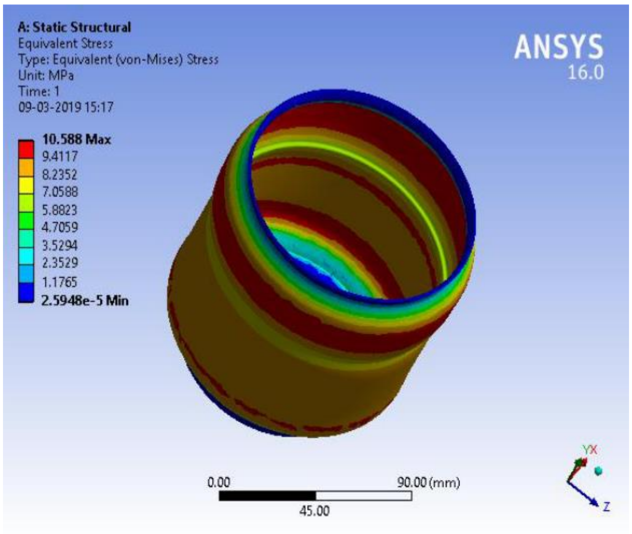
To bring out the required solution, the modal analysis carried provided the idea for the modification of design, the vibrations from the process act an essential role in the failure of the jar, and geometrical design changes have been carried out and the required changes have been minimal and to restrict the cost of production.



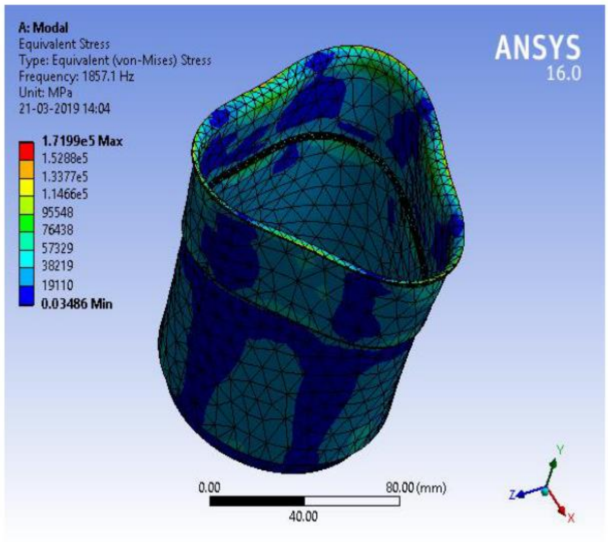
5.1 NEWER MODIFIED DESIGN OF THE JAR



5.2 STRESS ANALYSIS OF NEW DESIGN

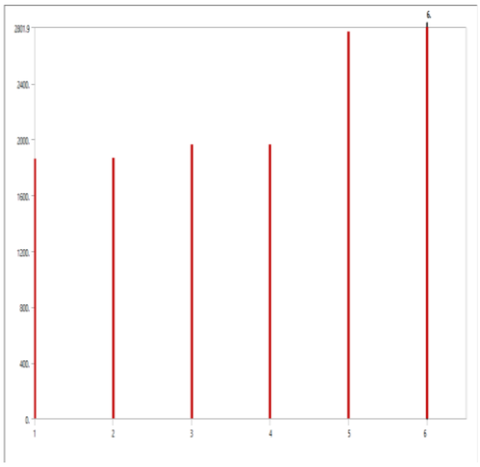


5.3 DEFORMATION ANALYSIS OF NEW DESIGN



5.4 Modal Analysis of The New Design

	Mode	Frequency [Hz]
1	1.	1857.1
2	2.	1863.7
3	3.	1958.2
4	4.	1960.7
5	5.	2771.8
6	6.	2801.9



VI - CONCLUSION

Since alternate material suggestion is not feasible, for several reasons such as production cost, availability and health hazards, the alternate material is not the suggested option for the solution of jar crack while usage time.

The newer design with minimal changes such as thickness of the specimen, radius reduction has been carried out, analyzed and compared with the analysis of the existing design.

On comparison, the newer design is more rigid, non-crack prone and provides better wear and tear of the product with the modal analysis and stress analysis reports and deformation results.

Hence, the newer design is put forth for the solution of the design for better results and hassle free experience for the customers, thereby keeping up with the market competition with an upper-hand of better life of the jar.

REFERENCES

1. I. M, Bernstein, Handbook of stainless steels, New York, NY: McGraw-Hill, 1977
2. T. Santonen, H. Stockmann-Juvala, A. Zitting, Finnish Institute of Occupational Health, Helsinki, Finland (2010).
3. Technical document guidelines on metals and alloys used as food contact materials.2002, Council of Europe retrieved on Mar. 13, 2002 from: http://www.coe.int/t/e/social_cohesion/soc-sp/public_health/food_contact_e.html.
4. a) F. S. Mohammad, E. A. H. Al Zubaidy, G. Bassioni, , *Int. J. Electrochem. Sci*., 6 (2011) 222; b) G. Bassioni, F. S. Mohammad, E. A. H. Al Zubaidy, I. Kobrsi, *Int. J. Electrochem. Sci*., 7 (2012) 4498; c) F. S. Mohammad, E. A. H. Al Zubaidy, G. Bassioni, *Int. J. Electrochem. Sci*. 9 (2014) 3118.
5. P. Agarwala, S. Srivastavaa, M.M. Srivastava, S. Prakasha, M. Ramanamurthy, R. Shrivastav, S. Dassa, *The Science of the Total Environment* 199 (1997) 271
6. M. Accominotti, M. Bost, P. Haudrechy, B. Mantout, P. J. Cunat, F. Comet, C. Mouterde, F. Plantard, P. Chambon, J. J. Vallon, *Contact Dermatitis*,38(1998)305
7. G. N. Flint, S. Packirisamy *Contact Dermatitis* 32(1995) 218
8. Expert Group on Vitamins and Minerals. Safe upper levels for vitamins and minerals. Great Britain: Food Standards Agency; 2003.
9. G. Herting, I. Odnevall Wallinder, C. Leygraf, Journal of Food Engineering, 87(2008), 291
10. R. Cornelis, J. Duffus, P. Hoet, Elemental speciation in human health risk assessment, Environmental health criteria, 234(2006)