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Design and fabrication of helmet using 3D printing technology to increase the heat transfer

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ABSTRACT

3D printing is a form of additive manufacturing technology where a three Dimensional object is created by laying down successive layers of material. It is Also known as rapid prototyping. This is a mechanized method where by 3D objects are quickly made on areas on ably sized machine connected to a computer containing blue prints for the object. The 3D printing concept of custom manufacturing is exciting to nearly everyone. This revolutionary method for creating 3D models with the use of ink jet technology saves time and cost by eliminating the need to design , print and glue together separate model parts. Now, you can create a complete modeling a single process using 3D printing. Subsequently, the aim of this study was to assess that two wheeler driver safety helmet and to a ideal designing the improvements on the safety helmet based on several designing techniques of industrial engineering. Further designing of the improvements made on the safety helmet was carried out using catia where else a 3D printer was used to print out the helmet.

Keywords: Brick, Copper slag, Compression strength, Environment, Population, Red soil, Recycle.

INTRODUCTION

Bricks are one of the oldest types of building blocks. They are an ideal building material because they are relatively cheap to make, very durable, and require little maintenance. A brick is a block of ceramic material used in masonry construction, usually laid using various kinds of mortar. Bricks dated 10,000 years old were found in the Middle East. Examples of the civilizations who used mud brick are the ancient Egyptians and the Indus Valley Civilization, where it was used exclusively. The first sun-dried bricks were made in Iraq, in the ancient city of Ur in about 4000 BC. The copper slag production in industrial is large and increases with time. In each country the copper slag composition is different, since it is affected by socioeconomic characteristics, consumption patterns and waste management programs, but generally the level of copper slag in waste composition is high. The largest component of the copper slag smelting As we know that Copper slag is by-product obtained during the copper smelting and refining process. it is a product which contains 30-35 percentage of copper,12 per. of silica and 5 percentage of calcium. Our life rivers pond obscure and clean water to drink. Some particular community to fulfill there religious customs and worship god. They deposits lots of waste things to make this water resources unfit. Worship system causes water pollution and they are likely short-lived.

SCOPE

I future there are n number of composite materials are used like calcium carbonate and magnesium carbonate etc. The ventilation part is used to reduce the maximum amount of hair losing is avoided. The people like to wear the helmet when there is present the ventilation part in the helmet.

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LITERATURE STUDY

Various books and journals were collected for reference and were studied before starting the project work for having an idea about how the project should be done. The collected journals are:

[A.F. Abdullah and M.I. Ahmed] This paper deals with the development of cooling system for motorcycle helmet using thermoelectric technology. The system consists mainly of a heat sink and thermoelectric module. When electrical voltage is applied to the thermoelectric module, it will create a temperature difference across the thermoelectric module.

[A. Chelliah] The helmet is critical safety equipment for a two wheeler drivers. The primary purpose of helmet is to protect the head against injuries and to safeguard the eye from sunlight and dust particles. It is crucial that the motorcyclist is comfortable while wearing the helmet.

[Deshpande Atish Kishor] Human life is so precious and valuable, that it should not be compromised under any cost. The concern over the safety of vehicle drivers has pushed for invention of new equipment that can save lives.

[Dr Eric Gardner]- The origins of the crash helmet date back to the Brook lands race track in early 1914 where the medical officer, noticed he was seeing a motor cyclist with head injuries about every 2 weeks.

Problem identification

The present helmet was manufactured using polystyrene, so due this material helmet weight is increased. Another major problem occurs while wearing helmet is headache which is caused by stagnation of heat inside the helmet. Because of lack of ventilation for circulation of air. Sweating and hair loss will be more. The rider will be reluctant to wear the helmet for a prolonged duration due to the intensity of heat inside the helmet. Hence many avoid using the helmet even though it helps in the safety.

Planning

As per the survey taken from few cities some of the demerits was found in present helmet. So in order to eradicate that kind of demerits some steps had been taken to overcome that problems. From our survey result head ache, neck pain, sweating, hair loss are the major problem occurred while wearing helmet. So we has planned to use pin fin technology to dissipate the heat helmet. So we has planned to print out the helmet using FDM (fused deposition modeling) method. It comes under rapid prototyping technology. Then prototype is built.

Rapid prototyping

Rapid prototyping is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology.

TYPES OF 3D PRINTING

- FDM (Fused Deposition Modeling)
- SLA (Stereolithography)
- DLP (Digital Light Processing)
- SLS (Selective Laser Sintering)
- SLM (Selective Laser Melting)
- EBM (Electron Beam Melting)
- LOM (Laminated Object Manufacturing)
- BJ (Binder Jetting)
- MJ (Material Jetting / Wax Casting).

FUSED DEPOSITION MODELING (FDM)

FDM is the most common 3D printing method used in desktop 3D printing. Thermoplastic filament is heated and extruded through an extrusion head that deposits the molten plastic in X and Y coordinates, while the build table lowers the object layer by layer in the Z direction. Effectively, the object is built from the bottom up. If an object has overhanging parts, however, it will need support structures that can be removed after the printing is finished. This type of 3D printers is a cost-effective means for product development and rapid prototyping in small business and education sectors since it's capable of fabricating robust parts reliably and quickly.

Fused deposition modeling (FDM) technology was developed and implemented at first time by Scott Crump, Stratasys Ltd. founder, in 1980s. Other 3D printing companies have adopted similar technologies but under different names. A well-known nowadays company MakerBot coined a nearly identical technology known as Fused

Filament Fabrication (FFF).With help of FDM you can print not only functional prototypes, but also concept models and final end-use products.

What is good about this technology that all parts printed with FDM can go in high-performance and engineering-grade thermoplastic, which is very beneficial for mechanic engineers and manufactures? FDM is the only 3D printing technology that builds parts with production-grade thermoplastics, so things printed are of excellent mechanical, thermal and chemical qualities.

3D printing machines that use FDM Technology build objects layer by layer from the very bottom up by heating and extruding thermoplastic filament. The whole process is a bit similar to stereolithography. Firstly special software ―cuts‖ CAD model into layers and calculates the way printer's extruder would build each layer. Along to thermoplastic a printer can extrude support materials as well.

Then the printer heats thermoplastic till its melting point and extrudes it throughout nozzle onto base that can also be called a build platform or a table, along the calculated path. A computer of the 3d printer translates the dimensions of an object into X, Y and Z coordinates and controls that the nozzle and the base follow calculated path during printing. To support upper layer the printer may place underneath special material that can be dissolved after printing is completed.

When the thin layer of plastic binds to the layer beneath it, it cools down and hardens. Once the layer is finished, the base is lowered to start building of the next layer. Printing time depends on size and complexity of an object printed. Small objects can be competed relatively quickly while bigger or more complex parts require more time. Comparing to stereolithography this technique is slower in processing.

When printing is completed support materials can easily be removed either by placing an object into a water and detergent solution or snapping the support material off by hand. Then objects can also be milled, painted or plated afterwards. FDM technology is widely spread nowadays in variety of industries such as automobile companies like Hyundai and BMW or food companies like Nestle and Dial.

FDM is used for new product development, model concept and prototyping and even in manufacturing development. This technology is considered to be simple-to-use and environment-friendly. With use of this 3d printing method it became possible to build objects with complex geometries and cavities. Different kind of thermoplastic can be used to print parts. The most common of those are ABS (acrylonitrile butadiene styrene) and PC (polycarbonate) filaments. There are also several types of support materials including water-soluble wax or PPSF (polyphenylsulfone).Pieces printed using this technology have very good quality of heat and mechanical resistance that allows to use printed pieces for testing of prototypes.

FDM is widely useful to produce end-use products, particularly small, detailed parts and specialized manufacturing tools. Some thermoplastics can even be used in food and drug packaging, making FDM a popular 3D printing method within the medical industry.

The price for those 3D printers depends on size and model. Professional ones usually cost from $10,000 and more. 3D Printers designed for home use are not so expensive. There are several models like Replicator of MakerBot, Mojo of Stratasys and Cube of 3D Systems. The price for these models varies from $1,200 to $10,000. However, new start-ups offer more and more affordable versions of FDM 3D printers, the price of which can be just about $300-$400.Also there are many fans of 3D printing or DIY'ers that prefer to create their own 3D printers from the very scratch.

There are websites that offer big variety of DIY kits and parts for RepRap printers. For more information please refer to the following article where you can find basic things about how to build 3d printers from scratch.

SELECTIVE LASER SINTERING (SLS)

SLS is similar to SLA, but the key difference is that this type of 3D printer uses powdered material in the build area instead of liquid resin. A laser is used to selectively sinter a layer of granules, which binds the material together to create a solid structure.

When the object is fully formed, it's left to cool in the machine before being removed. SLS is widely used for product development and rapid prototyping in a wide range of commercial industries, and also for limited-run manufacturing of end-use parts. The materials used in SLS can range from nylon, glass, and ceramics to aluminum, silver, and even steel.

This type of 3D printer requires the use of expensive high-powered lasers, however, which puts it a bit beyond the reach of the average consumer with the exception of professional 3D printing services like Shapeways, Sculpteo, and i.materialise. Selective Laser Sintering (SLS) is a technique that uses laser as power source to form solid 3D objects. This technique was developed by Carl Deckard, a student of Texas University, and his professor Joe Beaman in 1980s.

Later on they took part in foundation of Desk Top Manufacturing (DTM) Corp., that was sold to its big competitor 3D Systems in 2001. As was stated previously, 3D systems Inc.

Developed stereolithography, which in some way is very similar to Selective Laser Sintering. The main difference between SLS and SLA is that it uses powdered material in the vat instead of liquid resin as stereolithography does.

Unlike some other additive manufacturing processes, such as stereolithography (SLA) and fused deposition modeling (FDM), SLS doesn't need to use any support structures as the object being printed is constantly surrounded by unsintered powder.

Like all other methods listed above the process starts with creation of computer-aided design (CAD) file, which then needs to be converted to .stl format by special software. The material to print with might be anything from nylon, ceramics and glass to some metals like aluminum, steel or silver. Due to wide variety of materials that can be used with this type of 3d printer the technology is very popular for 3D printing customized products.

SLS is more spread among manufactures rather than 3D amateurs at home as this technology requires the use of high-powered lasers, which makes the printer to be very expensive. Though there are several start-ups the work on development of low-cost SLS printing machines.

For example, Andreas Bastian has shared details about his developedSLS printer that uses carbon and wax for printing. Another great example is the Focus SLS printer that can be easily used at home conditions and initially was presented at Thingiverse. More details about it can be found following this link.

SELECTIVE LASER MELTING (SLM)

SLM is sometimes regarded as a subcategory of the SLS 3D printer type, where SLM uses a high-powered laser beam to fully melt metallic powders into solid three-dimensional parts. Typical materials used are stainless steel, aluminum, titanium, and cobalt chrome. For applications in the aerospace or medical orthopedics industry, SLM is used to create parts with complex geometries and thin-walled structures, with hidden channels or voids.

Elsewhere, as in the video above, it's been used to fabricate gas turbines for the energy industry. Selective laser melting (SLM) is a technique that also uses 3D CAD data as a source and forms 3D object by means of a high-power laser beam that fuses and melts metallic powders together.

Vero blue

Polyjet vero blue.Vero Family Combining Dimensional Stability and High *Detail* Visualization, This *materials* Simulate opaque, Rigid Plastics. They give you the power to rapidly prototype Models that Closely Resemble the appearance of your finished product. Durable and Strong, This family of photopolymers provides.

Material properties

3D printing service is based on acrylic-based photopolymer materials. These materials are used to create highly accurate 3D models and parts with fine detail which may be used in a wide range of Rapid Prototyping and Rapid Manufacturing applications.

HELMET TESTING

Philosophy and Concepts of Helmet Testing

It is important to realize that a lot of product type testing like helmet testing does not seek to precisely reproduce real life situations, rather it attempts to define a set of requirements that is analogous to the types of situations that might be encountered while engaged in a prescribed activity. Helmet tests are designed to be repeatable, measurable and include a fixed range of situations a helmet might reasonably encounter. At this point the concerns of helmet testing does not include responses of the neck or body as they react with the head during a crash. It is strictly a measurement of how a helmet reacts during an event to protect the wearer's brain. At Snell we believe that as technology continues to evolve, so should helmet design and manufacturing techniques.

TEST TYPES

Manual Impact Test

This test involves a series of controlled impacts where a helmet is positioned on a metal head form and then dropped in a guided fall onto various steel test anvils which simulate different impact surfaces. The head forms are instrumented with an accelerometer to measure peak G force or acceleration which is measured in "G"ravitational units. The impact energy (drop height and mass), or how hard the helmets are impacted is unique to each standard. However, in any valid test, if the peak acceleration imparted to the head form exceeds certain threshold value, the helmet is rejected.

Positional Stability (Roll-Off) Test

A head form is mounted on a stand so that it points face downward at an angle of 135 degrees. The helmet is placed on the head form and the straps and buckles adjusted to obtain a "best fit". A wire rope is hooked to the rear edge of the helmet and brought forward so that its free end runs across the helmet and downward towards the floor. The free end of the rope has a mechanical stop with a 4 kg weight resting on the stop. The weight is raised to a prescribed height and dropped onto the stop. The resulting shock places a rotational load on the helmet. The helmet may be shifted, but must not roll off the head form.

Dynamic Retention Test

The helmet is placed on a head form and the chin strap fastened under a device approximating the contour of the jaw. The jaw piece is loaded with a 23 kg weight for approximately one minute. The retention system is tested by simultaneously removing the 23 kg weight and applying a 38 kg mass in an abrupt guided fall. The retention system fails if it cannot support the mechanical loads or if the maximum instantaneous deflection (stretch) of the retention system exceeds 30 mm. Drop heights for the fonts 38 kg mass are different for each standard, however the mechanism and failure criteria are similar for other types of headgear.

Chin Bar Test

The chin bar test applies to full face motorcycle, special application racing and kart racing helmets. The helmet is affixed to a rigid base with the chin bar facing upward. A 5 kg weight is dropped through a guided fall to strike the central portion of the chin bar. Maximum downward deflection of the chin bar must not exceed the stated distance.

Shell Penetration Test

The shell penetration test applies to motorcycle, special application racing, kart racing, skiing and equestrian helmets. The helmet is affixed to a rigid base. A 3 kg sharply pointed free 3d models striker is dropped in a guided fall onto the helmet from a prescribed height. The test striker must not penetrate the helmet or even achieve momentary contact with the head form.

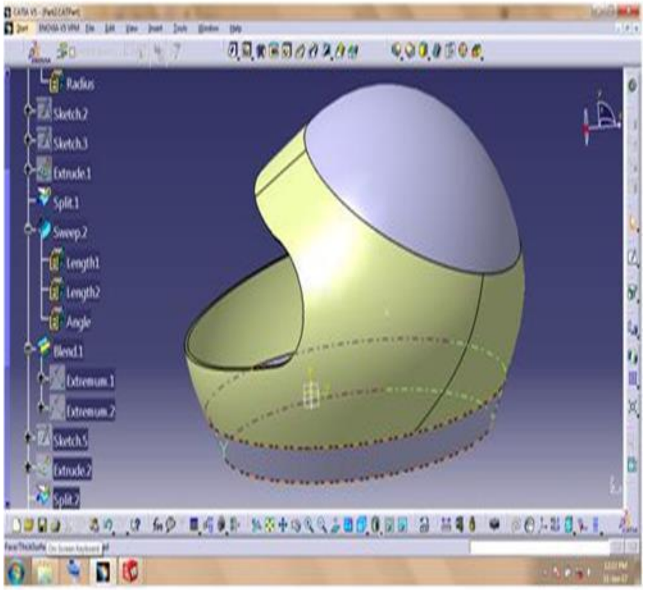
Face shield Penetration Test

The face shield penetration test applies to full face motorcycle, special application racing and kart racing helmets. The face shield is affixed to the helmet and shot along the center line in three separate places with an air rifle using a sharp icons soft lead pellet. Pellet speed will be approximately 500 kph. For both types of shield the pellet must not penetrate, and for the racing helmet any resulting "bump" on the inside of the shield must not exceed 2.5 mm.

Flame Resistance Test

The flame resistance test applies to special application racing helmets only. The test is conducted using a propane flame of approximately 790 degrees centigrade. The flame is applied to the shell, trim, chin strap and face shield for a specified number of seconds, and any resulting fire must self extinguish within a specified time after flame removal. During the whole process the temperature of the interior lining of the helmet must not exceed 70 degrees centigrade.

DESIGN



The figure present helmet design which is drawn by catia software .Which is made of polystyrene material. This helmet shows that normal shape and specification of helmet. In this design there is no possible way to pass the inlet air. So heat transfer can't occur at the inside helmet. So we planned to modify the design as per public opinion and we have decided to place some cooling technologies in present helmet. Some technologies are like air hole helmet, water cooling helmet, pin-fin technology.

The figure shown represents our project design fin is placed in between the fin base and fin wall. This helmet made up of vero blue material and printed by 3d printer. While printing the helmet on 3d printer supporting material is needed to print the helmet. Here we used SR30 material as supporting material.

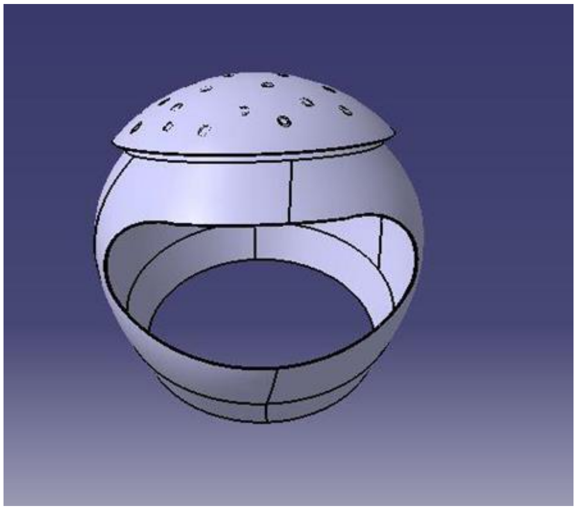


Fig1.Modified helmet with ventilation holes

Analysis

In our project analysis was made between the present helmet design and our project design between this two helmet design velocity of air and heat transfer was analyzed.

Boundary physics for FFF

The above figures are given represents velocity analysis for present helmet design and modified helmet design. Both the design are taken in a enclose box Boundary condition applied here is 40km/hr (or) 11.11 m/s. Due to curved surface tetrahedral mesh is used.

Ansys workbench 14.5and 14.0 software is used to analysis the design. Inlet air comes in front of the enclose box. Then the comparison was between the present helmet design and modified helmet design. After the comparison of both the helmet design the velocity of air is more in present helmet design.
Maximum velocity of air for present helmet is 4.092e+001 and maximum velocity of air for modified helmet is 2.832e+001. So speed of air is less in modified design compared to present helmet design. Air flow was analysed in ansys fluent analysis(CFD).

Another boundary condition applied here is pin fin temperature 60^0c. Pin fin is drawn between the fin wall and fin base. Design is drawn with the catia software. After the air flow analysis is finished then heat transfer coefficient analysis is made between the present helmet design and modified helmet design.

The figure represents heat transfer analysis for present helmet .In this helmet design inlet temperature was 38^0c, for this helmet maximum heat transfer coefficient was 3.349e+002.Ansys workbench 14.5 software is used to analyse the helmet. Inlet air goes in front of the helmet. In above mentioned analysis report shows blue color indicates starting point of the analysis and red color indicates maximum value of heat transfer coefficient.

Heat rejection

From our analysis report velocity of air for present helmet design is 4.092e+001 and velocity of air for modified design is taken from journal 2.832e+001, compared to our project design velocity of air is more in present helmet design. Then from another analysis report heat transfer coefficient for present helmet is 3.349e+002 and then for modified helmet design heat transfer value is 4.984e+002 from above heat transfer coefficient result heat rejection is more in our modified design. So finally heat rejection is possible in our project design.

So then our project next move to the prototype stage. If heat is not possible in our design means it will again move to the previous stage. With our final analysis report we had proved our design had rejected the heat.

Draft analysis

This type of analysis is performed based on color ranges identifying zones on the analyzed element where the deviation from the draft direction at any point, corresponds to specified values.

Sometimes, in the case of extremely closed values, it is recommended to switch to the Quick mode to improve the color. display accuracy.

The maximum draft analysis accuracy is 0.01 deg. According to the graphic card performance, this accuracy can be debased.

The difference mapping analyses of the same even if you have set the mapping analyzes in no show. You need to visualized them one after the other.

Deformation due to heat

We were looking for the right wearable to attach our portable cooling technology to, and set out to explore if the time had come for a cooling helmet to hit the market place. For an idea to take flight as a product in the market, three important factors need to come together - a compelling market need, a design that has a low barrier to customer adoption, and technology that enables a price-point that customers are willing to accept .

Total heat flux

Bicycle helmets exhibit complex structures so as to combine impact protection with ventilation. A quantitative experimental measure of the state of the art and variations therein is a first step towards establishing principal of bicycle helmet ventilation.

A thermal head form mounted in a climate regulated wind tunnel was used to study the ventilation efficiency of 24bicycle helmets at two wind speed.

CONCLUSION

In this study the heat dissipated from the helmet is from 3.349e+002 to 4.984e+002. It is effective and afford. This project overcomes the present helmet disadvantages. It leads to good results in providing light weight and safety helmet for two wheeler drivers .In this method we created a prototype. And we are planned to manufacture it and distributing in market with low cost and full safety, poor people also can use this helmet at the low cost.

FUTURE SCOPE

The Pin Fin Technology helmet acts as a basic platform for the coming Generation of more aiding devices to help the visually impaired to be safer. We used thermoplastic as a project material, In that thermoplastic we choosed ABS material. When compared to other helmets it is a lite weight. Strength is better than to the normal present helmet. Headache is reduced by the use of this helmet because for cooling the helmet and upper surface of head (Hair region) we used pinfin as cooling parameter. With the help of present 3D printing technology the cost is expensive for manufacturing the helmet, So the research is going on to minimize the cost of helmet.

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