Thermal Analysis of Safety Shoe Toe Cap

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Abstract— Shoe toe bonnets/caps are the shielding equipment worn in the production company to care for workers' feet from heat. Steel is generally used for safety heavy toe shoe caps that have high thermal conductivity but now the usage of polymer material is growing because of the low pressure & less thermal conductivity. This study centers on the design & thermal enquiry of a safety shoe toe bonnet/cap by employing nylon 66 & carbon fiber (CF) in various weight ratios. Safety toe cap design is finished in Siemens NX Uni-graphics subsequently Finite Element Analysis (FEA) employing ANSYS software. ISO 20345: 2011 benchmark is followed for thermal analysis and then compared with steel shoe toe caps. Safety toe cap design is done in Siemens NX Uni-graphics followed by Finite Element Analysis (FEA) using ANSYS software. Comparison with steel shoe toe caps.

Keywords: toe caps, polymer, thermal conductivity, nylon 66, & carbon fibre

I. INTRODUCTION

Common consumer products using commercially available plastic products like: fishing rods, basketball bats, & water storage tank, roof tiles & safety toecaps. Finite element (FE) analysis has traditionally been used as an economical technique for designing & forecasting product performance underneath different service circumstances [1]–[3].

The shift from using traditional goods to plastic goods in safety products has now changed to FE modeling approaches for the productive industry. While designing common/general merchandises using composite materials related to advanced FE analytical capabilities may not be necessary, nevertheless companies face difficulties in the design, manufacturing and analysis stages. The main reason remains in the fundamental dissimilarity b/w traditional metal / plastic constructions & composite materials: traditional materials of isotropic character offer equal strength in all directions; while the strength properties of composite materials are significant. Therefore, the FE analysis calls for changes in the setup of material models & failure modes [4]–[8].

This research involved a systematic analysis of different product design using composite materials over traditional metallic components, with a safety toecap selected as the target product. In this research, the issues of FE modeling, analysis, optimization & manufacturing of the development method for common plastic products were investigated. "Safety Toecap" is by definition a protective cover over the toe cap of safety shoes. They are commonly employed as protective components in safety footwear to counteract potential risks to people such as falling objects, side effects, cuts, interruptions, tension and risks other potential exposure to chemical or thermal hazards [9]–[13].

While toecaps made of different materials may provide protection against a range of risks, toecaps are mostly made of steel or plastic.

To raise thermal characteristics by employing Carbon Fiber Reinforcement.

Raising the front & back depth of the thumb cap to increase additional height & strength [14]–[16].

II. TYPES OF POLYMER [17]–[20]

Thermoplastic

Thermoplastic, or thermo-softening plastic, is a plastic polymer/composite material that turn out to be pliable/moldable at certain high temperatures & hardens on cooling. Maximum thermoplastics have from top to bottom molecular weight.

III. MATERIAL USED

The material used for the fabrication of the toe are:

Carbon Material (with difference percentage)

Polyamide 66 (with difference percentage)

Nylon 66 or Polyamide 66 and polymer reinforced with carbon fiber has good thermal properties toes composite polymer thus making it a better substitute for bulky and expensive steel toe cap at particularly high temperatures and harden on cooling. Most thermoplastics have a high molecular weight [21]–[24].

IV. DESIGN

The 3-D mode of the toe cap is shown in **Figure 1**.

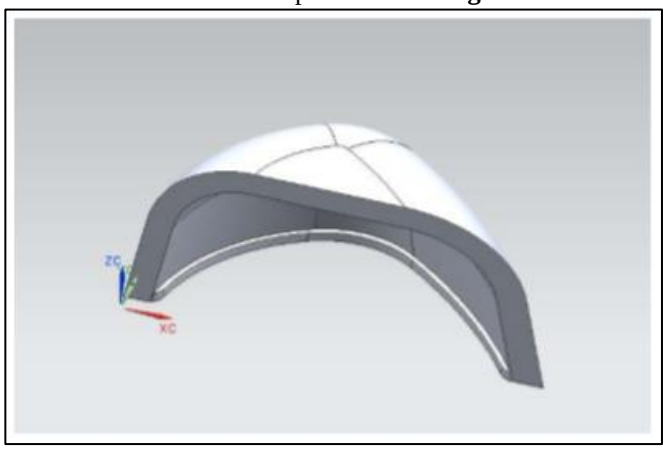

Figure 1. 3D Model of safety shoe toe cap

Analysis

Analysis of the toe cap is done in ANSYS software

Simple Toe Cap

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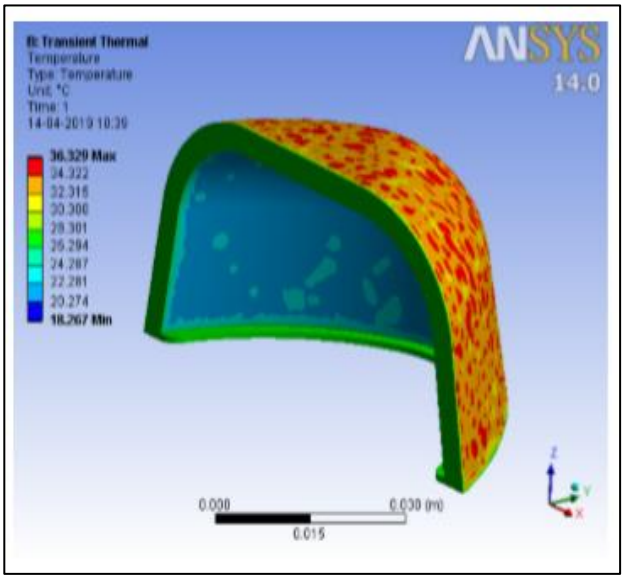

Figure 2. PA 66

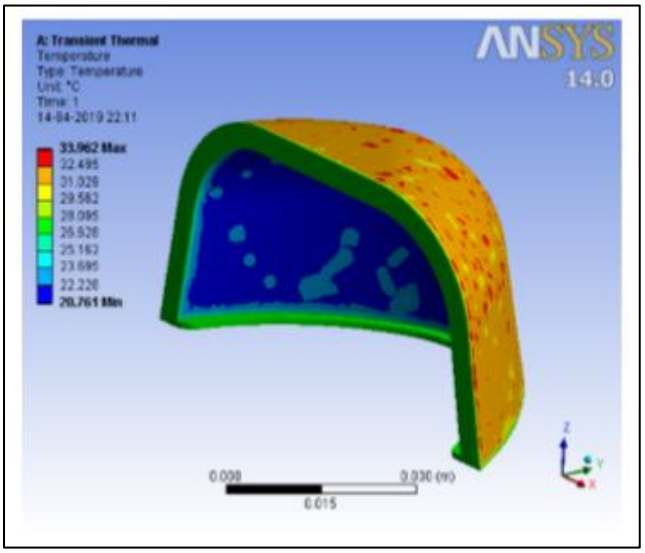

Figure 3. PA66 + 10 CF

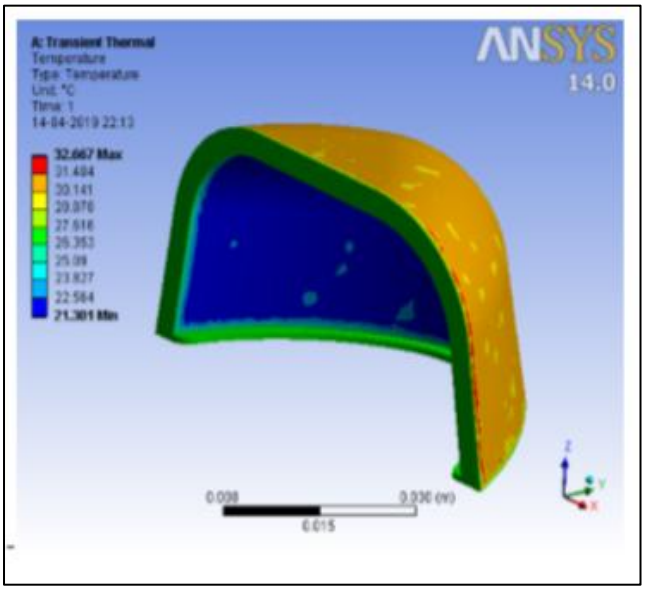

Figure 4. PA66+ 20 CF

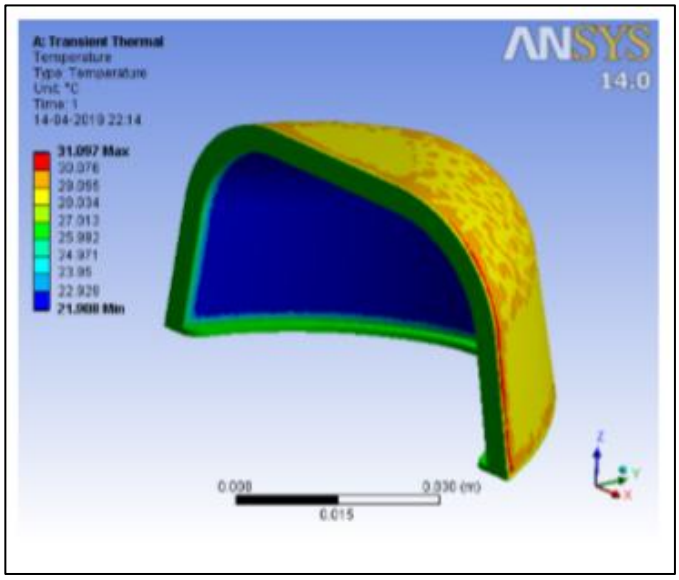

Figure 5. PA66+ 30 CF

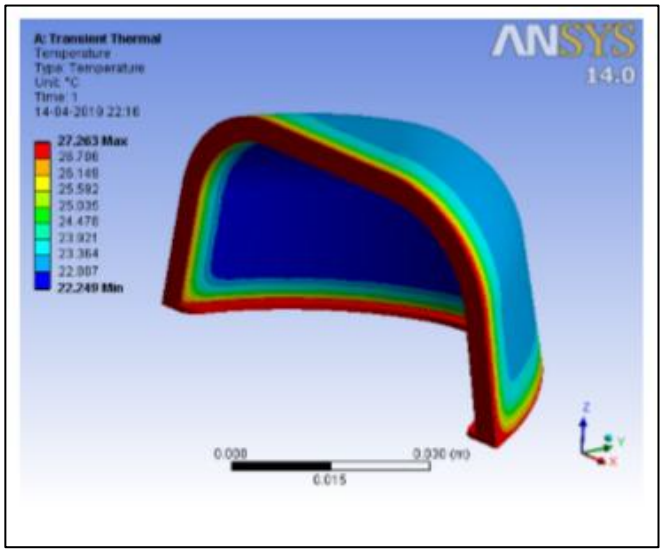

Figure 6. SS

V. HONEY COMB STRUCTURE OF TOE CAP & RESULTS

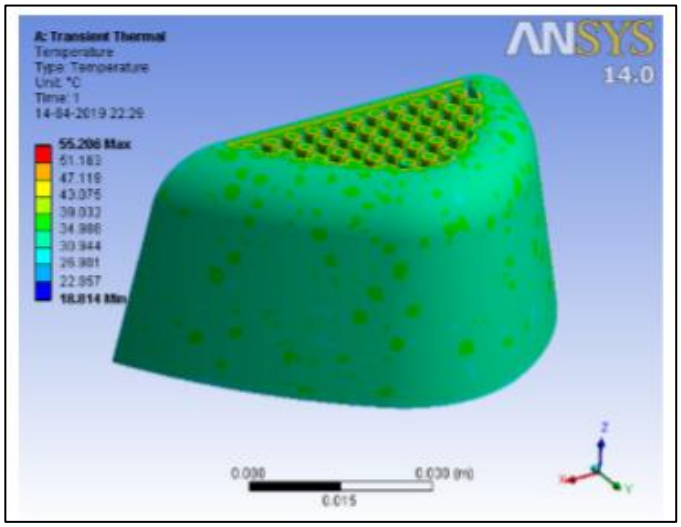

Figure 7. PA 66

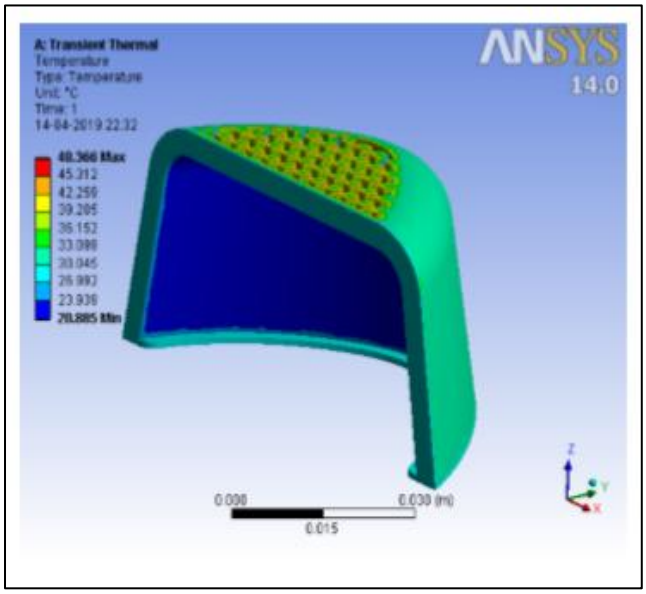

Figure 8. PA66+ 10 CF

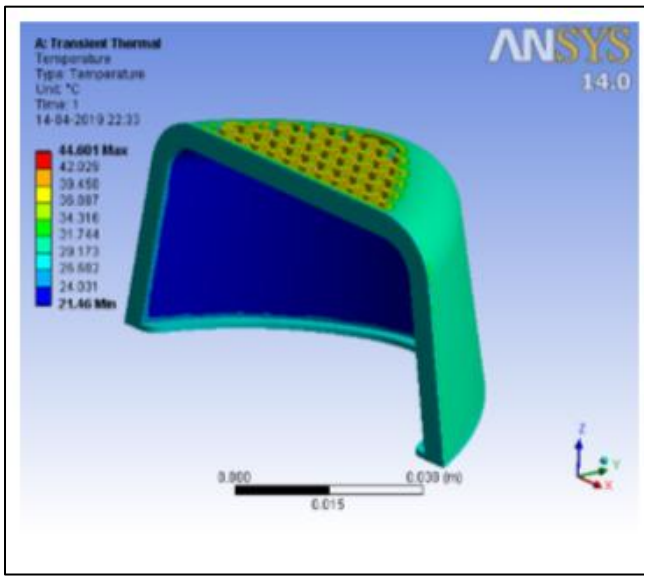

Figure 9. PA 66+ 30 CF

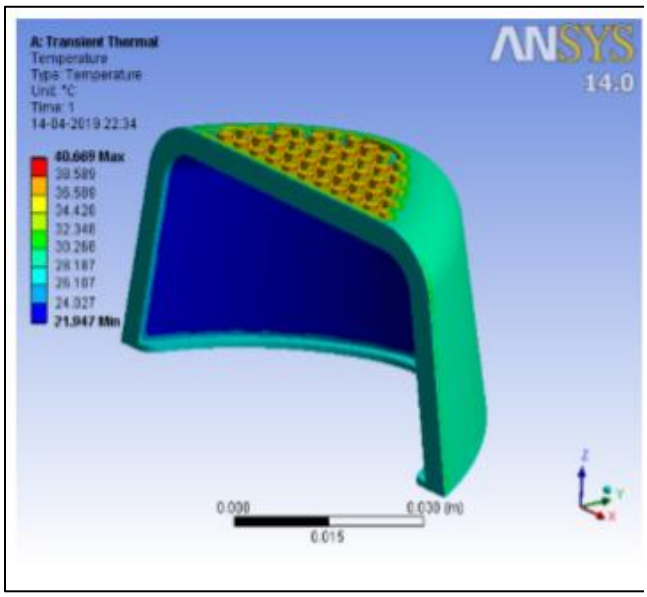

Figure 10. PA66+ 30 CF

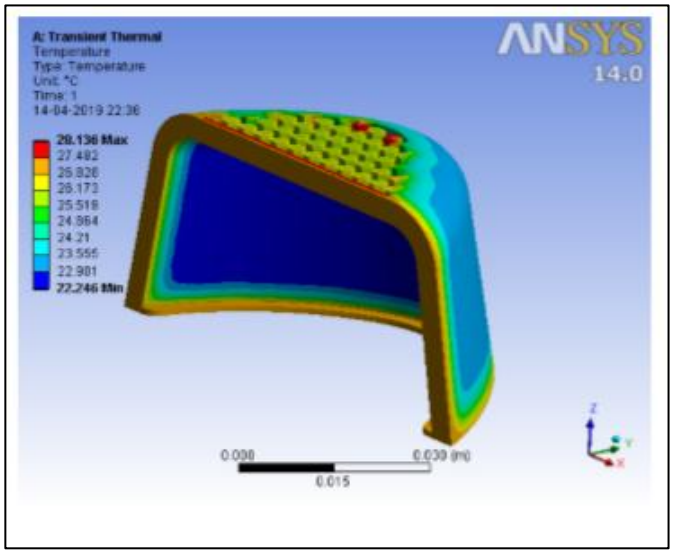

Figure 11. SS

Ribbed Toe Cap

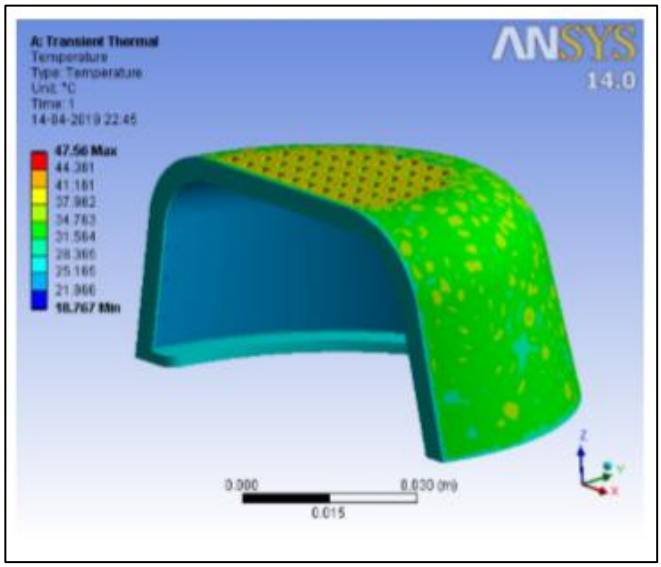

Figure 12. PA 66

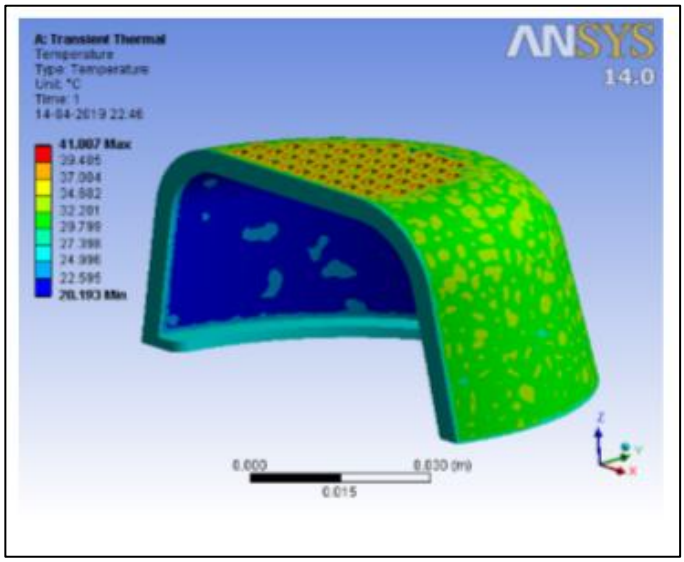

Figure 13. PA66+ 10 CF

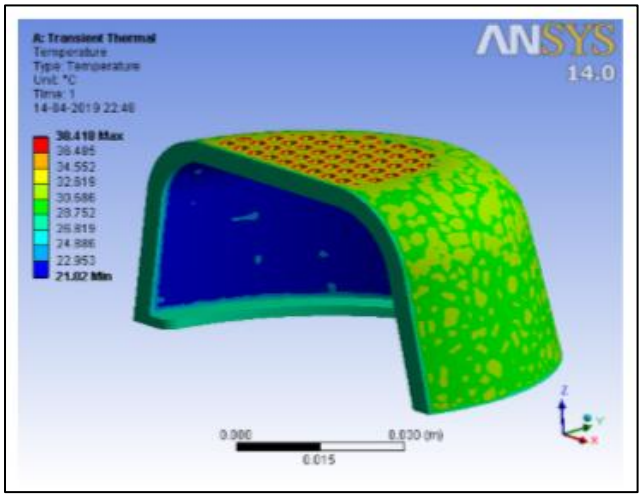

Figure 14. PA66+ 20 CF

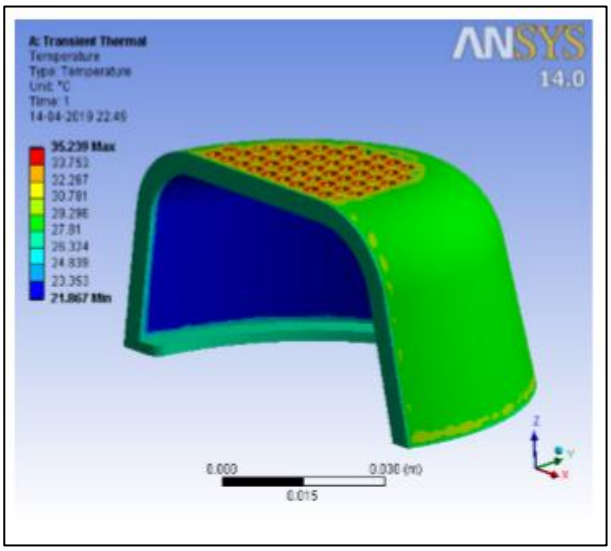

Figure 15. PA66+ 30 CF

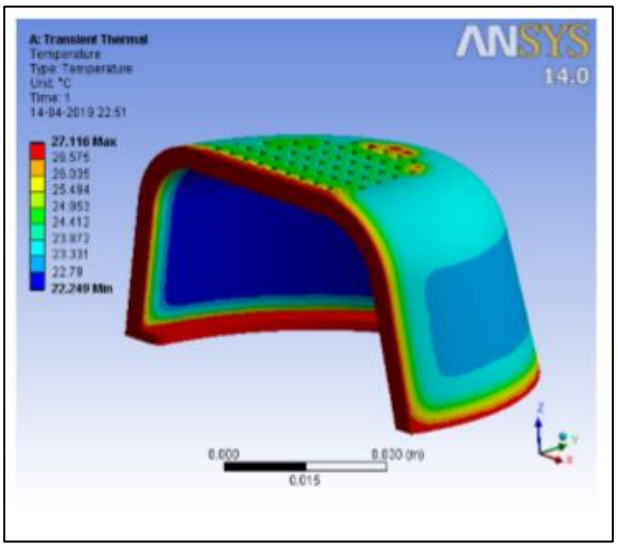

Figure 16. SS

VI. RESULTS

The analysis results are given in the **Figure 17** there are different design of the Safety Shoe Toe Cap and every model is analysed separately in ANSYS application.

		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

Figure 17. Analysis data result

VII. CONCLUSION

After the analysis following advantages & disadvantages can be considered

Advantages

Decent tensile strength, & flexural modulus/modulus, & lateral stability, fracture & wear characteristics related to basic polyamide 66 plastic, great thermal conductivity value.

Disadvantages

Molds may have anisotropic characteristics, Poor electrical resistivity with substantial decrease in stretch at rest. Extended equated to unmodified polyamide 66 plastics.

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