



Design and Modification of Toe Cap for Safety Shoe in 3D Printing

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Abstract -An investigation about the latest technology in 3D printing, we have planned to do toe cap for safety shoe. Our paper is to modify the design of the toe cap in steel material, why we modify the design is to increase the strength, stiffness and reduced corrosion. From a finite element analysis and experimental test result of toe cap prototype is taken in software package using Ansys15.0.It was found that the significant influence is to modify the design of steel toe cap. The prototype is printed by ABS (Acrylonitrile Butadiene Styrene) material using advance 3D printing machine. By modify the design pattern die amount is decreased by using the advance 3D printing machine. Experimental result of toe cap is to improve the strength of toe cap modify design and reduce corrosion.

Keywords: Toe cap, FEA, 3D printing, ABS, Steel, etc

I. INTRODUCTION

In a safety footwear, the context of the global evolution most of footwear, has been adopted creative and different orientations. Its optimization solutions amplify the market targets, mainly combining ergonomic aspects, biological and mechanical features since its conception. Our main theme is to modify the design of the steel toe cap. The Light-weight design has been a driving force for the research and application of light alloys, and in particular, high-strength steels.

Fig.1: we are using FDM (Fused Deposition Modeling) technology. It's the 3D printer on which thousands of design engineers test the designs. By producing models in house instead of outsourcing to a service bureau, you can keep your most ground-breaking product designs confidential which Collaborate with your colleagues. Faster, Easier, What's more powerful: Showing a flat drawing, or a three-dimensional model everyone can hold, your ideas into strong, functional models ready for collaboration and testing. 3D Printers build accurate, stable 3D models in ABS plus plastic.

These aren't fragile lab beauties either. ABS plus is stronger than materials typically used by competitive 3D printers.



Fig.1: FDM 3D Printing Machine

Only makes 3D printing so affordable and trouble-free. Outsourcing your prototypes can take days and cost hundreds of dollars. A 3D Printer can create the same prototype in just hours a fraction of the product cost. Conquer deadline pressures and speed your paper to conclusion with help from a 3D printing machine.



Fig.2: Toe Cap Model

A substantial reduction of weight due the thickness optimization, and lower volume rates compared with the polymeric solutions are goals for the framework shown in fig 2. This study presents a FEA to compare among the performance achieved with these models and the original

reference with 2.0mm thickness, concerning static stiffness values duly calculated in plastic domain.

The accumulated knowledge in other areas with the application of this deformation phenomena and similar requests to apply higher resistance steels was re-used. High Strength Stainless Steel are covered, combining a high energy absorption potential for dynamic and quasi-static loading, the local hardening effects of the material and strain rate sensitivity. The research program includes advanced steels with the extended phase to achieve tensile values up to 1400 MPa. The High-strength steels are also associated to strain-rate dependence and higher values of absorbed energy at high strain rates, when compared to other similar strength materials. In this paper, two ultra-high-strength and fully steel grades were selected from the research project and one of the main objectives of the present study was to assess the influence of intermediate strain rates on crash worthy properties for an axial impact velocity

II. MATERIAL PROPERTIES

A. Stainless Steel Toe-Cap

The Stainless steel is the generic name for a number of dissimilar steels used for their resistance to corrosion. The key element they all share is a certain percentage of chromium 10.7%. Elements are nickel and molybdenum, are added to improved higher corrosion resistance, chromium is always the deciding factor. I Corrosion a natural fact, as nature seek to combine together. In which Iron occurs naturally as iron ore particle. The Pure irons are therefore unstable and wants to "rust"; that is, to combine with oxygen in the presence of water in an same ships wrecked on the tool, covered at high tides in exposed at low level, would rust very continuously. Steel are did not begin to be in large quantities before the nineteenth century. The Carbon steel can be defined as an alloy of a small metal of carbon is combined iron. Despite its various additions stainless steel still behaves as stainless are in the nickel alloys that are really alloys of an pure iron only being one. Even highly alloyed stainless steel grades such as 304 are a minimum of 62% iron.

Carbon steels without any protection will form a coating of rust which will in a sense protect the rest of the steel. This is called general corrosion. Another lateral way of reducing corrosion is to put corrosion inhibitors into the solutions that would otherwise cause iron to corrode.

B. ABS Toe-Cap

ABS (Acrylonitrile Butadiene Styrene) [15] is a thermoplastic resin commonly used for injection molding applications. ABS Plastic is a copolymer of Acrylonitrile, Butadiene, and Styrene, and generally possesses medium strength and performance at medium cost. ABS is a common thermoplastic resin and can often meet the property requirements at a reasonable price in a market ABS is considered the best of the styrene family.

ABS is stands for acrylonitrile, butadiene, and styrene. The advantage of ABS is that this material combines the strength and rigidity of the acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber. The most use full mechanical properties of ABS are resistance and toughness. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. The impact test can be increasing the scope of polybutadiene in relation to styrene and acrylonitrile although this causes changes in other properties. Impact resistance does not fall off rapidly at lower temperatures.



Fig.3: 3D Printing Models

Even though ABS plastics are used largely for mechanical purposes, they also have good electrical properties are fairly constant higher range of frequencies but, properties are little harmed by temperature and atmospheric humidity in the acceptable operating range of temperatures.

C. Machining

ABS is easily machined. Common machining technique are include turning, sawing, die-cutting and shearing. ABS can be cut with standard shop tools and line bent with standard heat strips. ABS can be chemically affixed to itself and other like-plastics.

III. IMPACT TESTING

A. Test On Stainless Steel

Stainless steel grade 304L are base and welded material test specimens at -20% of and welded specimens at room and elevated temperatures were subjected to dynamic impact loads in order to achieve strain rates in the 4 to 40 per second range, depending upon temperature. Higher strain rates at the lower temperatures were easier to achieve than at higher temperatures. In discussing the impact tensile test results, it is important to remember that there is variability in material properties, even within a single plate. As indicated in Reference 5, material properties including yield strength can typically vary by 7% and the tensile strength of welds can typically vary by 10%. Similar variations were experienced during the impact testing, with the same material heat, drop weight, and drop height producing varying strain results in multiple test specimens. In light of this, the impact results were not expected to behave as a precise linear or quadratic function.

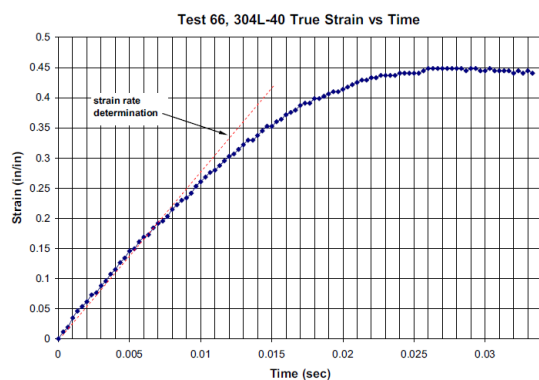


Fig.4: Graphs for Impact Test

Fig 4 material impact testing, using the ITM, yielded the actual strain history response of the test specimen to a defined level of impact energy. Using the "total impact energy method" previously discussed, the amount of impact energy absorbed by the test specimen was compared to the amount of energy under the quasi-static true stress strain curve are determine the factors. These factors, calculated for each impact test, are then plotted against the achieved strain rate for each material and temperature. The significance of the factor versus strain rate curves is that one is able to predict how much a strain rate curve will increase relative to the quasi-static stress-strain curve without having to perform testing at that specific strain rate. This approach was based on using the average of at least three impact tests at the specified strain rate (+/- 2 per second). With the factor versus strain rate curve approach, many tests

(at least 20 impact tests) are used to establish a linear curve fit over the identified strain rate range and the curve fit is then used to calculate the factor needed to generate the strain rate elevated true stress-strain curves. These factor curves are presented with the acknowledgement that the full range of strain rate information has not yet been achieved so the presented curves are indeed limited to the range of strain rates indicated. The assumption of a linear variation was deemed acceptable at present but may very well change with additional data at higher strain rates.



Fig.5:Stainless Steel Material

IV. FINITE ELEMENT MODELLING

The finite element analysis of the impact tests was carried out with an explicit plastic finite element code: ANSYS, with the Explicit Dynamics module of the workbench solver. In is represented the finite element model for the geometric toe cap model, which was simultaneously the target focus of the present study. The numerical model was performed by independent parts the representative mass body, a bottom layer for the constrained support of the toe cap, and the toe cap model which performed the numerical analysis. Impact velocities and impact test values according to experimental testing were properly applied to the part. Its normative configuration in the contact region was considered and the rest of the toe cap was modified in order to optimize the model. In a toe cap element was guaranteed regarding to the guided displacement evolution of the result is done, a toe cap was considered and a friction coefficient with the toe cap surface was applied in finite element analysis of the impact tests was carried out with an explicit plastic finite element ANSYS with the Explicit Dynamics module of the Workbench solver. In is represented the finite element model for the geometric toe cap model. The toe cap model was performed by three independent parts: the representative striker body, a bottom layer for the constrained the toe cap model which performed the Ansys analysis. Impact velocity of toe cap is values according to experimental testing were properly applied to the toe part. Its steel toe cap is configuration in the contact region was considered in 3D printing. It was simplified in order to optimize the numerical model. Conditioning

movement of the toe cap element is varied regarding to the guideless of impact test. A rigid body was considered and a friction coefficient with the outer toe cap surface was applied.

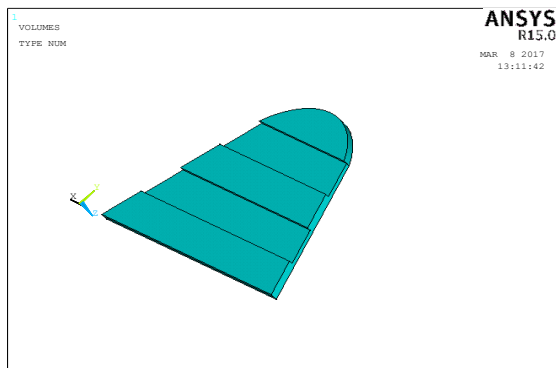


Fig.6: Bottom view model

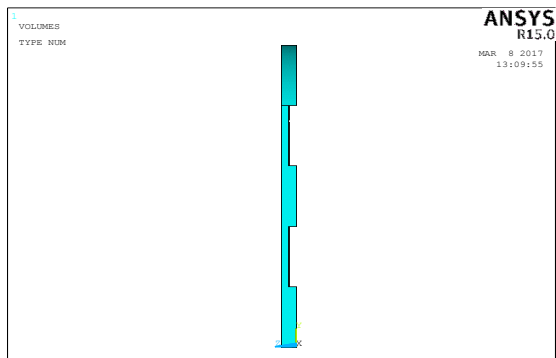


Fig.7: Side view model

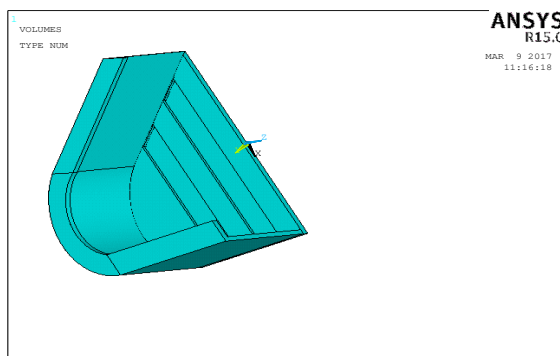


Fig.8: Isometric model

In this approach is well known to accurately a relative complex geometry but less than using solid models, and thus a much less run-time for the problem solver. The factor is considered in 3D printing in high impact velocities and thus expecting extended simulations. In a toe cap model was resized into triangle based prism elements. The mesh sensitivity was studied to compromise run-time efficiency with desirable accuracy. Thus, a

total mesh with indicator of evaluation of reference and an average value of 0.20 and maximum value of 0.87 was taken. The true stress–strain curves were introduced in tabular form in ANSYS 15.0 and the thickness of material is checked. Other material properties were considered, e.g., $E = 205$ GPa, $\mu = 0.3$, $\rho = 7830$ kg/m³.

V. EXPERIMENTAL RESULT

The results of the impact testing of model and combining material and thickness values are noted. The information is complemented with the conventional steel toe cap model. In an impact toe cap was constant throughout the tests with an experimental value of 25,003 N and test velocities resulting from the free-fall drop height are similar and they are indicated as well as input variables. The results are related to the crushing displacements of prototypes, load responses and absorbed energy value. The preliminary analysis for the first 3mm is also covered. As noted above, all toe caps under study have similar base shape/size for different values of thickness and weight, consequently. Accordingly, these values also revealed slightly lower capacity of load reaction and energy absorption.

The prototype model is worth noting that the same models show the most significant increase when absorbed energy per unit weight is analysed, and even more, comparing to the conventional steel toe cap selected in this study (note that the previous 2.0 mm model shall be out of this particular analysis, due to the values are deformation in the limit of normal approval). In another value for this standard model with thicker shell portions and thermally treated may allude to an improved response HSS used in this application.

The shell model of prototype is taken in an abs material the prototype are also observed that this last geometric model have induced a greater efficiency of work hardening, regarding critical thickness reductions.

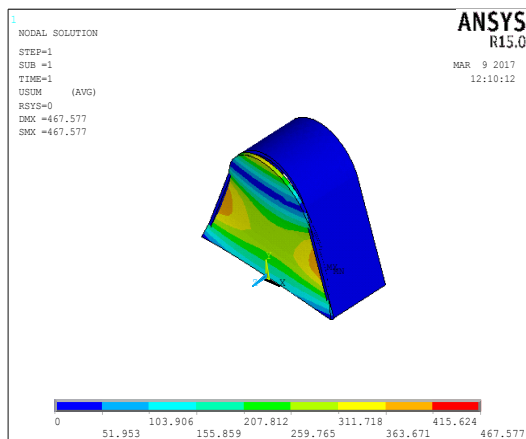


Fig.9: Experimental Result

Related causes such as: stiffness loss, thinning effects associated with forming processes for advanced steels, differential thickness values of toe cap components, and issues associated with the numerical simulation, such as the definition of boundary conditions, convergence criterion parameters of the FE code, among others, are justified. The influence on the accuracy of numerical simulation of the prototype thickness decrease, considering a range of thinning effects of around 5 to 10%, was exemplified and performed for the same 2.0mm model, considering a fact-finding 2.0mm thickness mode. The results have converged on the accuracy of previous experimental values.

DISCUSSION AND CONCLUSION

In this study, new geometric models were investigated using stainless steel materials and a thickness range of 1.8 to 2.0mm to address the potential of the energy optimization for thickness reduction and the new prototype output model is take in 3D printing. Finite element simulations of the elastic behaviour and experimental static compression tests were performed and the following conclusions could be drawn.

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