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DESIGN AND 3D MANUFACTURING OF STAR SENSOR BRACKET FOR SATELLITES

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Abstract

This report starts with a basic introduction of the satellite and it components, AM technologies and their potential applications, identifying limitations and proposing actions to overcome existing barriers including the problem definition. The literature review and history of additive manufacturing is set out. This chapter also includes the present scenario, basically comparing both the situations. The report is followed by the requirements for designing and manufacturing, an explanation of the software used for designing and analysis, also about the manufacturing process used and few specifications of the machine component. The methodology and various manufacturing processes are explained in detail. Each process is discussed in brief with a schematic diagram representing the process. The most common processes are Selective Laser Sintering (SLS). This is followed by the chapter explaining the design procedure. The part modeling wasdone in solidworks 2018. In this chapter there is a step by step procedure for modeling of the component. At the end of this chapter there is a drawing of the component with various views for better understanding of the viewer.Following the modeling procedure, the report continues with the analysis section. In this chapter the analysis is discussed by a step by step process. The analysis was also done in solid works. The results of the analysis are displayed in a pictorial form. There are two parameters that are taken into consideration and three types of analysis were done. The necessary calculations are shown. The factor of safety is calculated for all theparameters taken into consideration just to ensure that the component designed is safe under all conditions. The results of the analysis are displayed in tabular form . This chapter consists of all the results from start of the analysis. The results are also compared based on the materials. Finally the conclusion is given by proposing the best material suitable for manufacturing the bracket. References are added for detailed information of the reader.

INTRODUCTION

Star Sensor bracket

In the previous concepts of the star sensor brackets had some or the other drawbacks due to which single star sensor bracket / star sensor bracket had come into existence. This bracket was designed in such a way that it could cover all the orientations and serve the purpose of both triple star sensor bracket and double star sensor bracket. The new bracket had more strength than the previous two and having a mass of 0.7kg.

Star Sensor:

Star trackers or star sensors can determine the absolute attitude of the satellite by taking an image of the stars, unambiguously identifying the stars in the image, and calculating the coordinate transformation between the stars in the image and their coordinates in a catalog. This provides attitude information for three axis and, in contrast to magnetometers and Earth sensors, star trackers work also outside of the Earth's orbit in free space.

Materials Used and their properties:

The mostly used materialfor aerospace conditions is aluminum which is lighter in weight.to increase it strength of the aluminum alloys are added. It has high thermal resistance properties, also it is economical and easily available.

There are total four alloys of aluminum we have taken into consideration. They are Al 2014 T6, Al 2014 T4, Al 1060 and Al 1050.

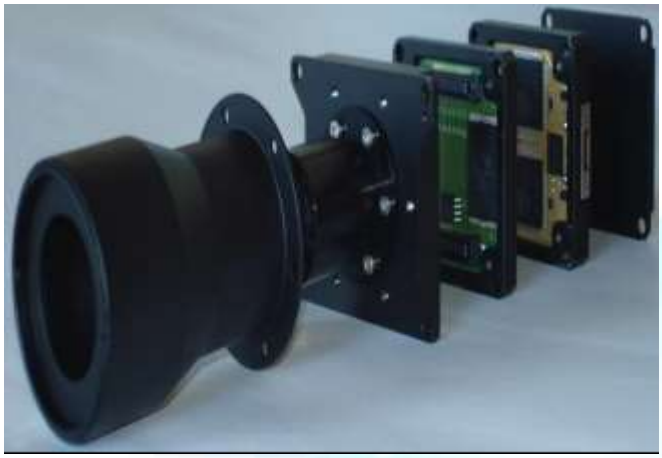

Fig1: Star sensor(Model)

Al 2014 T6: Is has high strength and hardness. It is used in heavy duty forgings, Plate and extrusions for aerospace fittings, Wheels, Tanks and major Physical components, heavy duty automobile frame and suspension components at high loading conditions. 2014 exhibits poor corrosion resistance for an aluminum alloy.

Al 2014 T4: It has similar properties as that of Al 2014 T6 but it has different values for physical properties like shear modulus, mass density and Tensile strength

Al 1060: It has ductile material withgoodtensile strength and it has a good ability to undergo plastic deformation without being damage, corrosion resistance, electrical conductivity and thermal conductivity.

Problem Definition

The star sensor bracket which is used to usually bear the weight of star sensor which is mounted on that bracket and this bracket is rigidly fixed to the rover of satellite. This star sensor bracket is used to mount the sensor with certain angle to detect the star orientation and shape. This bracket initially had three sensors that are mounted to recognize the star. This was later improved to double star sensor in which two sensors were mounted and then now presently single sensor mounting bracket have come into existence. The angles and orientation of all the brackets initially made are all covered in this single sensor bracket. This bracket is made with modern alloy i.e. AL 2014 T6 which has high strength with more durability.

1. METHODOLOGY

Additive Manufacturing Technologies for Product Development

Selective Laser Sintering (SLM)

It is a powder based process of Additive Manufacturing. The metal powder is fed into the chamber of fabrication. A roller transports the metal powder to the place of fabrication. Then the geometry of each layer is taken from the design file and the laser head will get the g-codes and move on the designated paths. The laser will pass on the materials and melts them which it contacts. This process starts from the bottom and ends at the top. The powder particles which are untouched can be reused till thermal effects are not detected on them.

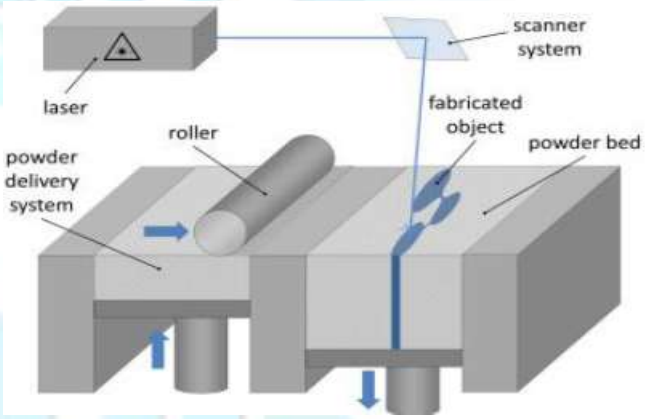

Fig 2: Schematic view of SLM

PART MODELING OF STAR SENSOR BRACKET

Modeling: The first step of process chain which involves creating 3D geometric models with CAD software. The 3D geometric models that are developed various functions can be carried out through them.

This step consumes more time than all other steps.

A drawing of the required model was given with the dimensions and the modeling was carried out in the designing software and it is shown below:

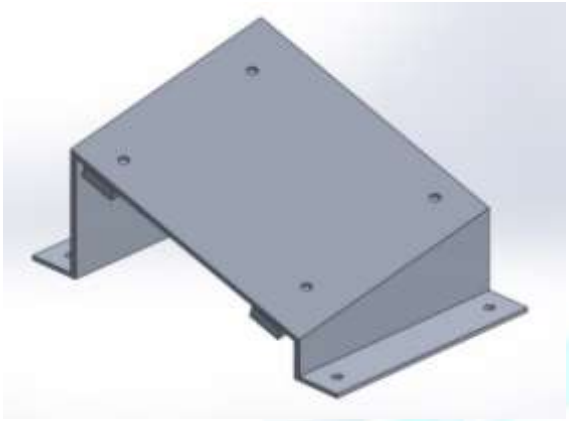

Fig 3: Star sensor bracket

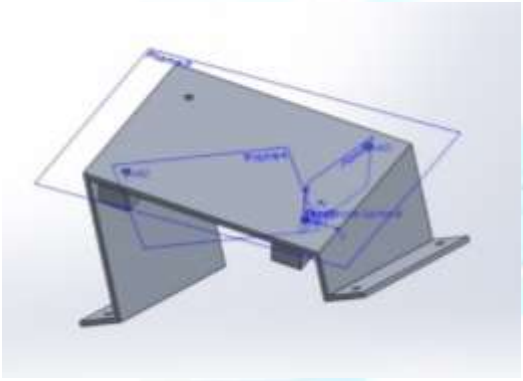

Fig 4: Brackets coordinates

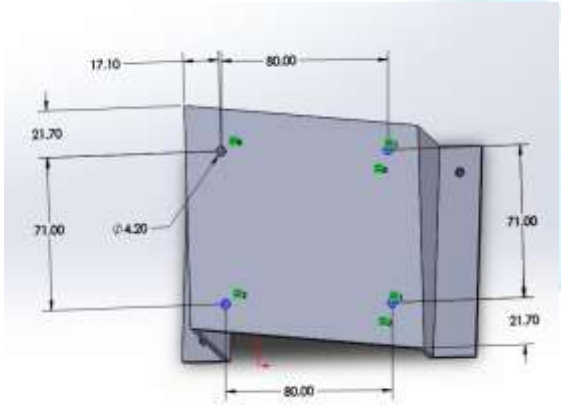

Fig 5 :Dimension

Meshing: In this irregular shapes for which analyzing is difficult meshing makes it easier. The process of dividing the complex shape into simple elements that will make easier to analyses the load applied on the object. It consumes time to get results, the better the meshing more accurate are the results.

Meshing of the model was done in the same software and it is shown below:

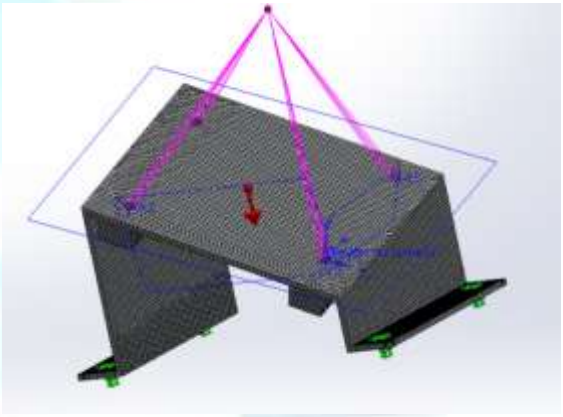

Fig 6: Meshing and COG of Sensor

ANALYSIS

Analysis: Analysis is the process to check the yield strength or before the breaking point of the material by considering the five theories of failures under different conditions like static and dynamic conditions for example pressure, external loads, thermal (temperature)etc.,structures, Mechanisms, systems and dimensions are important in the view of analysis.

VonMises Analysis: This is done to check whether an isotropic and ductile material will yield under different forces. The objective is to find the yield value for ductile metal that works for any complex Three-Dimension loading condition.

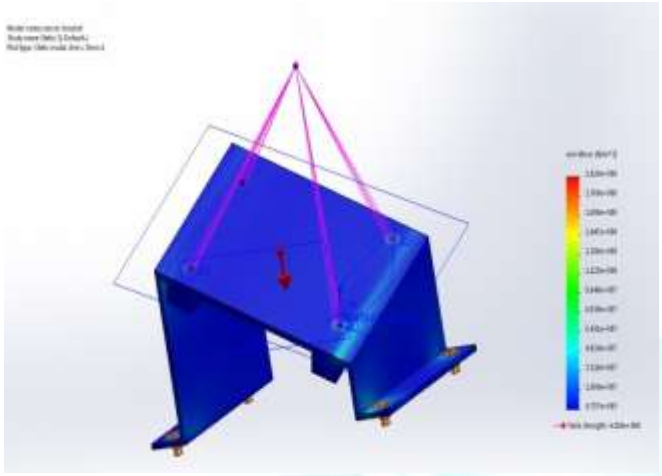

Fig 6: Vonmises analysis

Strain Equivalent Analysis: Stress–strain analysis (or stress analysis) is process to determine the stresses and in materials upon which forces are applied. In continuum mechanics, stress is a value that represents internal forces of a material and strain is the plastic deformation of the material.

Stress analysis was done in the same software and the results are shown below:

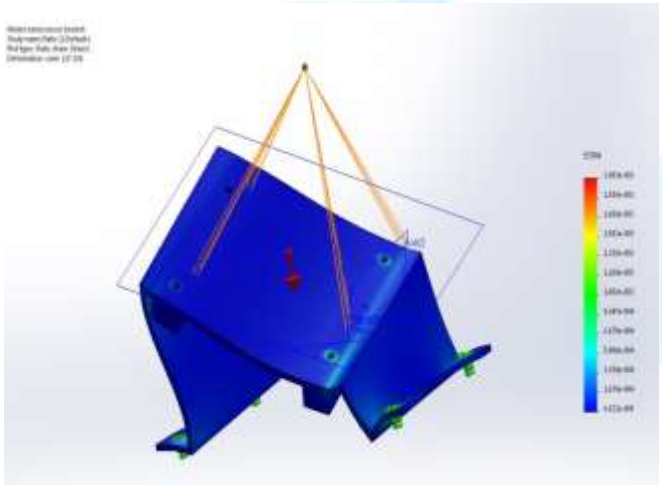

Fig 7: Strain Equivalent Analysis

Displacement analysis:

Table: Al 2014 T6 results at 30g (294.3m/s^2)

Displacement analysis is used to evaluate the amount of deformation occurred in a object under various load conditions.

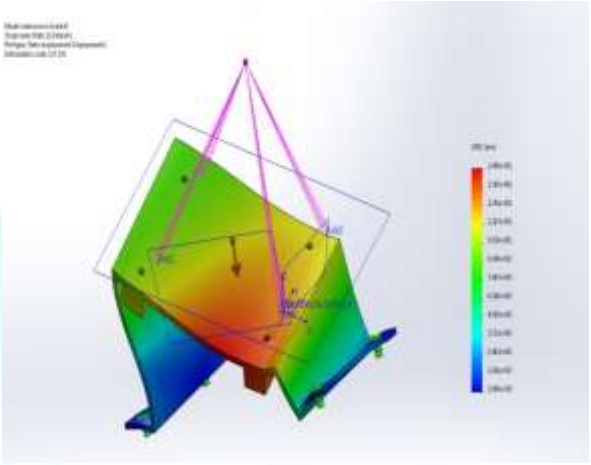

Fig 8 : Displacement Analysis

Al 2014 T6 Results

Static: (Force = 1g = 9.81m/s^2)

TYPE	Von Mises	Strain Equivalent	Displacement
Maximum	4.311 e + 05	3.403e – 06	8.797e – 04
Minimum	1.712 e + 01	1.782e – 10	1.000e – 30

Table: Al 2014 T6 results at 1g (9.81m/s^2)

Dynamic: (Force = 30g = 294.3 m/s^2)

TYPE	Von Mises	Strain Equivalent	Displacement
Maximum	1.293 e + 07	1.021e – 04	2.639e – 02
Minimum	5.135 e + 02	5.347e – 09	1.000e – 30

TYPE	Von Mises	Displacement	Strain Equivalent
Maximum	4.157e + 05	8.900e – 04	3.443e – 06
Minimum	1.651e + 01	1.000e – 30	1.804e – 10

Al 2014 T4 Results

Static: (Force = 1g = 9.81m/s^2)

Table: Al 2014 T4 results at 1g (9.81m/s^2)

Table: Al 2014 T4 results at 30g (294.3m/s^2)

TYPE	Von Mises	Displacement	Strain Equivalent
Maximum	4.311e + 05	8.797e – 04	3.203e – 06
Minimum	1.712e + 01	1.000e – 30	1.782e – 10

Al 1060 Alloy Results

Static: (Force = 1g = 9.81m/s^2)

Table: Al 1060 results at 1g (9.81m/s^2)

Dynamic: (Force = 30g = 294.3 m/s^2)

TYPE	Von mises	Strain Equivalent	Displacement
Maximum	1.247e + 07	1.033e – 04	2.670e – 02
Minimum	4.952e + 02	5.411e – 09	1.000e – 30

Table: Al 1060 results at 30g (294.3m/s^2)

Comparison of materials under different loads

Material		Von Mises		Strain equivalent		Displacement	
		Max	Min	Max	Min	Max	min
static analysis	Al 2014 T6	4.311e + 05	1.712e + 01	3.403e - 06	1.782e - 10	8.797e - 04	1.000e - 30
	Al 2014 T4	4.311e + 05	1.712e + 01	3.203e - 06	1.782e - 10	8.797e - 04	1.000e - 30
	Al 1060	4.157e + 05	1.651e + 01	3.443e - 06	1.804e - 10	8.900e - 04	1.000e - 30
Dynamic analysis	Al 2014 T6	1.293e + 07	5.135e + 02	1.021e - 04	5.347e - 09	2.639e - 02	1.000e - 30
	Al 2014 T4	1.293e + 07	5.137e + 02	1.021e - 04	5.347e - 09	2.639e - 02	1.000e- 03
	Al 1060	1.247e + 07	4.952e + 02	1.033e - 04	5.411e - 09	2.670e - 02	1.000e- 30

Table: Comparison of materials under different loads

Conclusion

As the bracket will be used in air and space above the ground level and the bracket can be used up to a force more than the gravitational force and the bracket should be able to bear the weight of the sensor and also the force due to gravity. The material of the star sensor bracket is Aluminum 2014 T6.

The designing is carried out in solidworks 2018 and the modeling is done as per the dimensions given. The step by step procedure is explained briefly and the results are displayed accordingly. Finally the drawing of the model is shown with all the views for better understanding of the model.

We have done analysis for three different materials Al 2014 T6, Al 2014 T4, and Al 1060. For all the analysis we have considered for two cases of forces, i.e static and dynamic conditions.

The first analysis was done for Von Mises stress. In this analysis the materials Al 2014 T4 and Al 1060 have deformed for the force applied while the material Al 2014 T6 has not undergone any deformation. Al 2014 T6 has good tensile strength and it gives good result under Von Mises and it can be used upto 30 times gravitational force (294.3m/s^2).

The second analysis was done for Equivalent Strain. In this analysis the materials Al 1060 and Al 2014 T4 have undergone deformation for the force applied while the material Al 2014 T6 didn't deform. Al 2014 T6 has good resisting capacity and it gives good result under Equivalent Strain.

The third analysis was done for the check of displacement. In this analysis all the three materials have given good results at both the conditions. But when compared more

keenly Al 2014 T6 has given better results than the other two materials. We here finally conclude that Al 2014 T6 should be used to manufacture the star sensor bracket as it gives good results in both the conditions and under all the possible load variations. Otherwise we can also use Al 2014 T4 as it has almost same properties and almost same results. So on the basis of all parameters we propose to use Al 2014 T6 material for our design.

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