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ANALYSIS AND OPTIMISATION OF A COMMON DTH DISH ANTENNA BRACKET ASSEMBLY (FAULT MODE EFFECT AND FINITE ELEMENT)

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Research Article

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ABSTRACT

The most popular form of communication for sending and receiving moving pictures, generally with sound, is television (TV). These transmissions are sent by either cable TV or DTH (Direct-To-Home). DTH is better than cable TV because it provides higher-quality images and can reach rural locations that cable TV and terrestrial transmission have not been able to reach. A crucial component of the DTH installation, the bracket must support the weight of the antenna, feed horn (LNB converter), and wind force acting on the antenna surface. It is crucial to signal reception since the quantity of signal received relies on the antenna's alignment angle. This interruption in signal reception is often brought on by a malfunctioning bracket assembly used to install the dish antenna. Therefore, it must have a strong enough bracket. The current research aims to investigate bracket failure and plastic component failure mode effect analysis, or FMEA. To overcome the current chronic field failure, optimization is done at the failure point site. Several design ideas were created, and the most practical idea was chosen. FEA software programs were used to study the stresses on the bracket.

Keywords: FMEA (Failure Mode Effect and Analysis), Die Designing Methodology, Dish Telivision, Direct to Home (DTH), Finite Element Method, Analysis, and Optimization**.**

INTRODUCTION

The most popular form of communication for sending and receiving moving pictures, generally with sound, is television (TV). The television receives the signals via DTH (Direct-to-Home) or cable TV. More than half of all households worldwide currently use cable television, also known as cable TV or CATV (Community Antenna Television), a system that transmits radio frequency signals to television sets via fiber optic or fixed coaxial cables. On the other hand, DTH stands for Direct-To-house television, which is described as receiving satellite programming in a house using a personal dish. DTH connects the broadcaster and the customer directly, eliminating the requirement for the local cable provider. Satellite programs are only available to cable companies, who subsequently deliver them to individual residences.

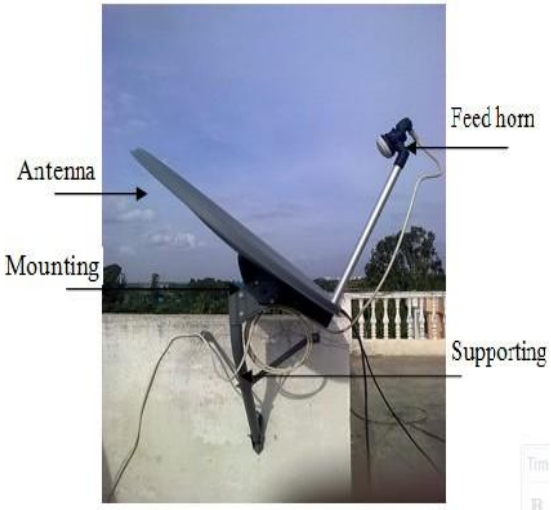


Fig 1.1 DTH dish antenna assembly

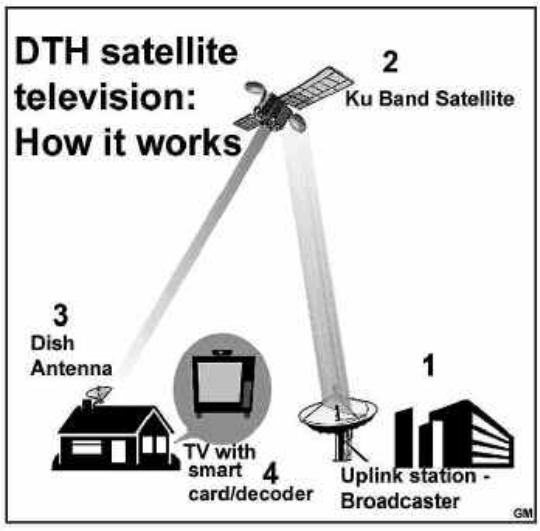


Fig 1.2 Conceptual diagram of a satellite communication

A broadcasting center, satellites, encoders, multiplexers, modulators, and DTH receivers make up a DTH network.

Ku-band transponders must be leased from the satellite by a DTH service provider. The multiplexer combines the data, audio, and video signals once the encoder has transformed them into digital format. A tiny dish antenna and set-top boxes for decoding and viewing several channels will be available at the user's end. DTH is a satellite-based encrypted broadcast that goes straight to the customer. Through the tiny dish antenna, the user receives DTH broadcast straight at his end. In contrast to a standard cable connection, a set-top box decodes the encrypted signal.

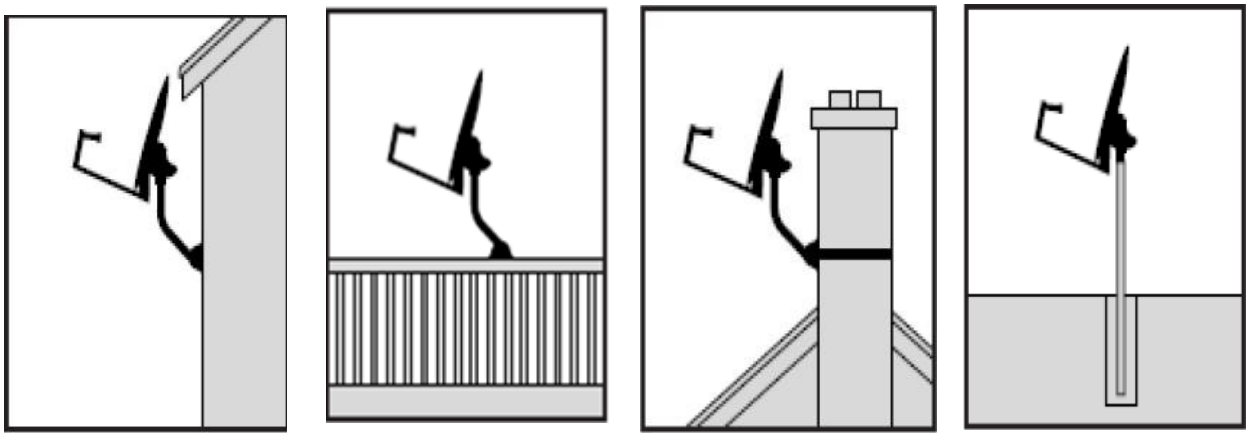
Antenna mountings

A crucial component of the DTH installation, the bracket must support the weight of the antenna, feed horn (LNB converter), and wind force acting on the antenna surface. It is crucial to signal reception since the quantity of signal received relies on the antenna's alignment angle. This interruption in signal reception is often brought on by a malfunctioning bracket assembly used to install the dish antenna.Potential mounting locations for antennae are shown in Fig. 1.3, and TV antenna wall brackets are shown in Fig. 1.4. Wall mounting brackets are perfect for both ground-up and wall-supported mast installations. The wall brackets include a tubular support leg for extra strength and are constructed of 16 gauge steel. They are also known as TV antenna mounts that do not penetrate roofs.

Problems encountered by the customers while using DTH service

1. The service is often interrupted when there is a lot of rain.
2. The majority of the time, the digital TV stops working and no signal is received when it rains.
3. Variation in the alignment of the antenna mounting bracket owing to environmental condition.
4. An issue with the signal receiver and setup box.
5. When there is a strong wind blowing over the antenna surface, the strength of incoming signals decreases.
6. Some DTH systems are not receiving TV channels even after the consumer has recharged.

Two or more horns are used in a novel dish design to detect various satellite signals. One beam strikes one of the horns while another beam strikes a different horn as the beams from other satellites reflect off the curved dish at different angles. The low noise block down converter, or LNB, is the main component of the feed horn. The signal that bounces off the dish is amplified by the LNB, which also filters out noise, or signals that do not include programming. The satellite receiver inside the viewer's home receives the filtered and amplified signal from the LNB.



Exterior wall Wooden rai Chimney Ground

Fig 1.3 Different antenna mounting locations



Fig 1.4 TV Antenna wall brackets

LITERATURE REVIEW

Literature Review on Design Concept selection methods: Abdus Salam [1] presented the mountings and their requirements to avoid any obstacles in the reception of electromagnetic signals using non-penetrating roof mount antenna assemblies. The various design concept selection methods provided by various authors are explained, along with the various benchmarking techniques. The benefits of using an X-Y antenna mount for data collection and satellite tracking tasks utilizing a servo-control system were proposed by Rolinski et al. [2]. An apparatus that uses suction cups or other suction devices to hold an antenna on a mounting surface and move it to another mounting surface was created by Eric Michael Olsen et al. [3]. Without the need for extra sensors, Chang-Ho Cho et al. created an antenna control system (discrete time controller) that can swiftly and precisely follow the target communication satellite and receive the signal emitted from it. In order to place and support a digital satellite dish antenna, Comazell Bickham [5] designed a portable, adjustable stand that removes the need to drill holes and physically connect the antenna to a home's surfaces using screws, bolts, or other fasteners. A motor-driven, movable mounting mechanism for a satellite TV dish antenna that scans a part of a geostationary TV relay satellite orbit belt in line of sight is described by Albert Hugo [6].

Literature Review on FMEA and Benchmarking: FMEA is used to find possible failure modes, assess how they affect the product's functionality, and suggest mitigation strategies. A method for identifying failure modes in product development has been devised by Irem Y. Tumer et al. [7]. To get data on the collection of common failures that a function encounters, a statistical clustering process is suggested. A novel approach called Life Cost-Based FMEA was created by Seung J. Rhee et al. [8]. It analyzes risk in terms of cost and is helpful for evaluating and choosing design options. Failure mode analysis for plastic components used in engineering applications was described by Derham et al. [9]. Sellappan Narayanagounder et al. [10] highlighted the shortcomings of conventional FMEA and presented a novel method for ranking failure modes according to risk importance. It is advised to use the Risk Priority Code (RPC) to rank the failure modes if two or more of them have the same RPN. A straightforward quantitative framework for the benchmarking process was created by Mohammad Reza Mehregan et al. [11]. The analyze phase is based on two well-known mathematical programming methods, TOPSIS and goal programming. The methods that engineering designers have learnt to use when choosing concepts were examined by Busby et al. [12]. Using the analytical hierarchy process (AHP), Hambali et al. [13] developed a concept selection methodology known as concurrent design concept selection and materials selection (CDCSMS) for suitable design and materials at the conceptual design stage.

METHODOLOGY

Generally the mounting bracket in DTH assembly is designed to mount the antenna and the feed horn. As already discussed the bracket plays very important role for supporting the antenna and also in the reception of signal. The presently used bracket is manufacturing with the ABS material. The investigation was carried out with respect to existing DTH antenna mounting bracket. A number of design improvements have been carried out on existing model since it introduced. The improved with new design concept version is designated as New model. Since it was realized that there are some areas where performance specification of new model can be improved.
In the existing design there are some disadvantages they are:

The material thickness is less in some areas (those are called critical regions).

The failure is occurring in the critical regions due to the developed stress.

Based on the disadvantages in the existing design the problem is taken up with different design concepts. The aim of the present work is to study the failure of the antenna mounting bracket. Optimization is carried out at the failure point location to overcome the existing chronic field failure. Different design concepts were developed and the best feasible concept is selected for design and analysis. The model has developed using the CATIA modeling software. The stresses and displacements were analyzed on the bracket using Hyper mesh preprocessor and NASTRAN solver packages.

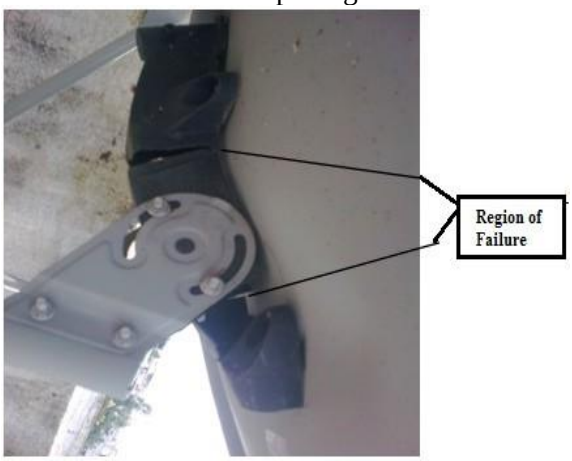


Fig 3.1 Existing mounting bracket failure zone

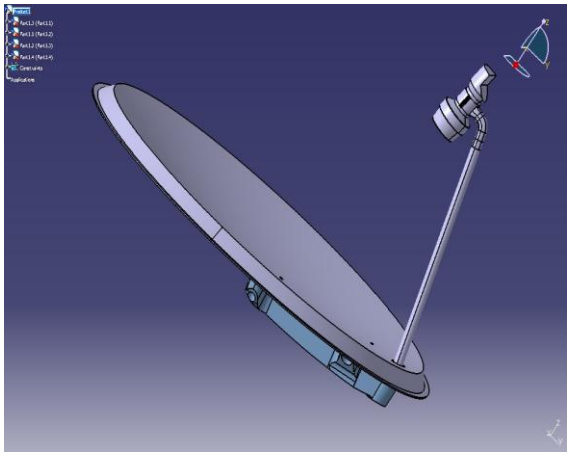


Fig 3.2: Assembled view of DTH using CATIA

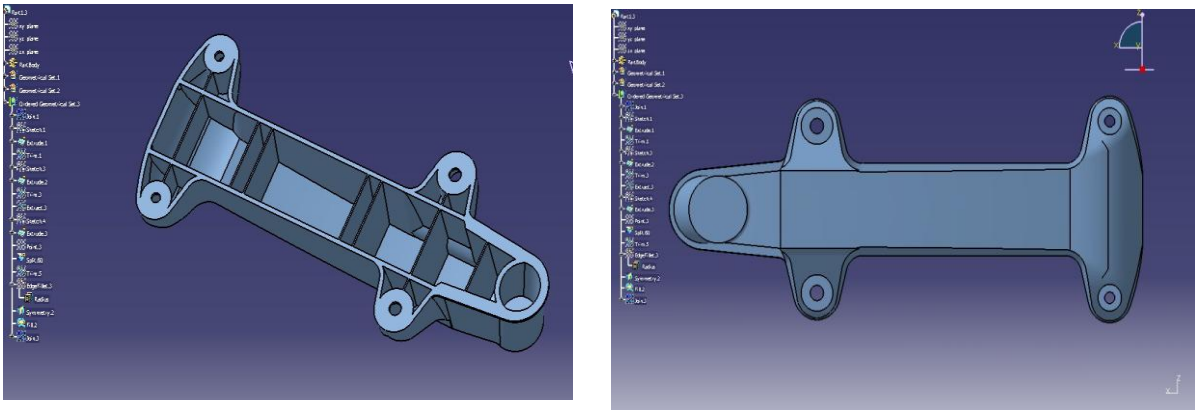


Fig. 3.3: Isometric view and Rear view Geometric model of the mounting bracket

When choosing the right antenna mount, these three factors to keep in mind: Size, Type and Cost. Figure 3.2 shows the assembly of the different parts of the DTH system and Fig.3.3 shows the different dimensions of the mounting bracket in the two different views.

Component modeling

Modeling of the component was done using commercially available software CATIAV5. It provides the tools to accurately model and document the design ready for rendering, animation, mechanism drafting, engineering, analysis and manufacturing or construction.

The selection of the appropriate antenna size helps in keeping the network up and healthy. It is decided based on the following:

Satellite Effective Isotropic Radiated Power (EIRP) at the particular location.

Rain attenuation at the location.

Adequate E_b/N_o (the energy per bit to noise power spectral density ratio) for reception of excellent picture quality.

FMEA (Failure Mode and Effect Analysis) and Benchmarking

Failure Mode and Effects Analysis (FMEA) is commonly defined as "a systematic process for identifying potential design and process failures before they occur, with the intent to eliminate them or minimize the risk associated with them". The FMEA technique was first reported in the 1920s but its use has only been significantly documented since the early 1960s. It was developed in the USA in the 1960s by National Aeronautics Space Agency (NASA) as a means of addressing a way to improve the reliability of military equipment. FMEA is used to identify potential failure modes, determine their effect on the operation of the product, and identify actions to mitigate the failures. A crucial step is anticipating what might go wrong with a product. Various benefits of FMEA

Improve product/process reliability and quality and increases customer satisfaction.
Early identification and elimination of potential product/process failure modes.
Prioritize product/process deficiencies to Provide focus for improved testing and development.
Capture engineering/organization knowledge and Minimizes late changes and associated cost.
Documents risk and actions taken to reduce risk.
Catalyst for teamwork and idea exchange between functions.

Types of FMEA's
There are several types of FMEAs, some are used much more often than others. FMEAs should always be done whenever failures would mean potential harm or injury to the user of the end item being designed. The types of FMEA are:
System - focuses on global system functions

Design - focuses on components and subsystems

Process - focuses on manufacturing and assembly processes

Service - focuses on service functions

Software - focuses on software functions

FMEA Methodology
The flow chart given below describes the procedure involved in the FMEA. The basic step is to identify the potential failure mode and its effect on the system. It also shows the parameters used to determine the criticality of an item failure mode are, the severity of its failure effects, its frequency of occurrence, and the likelihood that subsequent testing of the design will detect that the potential failure mode actually occurs.
Severity is a rating corresponding to the seriousness of an effect of a potential failure mode on the next higher level assembly, the system or the user. (Scale: 1-10. 1: no effect on output, 5: moderate effect, 8: serious effect, 10: hazardous effect)

Occurrence is a rating corresponding to the rate at which a first level cause and its resultant failure mode will occur over the design life of the system, over the design life of the product, or before any additional process controls are applied. (Scale: 1-10. 1: failure unlikely, 5: occasional failure, 8: high number of failures likely, 10: failures certain).

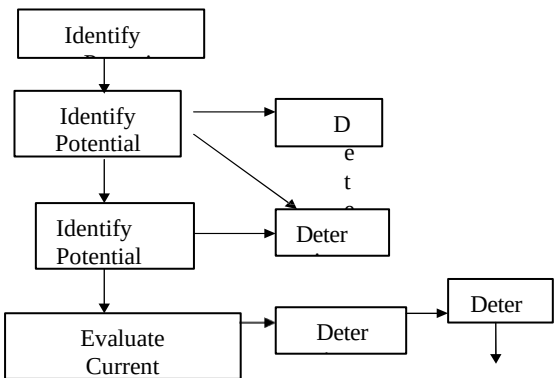


Fig 3.4: Flow chart of FMEA methodology

Detection is a rating corresponding to the likelihood that the detection methods or current controls will detect the potential failure mode before the product is released for production for design, or for process before it leaves the production facility. (Scale: 1-10. 1: will detect failure, 5: might detect failure, 10: almost certain not to detect failures)

Risk Priority Number (RPN)

The RPN is a mathematical product of the severity(S), the occurrence (O) and the detection (D). It is used to identify the most critical failure mode, leading to corrective action

In equation form, **RPN = S x O x D**

Reasons for observed failure

In effective loading due to weather conditions that is too much wind.

Unexpected load may occur due to negligence in the form of access to domestic animals.

Stress localization observed at the critical points.

Manufacturing defects may appear in the mounting bracket.

3.2.3 FMEA Worksheet

Table 3.1: FMEA work sheet for DTH mounting structure

Process operation, product function or purpose	**Potential failure mode**	**Potential effect(s) of failure**	**S E V**	**Potential cause(s) of failure**	**O C C**	**D E T**	**R P N**	**Recommended Action(s)**
Mounting bracket Support the antenna and LNB	**Crack initiation Breakage**	**DTH assembly fail to work**	**7**	**Excess load Manufacturing defect**	**6**	**4**	**168**	**Modify the design of bracket**
	Alignment angle of antenna	**Problem in reception of signal**	**6**	**DTH assembly not fitted properly**	**7**	**3**	**126**	**Fixing DTH at appropriate place. Assemble components properly**

3.2.4 Different types of mounting bracket




Type 1 Type 2




Type 3 Type 4

Fig 3.5: Different types of DTH antenna mountings

The scaling given in the above table for the benchmarking of the different types of DTH antenna mountings available in the market is as follows;

Bear to more weight corresponds to the ability of the bracket which can be able to withstand for the load (Scale: 1-10. 1-less weight, 5-average weight, 10-more weight).

Serviceable life related to the working life of the bracket without failure. (Scale: 1-10. 1-failure occurs very early, 5-average life, 10-failure doesn't occur).

Table 3.2: Benchmarking table of antenna mountings

Types Parameters	Type 1	Type 2	Type 3	Type 4
Bear to more weight	7	6	6	7
Serviceable life	8	6	6	7
Cost	5	7	7	4
Boundary(surface) contact	4	7	7	6
Geometry complexity	8	5	4	7
Total	32	31	30	31

The cost of bracket corresponds to the market price of the bracket. (Scale: 1-10. 1-very high cost, 5-high cost, 7-considerable cost, 10-less cost).

Boundary contact related to the area of contact or surface contact between the antenna and the bracket. It also relates to the amount of load transfer to the bracket, that is if the contact is good then the load will transfer equally to all portion of the mounting bracket and chances of failure is less compare to the poor contact. (Scale: 1-10. 1-less contact, 5-average contact, 10-full contact).
Geometry complexity corresponds to how easily the bracket can be manufactured. (Scale: 1-10. 1- very difficult to manufacture. 5-with considerable effort, 10- can easily manufacture).

Concept Design and Generation

Design requirements

To provide good enough strength to the bracket, the following parameters should be taken in to account in the design:

Ribbing pattern: Ribs are commonly used to give strength and rigidity to the product. At the same time, ribs help to have thinner walls and therefore reduce the amount of material. The structure of bracket can be strengthened by ribs in specific places in order to form a more rigid and stabilized structure. The ribs are strengthening plates mainly placed along the vertical direction for preventing deflection of lateral surfaces and thus creating a rigid structure and reduce deflection.

Thickness: By increasing the material thickness of bracket at critical points, it will greatly improve the bracket strength. The strength to weight ratio is improved by adding to material thickness. It is well known that when the thickness of a product is increased, the weight of a product increases proportionally. Thus, it is important to determine the right thickness of bracket.

Curvature structure: Curvature structure of bracket determines the level of contact with the antenna surface. Since the antenna surface is curved, the effect of load transfer to the bracket depends on the contact between antenna and bracket.

Material selection: Bracket design is greatly influenced by the material selected. There are 2 factors that must be considered by designers in determining the best design concept at the early stage of product development process, namely, (a) formability of materials and (b) recyclability of materials.

Cost consideration: It is about 70% of the cost of a product that is determined before production activity. Therefore, it is very important to design and develop mounting bracket which contributes to the cost reduction without sacrificing its safety and impact performance characteristics. The two most important costs required to be considered in designing the bracket, namely, (a) Material cost
(b) Manufacturing cost

Manufacturing process: Manufacturing process is also needed to be considered when designing antenna mountings at the early stage of the product development process with ease to fabricate.

Maintenance: There are two main factors influencing the selection of the antenna mountings related to maintenance consideration, namely, Easy to dismantle and Easy to install

Force Calculation

The static force develops in the DTH assembly due to the weight of the antenna and the feed horn (LNB) is given by

F (force) **= M (mass) x a(acceleratio**n due to gravity, 9.81m/s^2)

Force due to feed horn mass acts at the lower portion of the bracket, where the feed horn is placed and is given by

F = 200x10^{-3} x 9.81 where Mass of the feed horn is 200x10^{-3} kg F = 1.962 N

Force due to dish antenna mass

F = 1400x10^{-3} x 9.81 where mass of the dish antenna is 1400x10^{-3} kg F = 13.734 N

The force developed due to the wind pressure is calculated as follows The force equation is given by

$F = A \times P \times C_d$

Where, P = wind pressure of 0.04, Cd = drag co-efficient of 1, V = wind speed of 80 kmph A = the projected area of the item is given by

$A = \pi\ a\ b$ a= major dia= 0.62m, b= major dia= 0.55m A = 1.0713 m^2

Force F = 513.19 N

The total force acting on the antenna mounting bracket

= force due to antenna mass + wind force

= 13.734 + 513.19 = 530 N



This force acts on the mounting bracket where the contact between antenna surface and bracket takes place. Usually it is considered as uniformly distributed load and acting at an inclination since the bracket mounted at an angle with respect to horizontal surface.

Material Properties

Plastic material is used to manufacture most of the antenna mounting bracket since plastics have more advantages compared to the metals. Acrylonitrile-Butadiene-Styrene (ABS) material is used to manufacture the antenna mounting bracket. It has excellent impact resistance, aesthetic qualities, good strength, rigidity**,** abrasion resistance, dimensional stability, resistance to low temperatures, creep resistance and stiffness and low cost. And it ha many applications in making Machined prototypes, Structural components, Support blocks, Housings and covers, Telephone handset, domestic appliances (food processors, fans, TV sets), Food containers, radiator grills.

Concept Generation for Optimization

Design concepts selection (DCS) is an area of design research that has been under considerable interest over the years (Salonen and Perttula, 2005). It is one of the important activities for a product development process and decision making phase of concept design, where designers evaluate concepts with respect to customer needs. According to Gerrit Muller Selection techniques should be used in the early phases of product development when stakeholder are known and when requirements are established.

Here we developed mainly three concepts and the FEA model is developed by using basic model as reference for all three concepts and analysis was done. Based on the obtained von-misses stress results, the good concept selected.

Concept 1 Providing ribs

This concept is developed based on the literature that the ribs provide strength and rigidity to the product. In present model only horizontal ribs are present so we planned to provide vertical ribs. The two ribs are placed along vertical direction at equal distance from the center plane of the bracket.

Concept 2 Thickness increased

Actually at the failure point the material thickness is less as compared to the other part of the bracket, so from the literature the strength will increase as the thickness increased. Based on this we developed the above concept where material thickness is increased to some extent.

Concept 3 Ribs with thickness

In this concept the both features are included that is the thickness is increased at failure point and also ribs are provided in vertical direction.

Concept 4 Change of material

In this concept, material used for manufacturing the mounting bracket is changed. Instead of ABS material we used polypropylene thermo plastic material, since compare to the other material it has high strength and also low density.

The material properties are given by

Table 3.3: Polypropylene material properties

Property	**Value in metric unit**	
Density	**0.91 x10S**	**kg/mS**
Modulus of elasticity	**1.36**	**GPa**
Strength	**37**	**MPa**
Poisson's ratio	**0.3**	**-**
Flexural strength	**49**	**MPa**
Thermal expansion (20 °C)	**$90x10^{-6}$**	**$^{o}C^{-1}$**
Maximum work temperature	**150**	**^{o}C**

Finite Element Analysis of Mounting Bracket for optimization of concepts

In this initially the finite element model is generated and analysis is done for the basic model of bracket and taking basic FEA model as reference, the FEA models for the different concepts are developed and analysis done for each different concepts.

Basic model

Figure 3.6, 3.7, 3.9, 3.11, 3.13 shows the FEA model of the original bracket, concept-1, concept-2, concept-3 and concept-4 having QUAD4, TRIA3 elements and these elements are satisfied the all quality parameters and with the boundary conditions applied and the applied forces and the constraints at different points. The different color elements represent the different collectors having variation in thickness. Figure 3.8 shows von-misses stress distribution of the basic model, here we observed that the stress generated more at the section having thin cross sections, where the actual failure had taken place.

Model with ribs provided

The FEA model and Von-misses stress distribution for the concept-1 are shown in Fig. 3.9 and 3.10 respectively. Analysis result shows that stress developed in the bracket is slightly reduce compare to failure stress.

Model with thickness increased

The FEA model and Von-misses stress distribution for the concept-2 are shown in Fig. 3.11 and 3.12 respectively. Analysis result shows that stress developed in the bracket is reduced more compare to concept1.

3.4.4. Model with ribs and increased thickness

The FEA model and Von-misses stress distribution for the concept-3 are shown in Figures 3.13 and 3.14 respectively. Analysis result shows that stress developed in the bracket is reduce to considerable amount of failure stress.

3.4.5 Model with material change

The FEA model for this concept is same as the basic model but only material properties are changed. Von-misses stress distribution for the concept-4 is shown in Fig. 3.15. Analysis result shows that stress developed in the bracket is reducing slightly compare to failure stress.

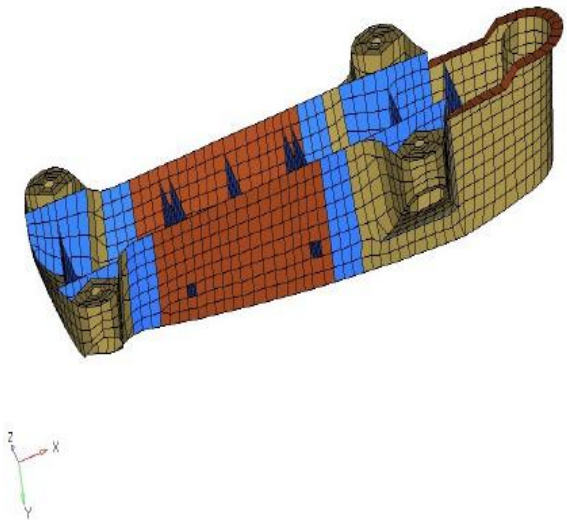


Fig 3.6: FEA model of the original bracket

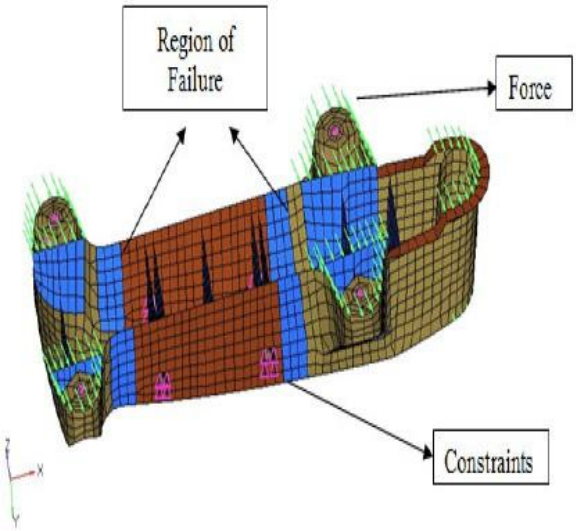


Fig 3.7: Basic FEA model with boundary conditions

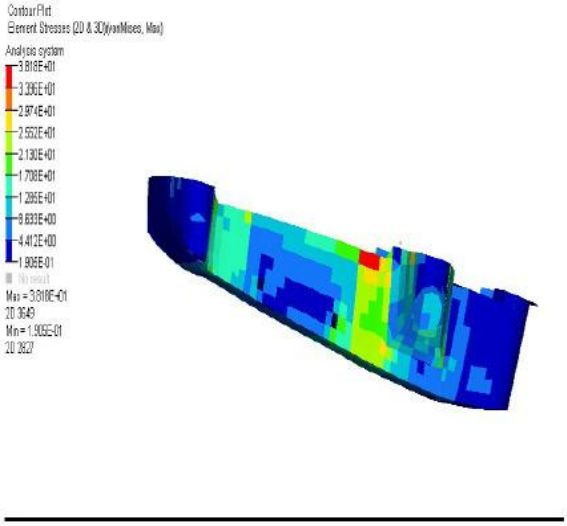


Fig 3.8: Von-misses stress distribution of boundary conditions

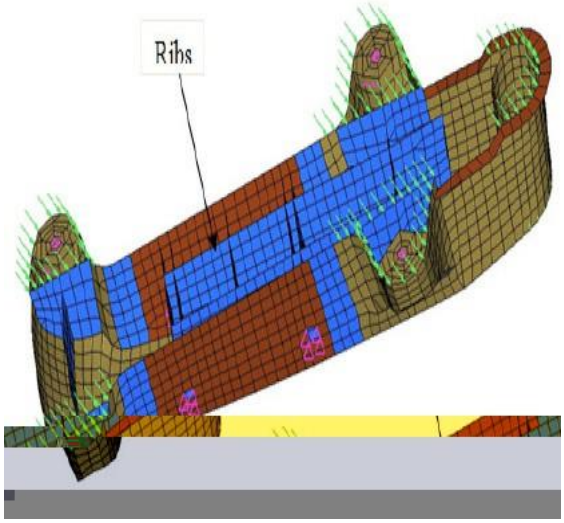


Fig 3.9: Concept-1 model with basic model

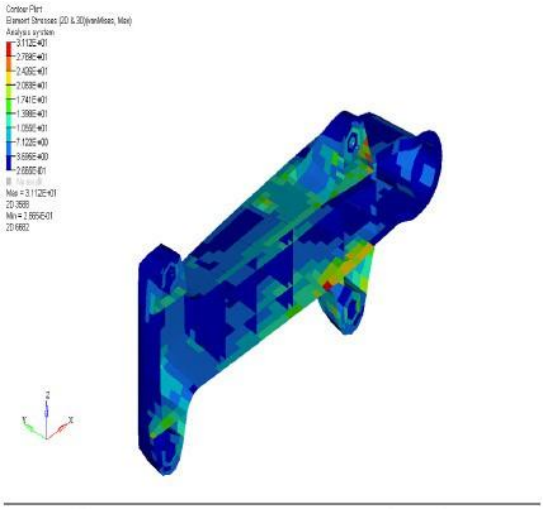


Fig.3.10: Von-misses stress distribution of concept-1 boundary conditions

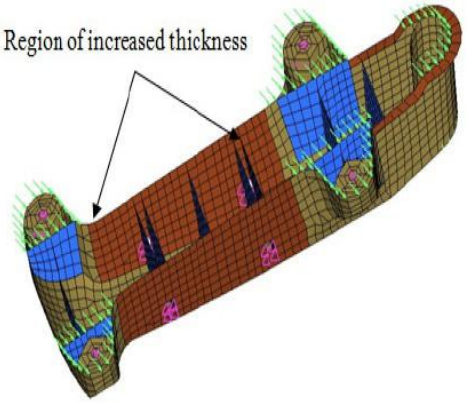


Fig.3.11: Concept-2 model with

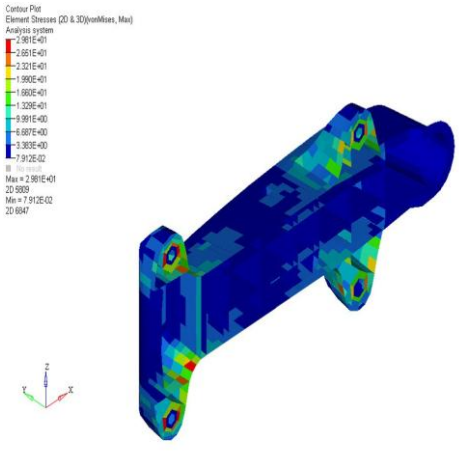


Fig.3.12: Von-misses stress distribution of concept-2 boundary conditions

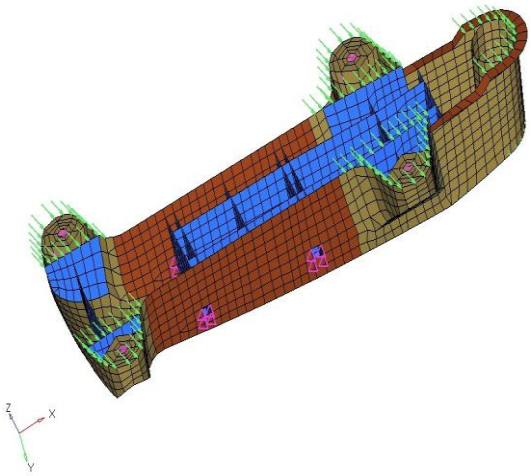
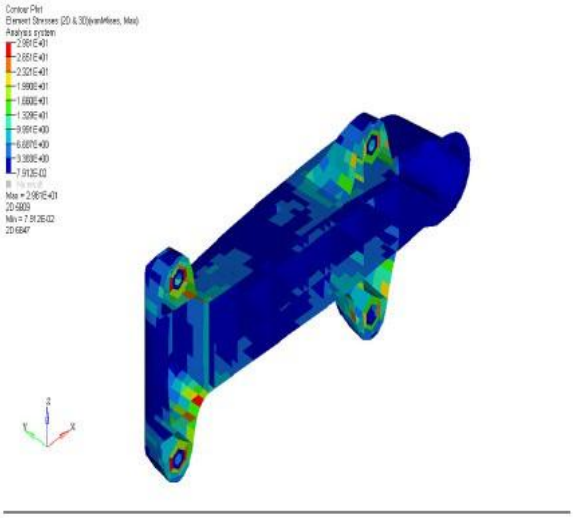


Fig. 3.13: Concept-3 model with

conditions



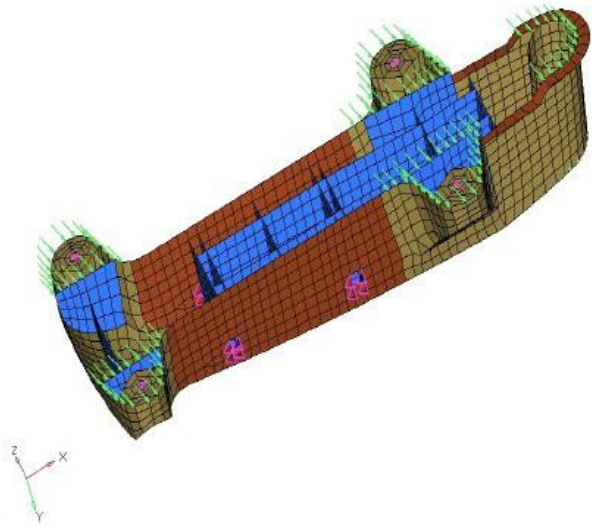


Fig.3.14: Von-misses stress distribution of concept-4

Fig.3.15: Von-misses stress distribution of concept-3

Validation of the Analysis

In this section the software and the element type used for the analysis is validated with the theoretical results for the stress developed in the bracket. The geometry of the bracket is symmetric therefore considered only half portion. Assuming it as simply supported beam. The different forces acting at different point are shown in figure below; all dimensions are in "mm".

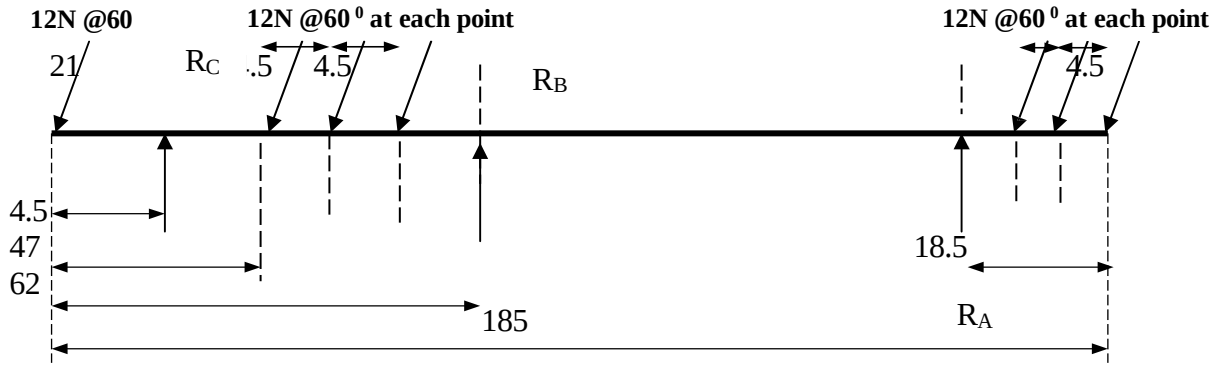
To obtain stresses in bracket

To obtain the combined stresses acting on the selected portion of the bracket, it is sliced in to three different sections which are as shown in the Fig 7.12 and Following are the steps followed to calculate the combined stresses acting at each section

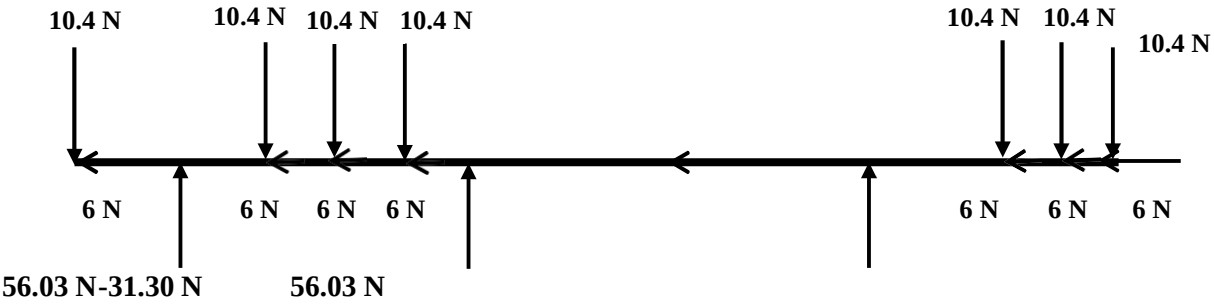
Evaluating the sectional area (A) and distance of centroid

Calculating moment of inertia at centroidal axis (I)

Obtaining bending (σ_b), direct (σ_d) and combined stresses (σ_c)

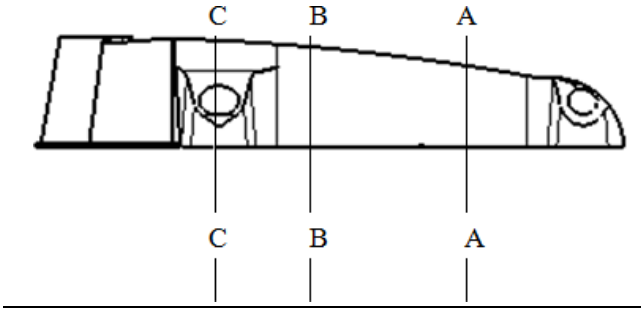


After resolving



At section A-A

2.5



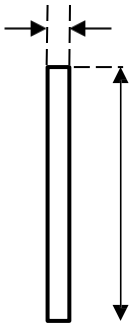


Fig 3.16: Different sections of bracket structure **Fig. 3.17:** Section A-A of Bracket

L=18.5mm from Tail (right end) point b=2.5mm;
h=10 mm;

sectionalarea= b x h = 2.5×10 = 25 mm^2

$I = \frac{b h^3}{12} = \frac{2.5 \times 10^3}{12} = 208.33\ mm^4$

Bending stress

$$\text{Bending Stress } \sigma = \frac{M \times c}{I} = \frac{-436.8 \times 5}{208.33} = -10.4832\ N/mm^2$$

C=10/2=5.0 mm

$$\text{Direct Stress } \sigma = \frac{\text{Reaction force at A} \times A}{\text{Sectional area}} = \frac{-18}{25} = -0.729\ N/mm^2$$

$$\text{Combined Stress} = -10.4832 - 0.729 = -11.203\ N/mm^2$$

Similarly A, $\bar{Y}$ I, σ_b, σ_d and σ_c for remaining sections are tabulated below.

Table 3.4: Combined stress values at different sections in bracket

Section	A mm^2	$\bar{Y}$ mm	I mm^4	σ_b N/mm^2	σ_d N/mm^2	σ_c N/mm^2
A-A	25	5.0	208.33	-10.4832	-0.729	-11.203
B-B	50	10.0	1666.67	-7.95	-0.48	-8.43
C-C	56.5	14	188.75	-16.4	-0.68	-17.08

Table 3.5: Comparison of theoretical analysis results

Sections	Theoretical (MPa)	Analysis (MPa)
A-A	-11.203	16.60
B-B	-8.43	13.29
C-C	-17.08	19.92

RESULTS AND DISCUSSION

In this chapter the analysis results of different concepts are interpreted and showed the variations of von-misses stress developed in the different concepts. In the above plot: 0,1,2,3,4 = represent the basic model, concept-1, concept-2, concept-3 and concept-4 respectively.

The percentage of reduction in the stress generated for different concepts are given in table. From the analysis plot we can observe that in the concept-3, the stress reduction is more compare to the other concepts, but we selected the concept-2 is best concept since Simple design and more feasible, Economical in the manufacturing point of view. The existing dies with slight modification, can be used for manufacturing the bracket.

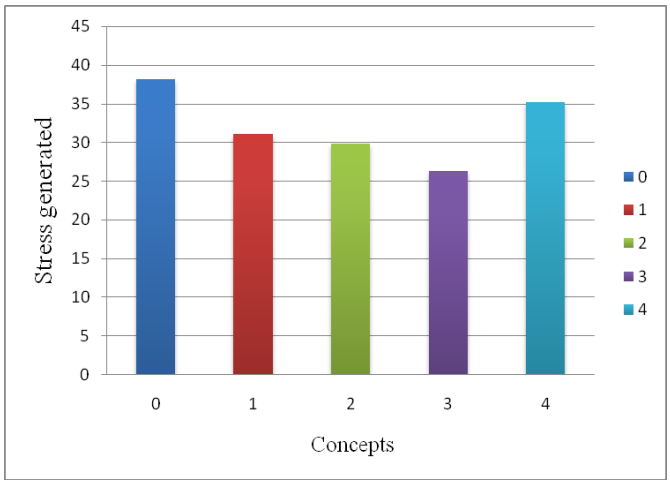


Fig 4.1: Stress generated v/s Concepts

Table 4.1: Stress reduction in different concepts

Concepts	% reduction
Concept1	18.50
Concept2	21.92
Concept3	31.04
Concept4	7.67

CONCLUSION

The goal of the current work is to increase the bracket's strength; for this, FMEA, benchmarking, and analysis have been completed while taking all relevant factors into account. According to the FMEA results, the mounting bracket failure has a higher risk priority number (RPN) than the other potential issues. As a result, the bracket's geometry has been modified.

Benchmarking has been used to identify the several market-available bracket types that are more practical. It demonstrates that type-1, type-2, and type-3 are almost equal in rank, but since type-1 has some drawbacks, consumers now mostly use the other two. The design concept-2 is the greatest option for producing the bracket, as was previously said. Thus, it is ultimately determined that the new design is superior to the current one. To create the prototype model, carry out the test experimentally, and compare the analytical and experimental findings, further research is needed. Future investigation may take into account certain factors, such as looking at the model under nonlinear conditions and the possibility of using composite materials to make the bracket.

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