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SAFETY – CLICK RAZOR

Matthias Hien, Vishnu Prasad, Sayed Ali, Jomon George Reji, Jofin Jo Raji and Jobin Joy

[1] Department One, Institution One, City One, Country One
[2] Department Two, Institution Two, City Two, Country Two

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Abstract

The firms that offer multi-blade razors control the global market for razors. Their strategy of raising production costs dramatically results in environmental harm. Recycling is not possible in this industry due to the manufacturing procedures, hence a significant amount of garbage is either burned or dumped in landfills. Additionally, studies have shown that multi-blade razors can negatively impact hair growth and cause skin rashes, among other difficulties. Our goal is to bring the classic safety razor to the market with certain adjustments in response to these difficulties. These improvements include a click mechanism in place of the thread mechanism and a 40-degree head position adjustment. These changes are meant to give customers a more eco-friendly choice without sacrificing a satisfying shave.

1. Introduction

Our goal is to develop a safety razor with an easy-to-use click mechanism that is produced using additive manufacturing technology. The main goals of this project are to redefine the double-edge razor that is renowned for its flawless shave and to solve the negative aspects of the current cartridge razors. To achieve this goal, an initial topology analysis was conducted on a design. Based on the results, a subsequent topology analysis was performed to finalize the design. The design process took place in SolidWorks software, where adjustments were made to the head, neck, and stem of the safety razor. Subsequently, simulations were carried out to assess the stability of the newly obtained design. This was crucial to ensure that the click mechanism functions seamlessly and that the razor can withstand displacement and drag forces applied during the shaving process.

The innovative manufacturing technique known as Additive Manufacturing (AM) involves building a product layer by layer using a digital model as a guide. This methodology is a sharp contrast to traditional manufacturing techniques such as formative manufacturing (e.g., injection moulding) or subtractive manufacturing (e.g., CNC machining), which entail material shaping or removal, respectively. AM is used in several industries, such as the automotive, aerospace, and healthcare sectors. Among its many benefits are reduced waste generation, low-volume production capacity, and design flexibility.

Additive Manufacturing (AM) has a wide range of applications in many industries. Personalized prosthetics and implants for the medical and dental fields; complex geometries and lightweight components for aerospace and defense industries; automobile prototypes and low-volume production parts; jewelry, fashion accessories, and other consumer goods; industrial and manufacturing process jigs, fixtures, and tooling; and architectural models, building components, and structural elements in architecture, construction, and engineering are a few noteworthy examples. AM is always coming up with new uses in new fields as technology develops.

Topology optimization is a methodology employed for designing structures with an optimal distribution of material, all while adhering to a specified set of design and load constraints. A prevalent technique in this domain is the density-based method. In this approach, a design domain is discretized into a finite element mesh, with material properties represented through a continuous density field. The optimization process involves iterative updates to the density field, enhancing structural performance while meeting the defined design constraints. For tooling components with complex internal structures and geometries that would be difficult or impossible to fabricate using conventional techniques, Additive Manufacturing (AM) offers a quick and affordable option. Lead times and production costs for tools may be shortened as a result of this capability. Additional benefits of AM include the ability to produce replacement or spare parts for tools on-demand, which reduces the need to keep large inventory and increases equipment uptime. Quick design iterations and concept testing are made easier with the help of rapid prototyping of tools.

A few tooling sector businesses have already used AM in their operations. One of the top producers of cutting tools, Sandvik Cormorant, for example, invented a 3D printing method specifically designed to create intricate tool geometries. Using AM in conjunction with topology optimization makes it possible to create complex lightweight structures, something that is difficult or impossible to do with conventional production techniques. The majority of wrenches are typically made via the drop forging process. A wrench is a tool used to provide grip and a mechanical advantage while applying torque to nuts and bolts. Conversely, Additive Manufacturing (AM) produces far less material waste since it requires less machining. Furthermore, topology optimization serves as a numerical technique that helps identify the best form and material distribution inside a given design space while still respecting predetermined design restrictions.

This paper presents an overview of the use of topology optimization in the design of a newly created safety razor, demonstrating the model's fabrication through Additive Manufacturing (AM). The essay explores the importance and reach of additive manufacturing (AM) in the tooling sector, with a particular emphasis on the redesign and 3D printing of a crucial production tool—the click razor—using AM methods. In addition, the study investigates topology optimization's application in determining the optimal material distribution for improved performance.

2. Material Composition

2.1 Stainless Steel 17-4 PH

Type 630, also referred to as Alloy 17-4PH (UNS S17400), is a martensitic stainless steel with chromium, nickel, copper, and niobium that precipitation-hardens. This alloy is well-known for its remarkable combination of high strength and hardness, as well as its superior resistance to corrosion. When supplied in the solution-annealed state, it is crucial to remember that using it above 572°F (300°C) is not advised.

2.1.1 Physical Properties : 17-4 PH

Physical Properties	Value
Density	7.75 g/cm3
Specific Heat	460 J/kg degree C at 24 Degree Celsius
Modulus of Elasticity	196 Gpa
Melting Range	1404-1440 degree Celsius
Hardness	30-40 HRC

2.2 ABS: Acrylonitrile Butadiene Styrene

It is a common thermoplastic polymer with a wide range of uses. With its three different monomers—acrylonitrile, butadiene, and styrene—ABS demonstrates an exceptional equilibrium between strength, durability, and thermal stability. Because of its versatility, ABS is very well-known and is frequently used in the manufacturing of consumer goods, electrical housings, automobile components, and other household items. This polymer is a popular option for producing a wide range of items since it is simple to work with in injection molding, extrusion, and 3D printing. The material has an appealing surface finish and is distinguished by its opaque look. ABS's chemical resistance, which includes resistance to acids and alkalis, further improves its usefulness for a variety of applications. It's crucial to remember that ABS may deteriorate in prolonged exposure to sunlight or ultraviolet (UV) radiation and that its thermal performance might not be appropriate for applications involving high temperatures. As a result, when choosing ABS for a given project, factors like application requirements and environmental conditions are quite important.

Physical Properties	**Value**
Tensile Strength	40 MPA to 50 MPA
Flexural Strength	70 MPa to 90 Mpa
Elongation at Break	10% to 50%
Temperature Resistance	105 to 110 degree celsius
Hardness	70 to 115 Rockwell M

3. Design

The utilization of DE blades is less common among users primarily due to the initial learning curve associated with them. Despite their exceptional sharpness and efficiency in hair cutting with fewer strokes, the safety concerns arising from user exposure while mounting the blades have diminished their value. However, DE razors are more environmentally friendly and easier to recycle compared to cartridge razors, which often contain plastics and contribute to material contamination.

Multi-blade razors, mainly manufactured in Asia, prioritize cost-cutting over quality, while DE blades are crafted globally, emphasizing quality and craftsmanship. Recognizing the need for a redesigned DE blade razor, we aim to reintroduce these razors with enhanced safety features, comfort, and recyclability.

The razor's head shape and construction significantly impact reachability and comfort, prompting a meticulous study to design a more user-friendly and slimmer stem. Our goal is to create a fully recyclable razor with a circular material flow, aligning with industry trends to minimize production costs and environmental impact while maintaining a focus on quality and craftsmanship.

Therefore, we have chosen to embark on the direction of redesigning a safety razor that incorporates DE Blades, with a primary focus on minimizing the learning curve and enhancing safety. We believe there are substantial opportunities for improvement, particularly considering the sustainable foundation inherent in DE razors. This endeavor aims to make DE blade razors more accessible, user-friendly, and safe, contributing to a positive shift in user perceptions and promoting a sustainable shaving experience.

3.1 Initial Design

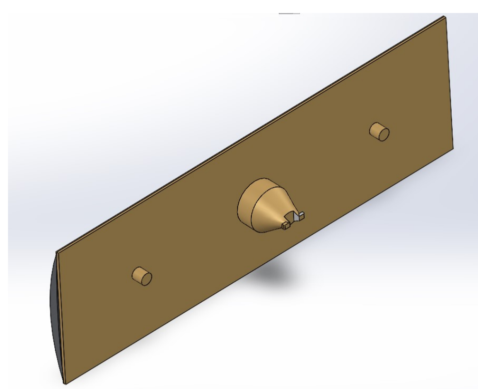
3.1.1 Safety razor

3.1.2 Head Mount with thread

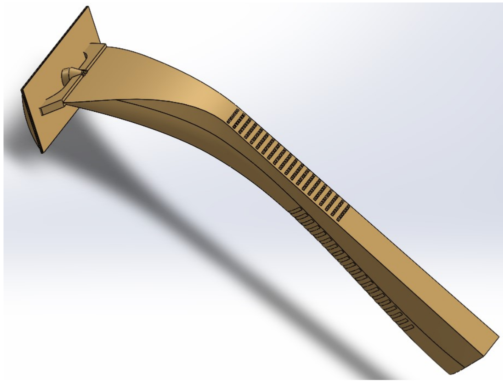
3.2 Design Re-Change

In the course of this redesign, the decision was made to transition from stainless steel to 17-4 PH, specifically for the razor's stem. This choice was motivated by 17-4 PH's superior hardness and wear resistance, contributing to enhanced durability. Concurrently, ABS was selected for the razor's header portion, leveraging its favourable chemical properties. Importantly, both materials were chosen for their skin-friendly nature, ensuring the absence of harmful effects during the shaving process. Moreover, this material selection strategy facilitated cost reduction compared to other razors available in the market.

Additionally, the design underwent modifications compared to the initial safety razor available on the market. The head's orientation shifted from a perpendicular position to 40 degrees, providing users with an improved shaving experience. Furthermore, the design addressed the inconvenience of changing blades in the earlier model, where the head had to be twisted and removed due to the thread mechanism. In the redesigned version, a clip mechanism was Implemented, allowing the head to fit seamlessly onto the stem. This modification makes it easier for users to remove the head without direct contact with the blades, enhancing both convenience and safety.



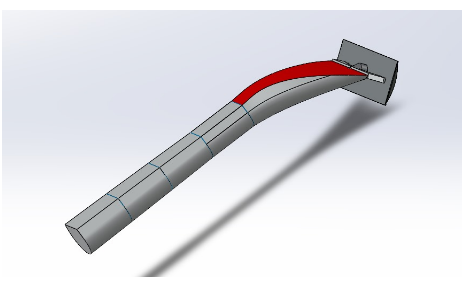
3.2.1 Clipper Introduced replacing Thread Cut



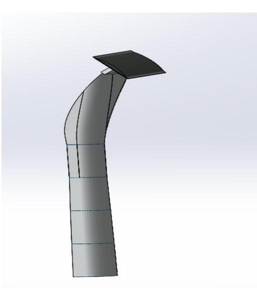
3.2.2 Re-designed Razor

4. Topology Optimization

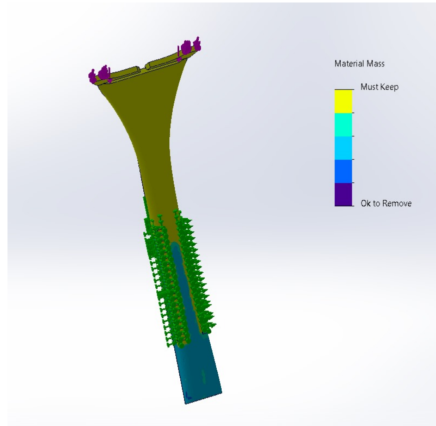
Topology optimization was primarily directed towards a specific segment of the razor's main body, specifically targeting the razor stem. In the initial phases of this procedure, we incorporated our chosen material, 17-4 PH, into the stem. Subsequently, force was applied to the material, aligning with the direction of how our hands hold the razor, imitating the grip used during shaving. The header plate, designed to secure the blade, has been designated as a preserved region to avoid any mass reduction in that specific area. Following the generation of the mesh, the topology optimization was configured to attain a 30% mass reduction target, resulting in the following output.



4.1.1 Initial Model Design

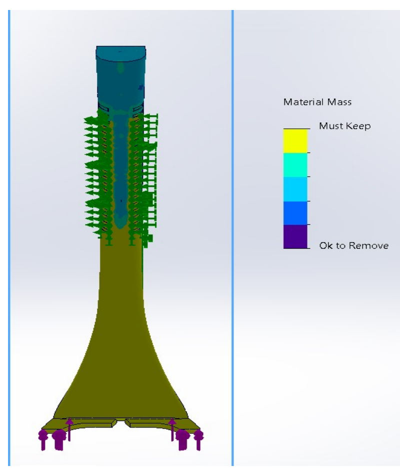


4.1.2 Initial model Stem Part



4.1.3 Topology Design for Initial Model

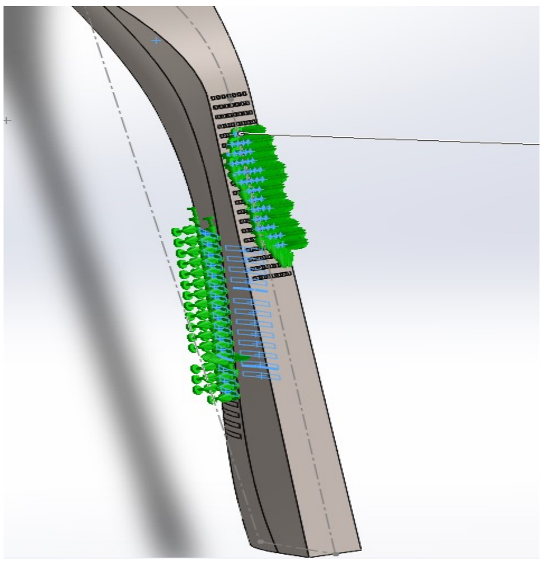
The initial topology optimization design was derived as outlined. Upon examination, it was observed that the stem part required further modification as the obtained design appeared excessively hollow. To address this, the model was exported to SolidWorks, and the length of the stem was reduced in an effort to minimize the blue zone portion of the design. Despite these adjustments, the outcome remained consistent. Subsequent modifications were exclusively focused on length reduction. After a series of continuous modifications, a decision was made to proceed with the achieved result, this is because further reducing the length of the stem on the razor could have adverse effects on the user experience during shaving. Such modifications could compromise both the comfort and aesthetic appeal of the razor. Consequently, we have chosen to retain the current topology as our final design and will proceed with the subsequent phases of the overall design process.



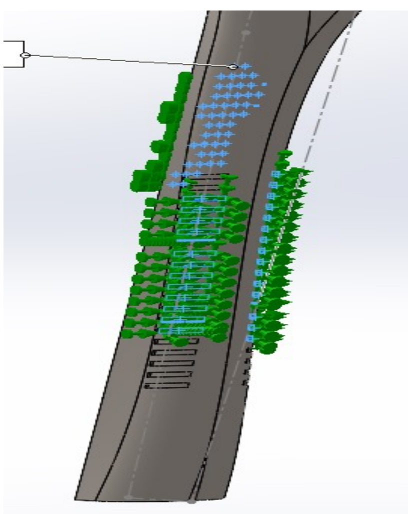
4.1.4 Final Topology Result

5. Simulation

During the simulation process, ABS material was incorporated into the razor, specifically towards the head. The simulation procedure mirrored that of the topology optimization. Initially, a force of 5N was applied, and subsequently, the study was repeated with an increased force of 10N, along with the application of a 500g drag force. The force application replicated the manner in which we typically hold a razor. The study was then conducted on the razor under these conditions. The representation of simulation is shown below along with its results

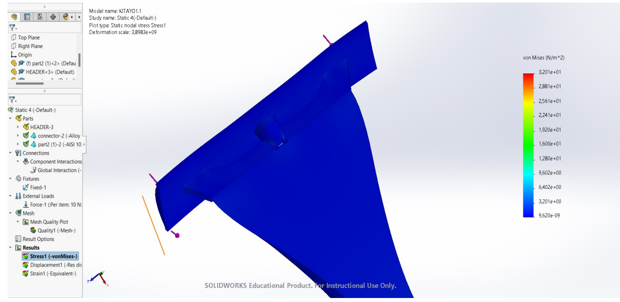


5.1 Force application

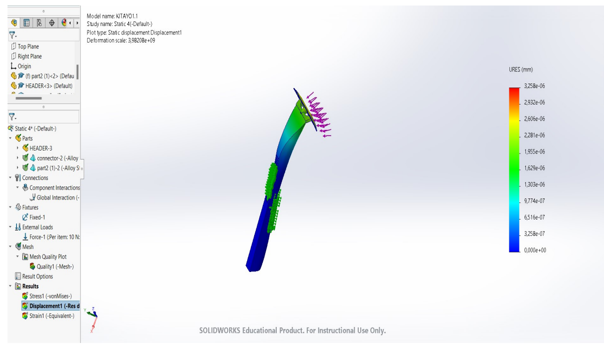


5.1.1 Force application

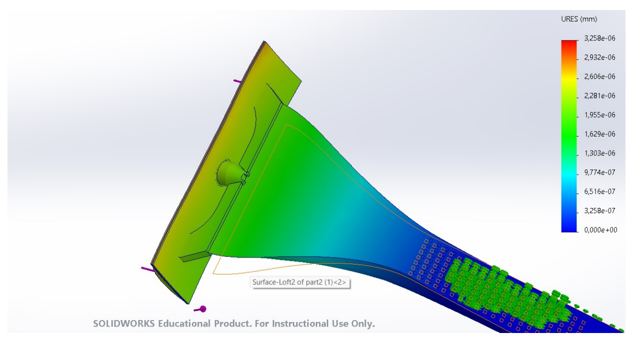
5.2 Illustration of Simulation Results



5.2.1 Results obtained after simulation: Stress



5.2.2: Result obtained after simulation: displacement



5.2.3: Result obtained after simulation: resultant displacement

The subsequent steps were derived from the simulation process, and the testing was conducted under standard conditions. The results for stress, strain, and displacement indicate that there are no significant issues with the modelling process. Furthermore, the analysis suggests that there are no concerns with the joints as all results fall within the yellow zone, indicating the absence of severe dangers or potential problems.

6. Conclusion

A novel razor design has been developed to enhance the conventional safety razor by incorporating DE blades, which is less common nowadays, it is known for its increased sharpness for more effective hair cutting. To address the drawbacks associated with user exposure while mounting the blades themselves during the process and also with the shaving experience the design is changed by the introduction of a clip for the replacement of thread. Additionally, the head angle has been adjusted from perpendicular to 40 degrees, aiming to enhance user comfort and provide a superior shaving experience.

The introduction of new materials, specifically 17-4 PH and ABS, was driven by their advantageous properties and cost-effectiveness compared to market-available alternatives. The selection process was guided by the desire to maintain optimal functionality while reducing costs. Utilizing topology optimization contributed to an overall weight reduction in the newly designed model.

This innovative design not only performs its intended functions flawlessly but also aligns with aesthetic standards, offering a comprehensive improvement over traditional safety razor.

7. Acknowledgements

We wish to extend our heartfelt gratitude to our research supervisor, Dr Matthias Hein, for his unwavering guidance, encouragement, and support throughout the entirety of this project. Our sincere appreciation also goes out to our colleagues and peers in the Department of Industrial Engineering and Applied Science for their valuable input and constructive feedback on our research. Their contributions have been instrumental in shaping the success of this endeavour.

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