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Design and Thermal Analysis of Safety Shoe Toe Cap

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Abstract—*The shoe toe caps are the protective devices that are worn in the industry to protect the feet of the workmen from heat. In general Steel is mostly used for safety shoe toe cap which are heavy and have high thermal conductivity but now the use of polymer composite is increasing because of their low weight and low thermal conductivity. This research focuses on design and thermal analysis of safety shoe toe cap using nylon 66 and carbon fiber (CF) in different weight ratios. Designing of safety shoe toe cap is done in Siemens NX Unigraphics followed by Finite Element Analysis (FEA) using ANSYS software. ISO 20345:2011 standard is followed to perform thermal analysis followed by comparison with steel shoe toe cap. Designing of safety shoe toe cap is done in Siemens NX Unigraphics followed by Finite Element Analysis (FEA) using ANSYS software. Comparison with steel shoe toe cap.*

Introduction

It is the common consumer products using plastic material that are commercially available today include: fishing rods, baseball bats, water storage tank, roofing tiles and safety toecaps. Traditionally, finite element (FE) analysis has been widely used as a cost-effective method for designing and predicting product behaviour under different service conditions, this was also the case for common consumer products. The switch from the use of traditional to plastic materials in products has now led to the transformation of FE modeling procedures for the industry. Although the design of common products using composites may not require highly advanced FE analysis capabilities, companies nevertheless experience difficulties in design, manufacture and analysis phases. The main reason lies in the fundamental difference between traditional metallic/plastic and composite material properties: traditional materials that possess isotropic characteristic offer equal strength in all directions; while the strength properties of composite materials greatly. Therefore, the FE analysis requires changes in the setup of material models and failure modes. This research involved a systematic analysis of the different different design of products using composites over traditional metallic parts, with a safety toecap chosen as the target product. In this research, the FE modelling, analysis, optimization and Manufacturing issues of the development procedure for common plastic products were investigated.“Safety Toecap” by definition is a protection cover over the safety shoe toe cap. They are widely used as protective elements in safety shoes to work against potential hazards to human such as heavy falling objects, impacts, cuts, penetrations, compressions and other potential risks from chemical or thermal hazards. Although toecaps made from various materials can offer protection against different range of hazards, toecaps are predominantly manufactured from steel or plastic.

1. To increasing thermal properties by using Carbon fibre Reinforcement.

2. Increasing the front and back depth of the toe cap to gain more height and strength.

Type of polymer

Thermoplastic

A thermoplastic, or thermo-softening plastic, is a plastic polymer material that becomes pliable or mouldable at a certain elevated temperature and solidifies upon cooling. Most thermoplastics have a high molecular weight.

Material used

Material that we used is

- Carbon Fiber (with difference percentage)
- Polyamide 66 (with difference percentage)

Nylon 66 or Polyamide 66 and Carbon fiber reinforced polymer is good thermal property thoes composit polymer thus makes itself a better replacement for steel toe cap with are bulky and expensive.

DESIGN

The 3D model of toe cap is designed in Pro-E.

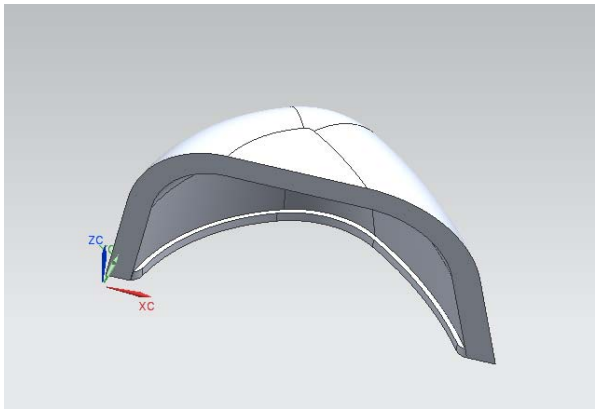

Figure 1. 3D model of safety shoe toe cap

Analysis

Analysis of the toe cap is done in Ansys software .

Simple toe cap

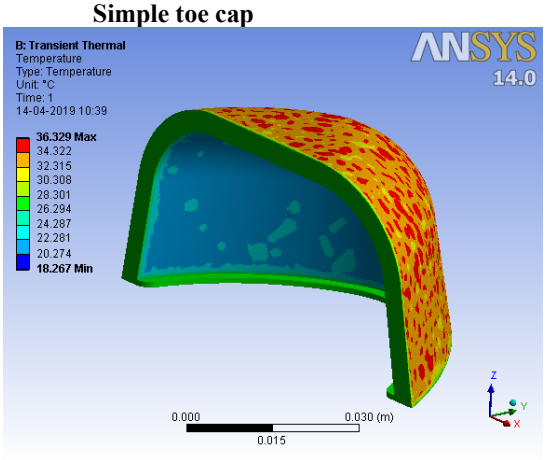

Figure 2. PA 66

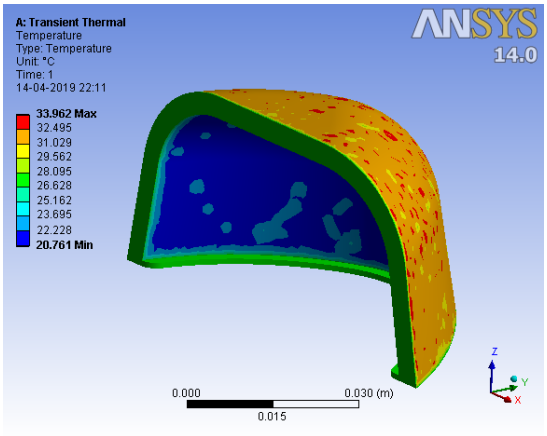

Figure 3. PA66+ 10 CF

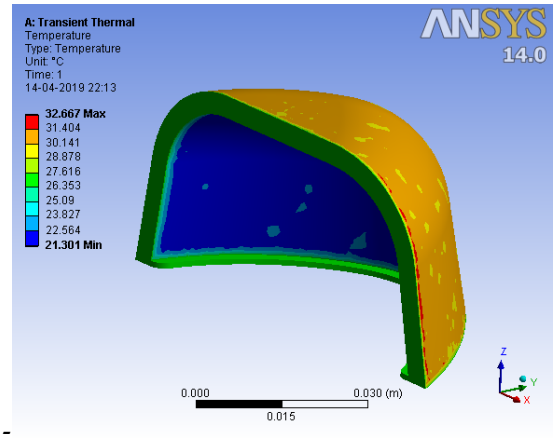

Figure 4. PA66+ 20 CF

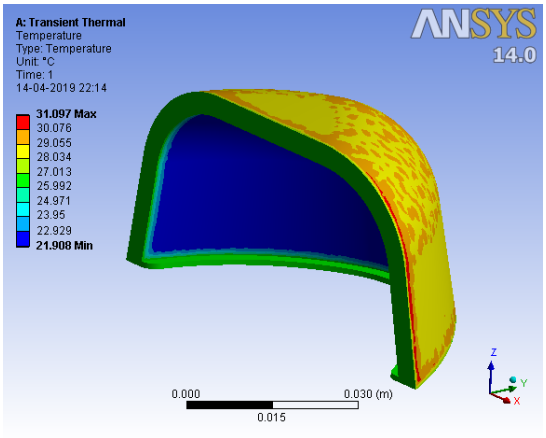

Figure 5. PA66+ 30 CF

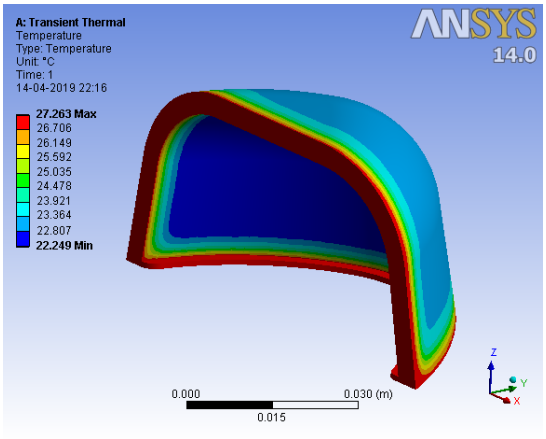

Figure 6. SS

Honeycomb toe cap

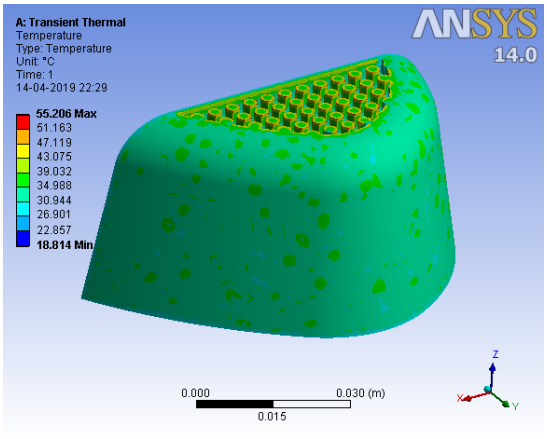

Figure 7.PA 66

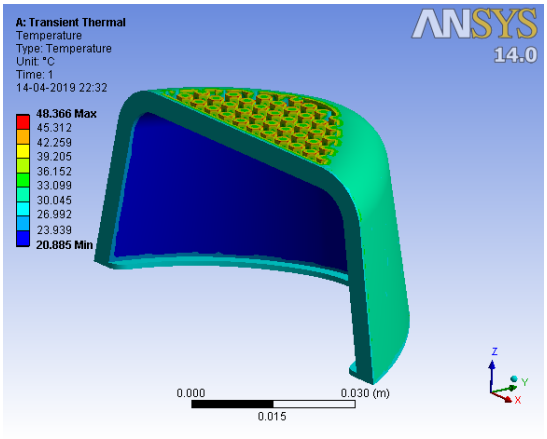

Figure 8. PA66+ 10 CF

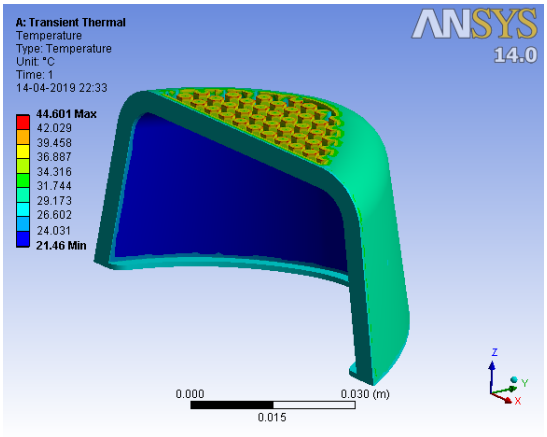

Figure 9. PA66+ 20 CF

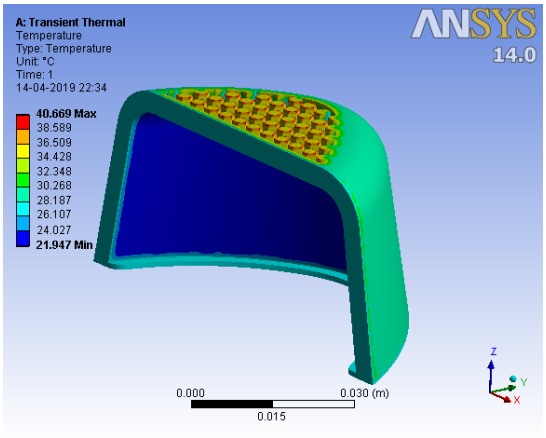

Figure 10. PA66+ 30 CF

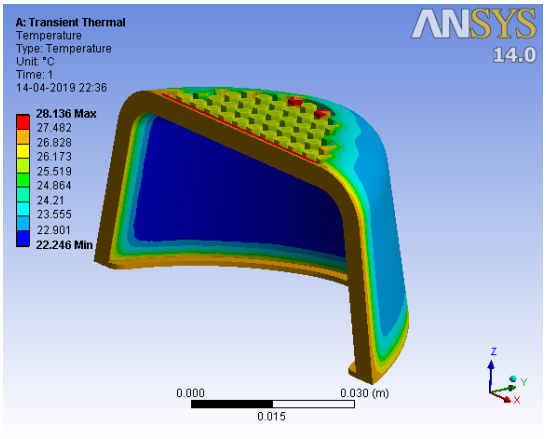

Figure 11. SS

Ribbed toe cap

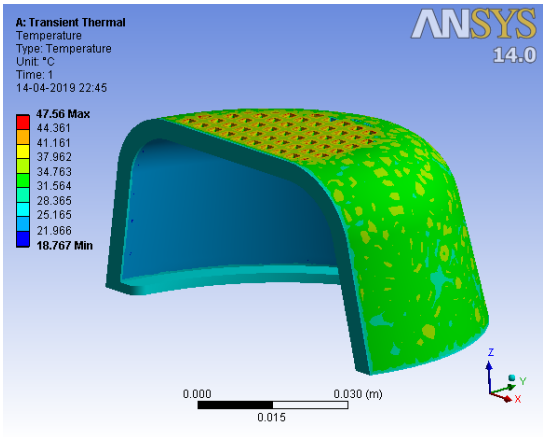

Figure 12. PA66

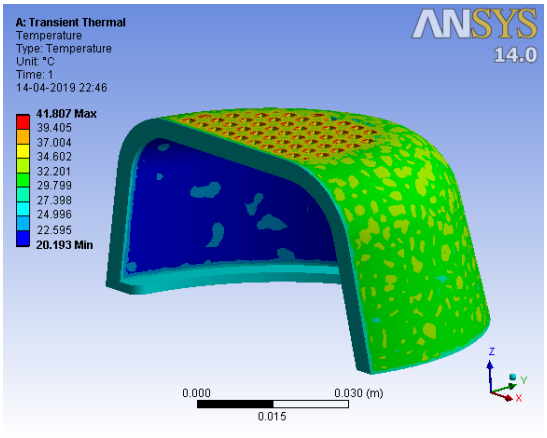

Figure 13. PA66+ 10 CF

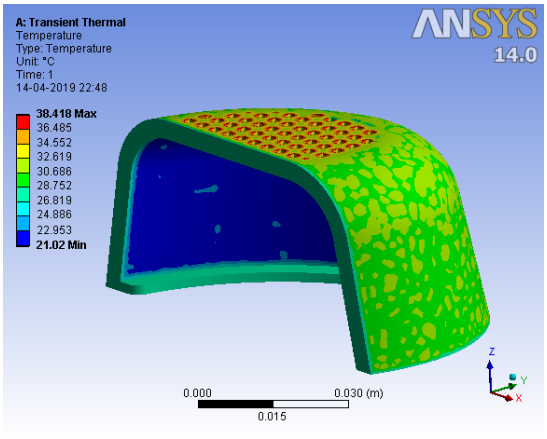

Figure 14. PA66+ 20 CF

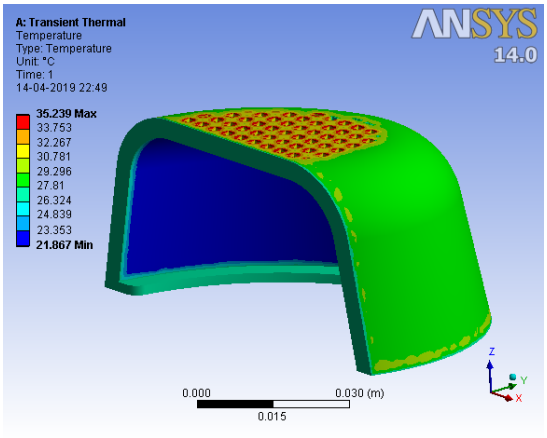

Figure 15. PA66+ 30 CF

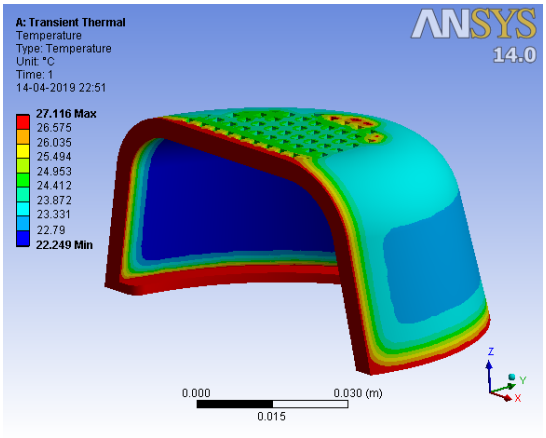

Figure 16. SS

Result and discussion

Table 1. Analysis data result

		PA66	PA66+ 10CF	PA66+ 20CF	PA66+ 30CF	SS
Simple	Min	18.267	20.761	21.301	21.308	22.249
	Max	36.329	33.962	32.666	31.097	27.263
Honeycomb	Min	18.814	20.885	21.460	21.947	22.246
	Max	55.206	48.366	44.601	40.669	28.136
Ribbed	Min	18.767	20.193	21.02	21.867	22.249
	Max	47.560	41.807	38.418	35.239	27.116

Advantages

Good tensile strength ,flexural modulus ,dimensional stability , friction and wear properties compared with unmodified polyamide 66 plastic ,high value of thermal conductivity.

Disadvantage

Mouldings may have anisotropic properties, Poor electrical resistance with significant reduction in elongation at break. Expansive compared with unmodified polyamide 66 plastics.

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