Design of a Personalised Faceguard for an Elite Cricketer

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Abstract

Personalised design of a consumer product such as faceguard is dominantly semantic design as its functional component is strictly governed by safety requirements specified by the standards. This paper, which outlines activities associated with design of a personalised cricket faceguard for a prominent elite cricketer, uses earlier developed methodology to demonstrate developmental efforts and decision making processes employed in order to combine functional and affective aspects of design. Selective laser melting, an additive manufacturing technique, was employed to achieve unique designs in order to elicit instrumental and aesthetic customer’s responses and allow innovation in form and structure not possible with traditional manufacturing methods.

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1. Introduction

In cricket, the strategy of fast bowling has long been a game strategy to jeopardise optimal batting performance. According to Landers [1], muscular tension and perceptual narrowing are the major effects that affect skill performance. To mitigate these effects, protective headwear has become a necessity for batsmen. Cricket helmets, lightweight, but hard, are designed to protect the skull by deflecting cricket balls and shield the wearer from impact. The face is protected by a helmet faceguard, which is generally of a cage-type construction, featuring a number of interconnected struts with an unobstructed viewing aperture proximate to the eyes of a wearer (see Fig 1). This type of faceguards is a compromise between the requirements of comfortable face protection and visibility. In addition to

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the assumed functionality of the faceguard, semantics of a faceguard design - more importantly its aesthetics - are becoming increasingly important. Possibly because of the game duration and the length of time it is on television, cricket is reliant on its aesthetic. In particular, carefully manicured cricket ovals, selection of colour-schemes used for on-screen graphics and design of the playing equipment are just a few examples emphasising the importance of the aesthetics in cricket.

Being a compromise between the requirements of comfortable face protection and visibility, the mass produced, or designed-for-many, faceguard is typically unable to cater for the individual needs of elite sportspeople, thus the individualisation in a form of a personalised design is necessary. This work which outlines activities associated with design of a personalised faceguard for a prominent elite cricketer, demonstrates developmental efforts and decision making processes employed in order to generate an artifact that consolidates the effective and aesthetic design with the personalised functional design.

1.1. Cricket Faceguards

Most popular cricket helmet models indicated that were certified against either the 1998 British Standard (BS 7928) [2], or the 1997 Australian/New Zealand Standard [3]; nether standards include projectile testing or include provision for failure due to contact with the helmet/faceguard face. At the time of this work, BS 7928:2013 standard [4] was just drafted. However, that was sufficient to provide a basis for the testing framework used in this work (see Fig 2).
2. Personalised Design

Typically product design and production consists of several distinct phases which are executed almost sequentially, with some iterations and overlaps. In this process, the product begins with an idea, generated by manufacturers, suppliers, or consumers, that seems to meet an existing or future customer need. Product developers then experiment and formalise concept proposals, which are translated into detailed designs and prototypes. Ultimately, the prototypes become production models, which can be tested and refined further [5-8]. If there is more than one potential customer, this basic sequence is extended to accommodate a replication of the design with varying levels of efficiency and output volumes from a few (batch production) to many (mass production), otherwise it becomes a personalised design process.

A process of personalised design used in this paper was adopted from Kajtaz et al. [9] and schematically shown in Fig 3. In this development approach, the functional and the affective/semantic designs are performed concurrently. Functional design encompasses activities such as certification, tailor-made shaping and sizing (including the ergonomics aspects too), and materials exploration. Affective/semantic design addresses aspects of aesthetic impression, semantic interpretation, and symbolic association in design. These parallel streams converge at the fabrication stage. In this approach, fabrication is based on a low-cost tooling, which allows merging of prototyping and the production, leading to a leaner development.

![Fig 3 – Schematic representation of the adopted methodology, adopted from Kajtaz et al. [9]](image)

2.1. Design Requirements and constraints

As the manufacturing process was predefined and consequently the material selection, component sizing was a remaining activity to ensure a satisfactory product performance. Fused deposition modeling (FDM) [10] was used to
prototype new designs and allow personalised fitting of helmet and sizing of parameters such as size of the viewing aperture, the face-faceguard clearance.

Safety standards and regulations clearly defined the functional requirements, however the affective user needs were subtle, ambiguous and generally more difficult to obtain due to the difficulties in describing them. Given that this was a dominantly user-centred design, the affective requirements were identified by probing user emotions. In order to effectively synthesise the affective requirements, a user persona was created by capturing symbolic associations needed to enhance the customer's celebrity brand or public image. The existing public image was the most critical constituent of this persona, which was investigated and reconstructed as a series of hypotheses through scanning and monitoring of the media, social media and interviews/questionnaires with the members of the cricket community. Therefore, it became obvious that the affective requirements related to the symbolic association or the social impact were dominating those related to the customer's personal aesthetic impressions, which is very similar to the case of mass-produced products, where the personal aesthetic impression is entirely absent. However, this is not expected to be the general case but rather an exception for some high profile public individuals.

The majority of design constraints are typically set by the intended manufacturing process. However by adopting additive manufacturing (AM), innovation in form and structure was enabled; and the semantic design enacted limits or boundaries and curtailed the design process in this work. In particular, some traditional design aesthetics are engrained in cricket culture that needed to be respected. Cricket as a sport has been played for over 4 centuries, so the design of the new faceguard needs to conform to a series of unwritten laws governing aesthetic impression. Although, it is difficult to fully quantify the unwritten law of cricket attire, a more “traditional look and feel” seems to be preferred fashion. One impetus was to ensure that the design was not radically different from pre-existing faceguard designs. This was to reduce any potential negative symbolic association that may lead to distancing from the peer group(s) or the sporting fans. Another constraining factor was utilising the existing mounting system to fit the helmet. Given that the faceguard needs to be adjustable, the original mounting mechanism had to be retained.

3. Concept Development

The initial concept development commenced with ideas that could be deemed as variations of an existing faceguard with an incremental introduction of semantics inspired by pop-culture and video games in order to explore levels of the customer’s acceptance of the novelty (see Fig 4, left).

![Fig 4 – Initial concepts (left), Iteration 1 concept (far right)](image)

Based on customer feedback, the initial set of concepts was modified through elimination of sharp edges in the following iteration (see Fig 4, right). Unlike the initial iteration, this iteration intended to exploit the used AM by presenting unique design features such as small radii bends, seamless bonding and a solid inset blended with the interconnecting segments.

Based on customer feedback, including a requirement that a faceguard should not obscure facial features, the design was refined; in particular to emphasise key facial features by smooth, flowing lines that blended into other segments of the faceguard (see Fig 5). Through iterative visual suggestions and affective and cognitive user feedback, the design was refined in collaboration with the customer to the final concept proposal (see Fig 6).
4. Construction

Selective laser melting [11-13] was used in this work to allow the creation of novel designs and enable lower time-to-market and a high level of flexibility. Raymor Ti–6Al–4V (Grade 23) powder with an apparent density of 2.55 g/cm$^3$, and particle size distribution of: 0–25 µm (34.1%), 25–45 µm (63.1%), >45 µm (2.8%). Although, the literature reports continuing improvements of the SLM technique [14-18] in order to fabricate parts with mechanical properties comparable to those of the conventionally manufactured titanium alloys [19, 20]; the alpha-beta alloy was annealed in an inert atmosphere. Fixtures (see Fig 7, left) were used to assist in retaining the manufactured geometry and to correct post-SLM-fabrication distortions.

5. Results

Heat treated and as-manufactured specimens were tested and successfully passed the Faceguard load-bearing test of BS 7928:2013. Review of high-speed video footage of the original design samples, indicated excessive flexibility and a lack of interconnections between the horizontal tiers. This led to an introduction of the small design adjustments such as additional vertical struts (see Fig 7, right) and the additional three test samples, which...
significantly improved that aspect. As each specimen endured two test trials, all specimens were visibly damaged after the second test due to stress concentration at the joints of the interconnected members (see Fig 6, right).

Overall customer response was positive, in that the final design "feels better" in comparison with the current faceguard. A comparatively quick development process that enriched the experience for the customer by providing instant gratification; and a greater sense of ownership were identified as the primary motives of such satisfactory customer response.

Fig 7 – Clamping fixture – schematics (left), adjusted design (right)

6. Conclusions

This work investigates the design of a personalised faceguard for an elite cricketer. It was found that:
• A process of personalised design was successfully used to allow functional and affective/semantic designs to be performed concurrently.
• Utilising additive manufacturing enabled innovation in form and structure, and the semantic design defined the limits of the design process.
• Fused deposition modeling (FDM) allowed rapid prototyping of new designs and personalised fitting and sizing.
• Selective laser melting (SLM) was used to manufacture the personalised faceguard not possible with traditional methods.
• The SLM fabricated faceguard passed the safety standards of BS 7928:2013, which made it comparable to its counterpart traditionally manufactured from conventional titanium alloys stock.
• The affective design aspects incorporated in the personalised faceguard significantly enhanced the customer’s satisfactions with the artifact whereby its uniqueness and symbolic association provided a greater sense of ownership.

Future work will focus on investigating the nature and causes of the observed structural failures and their potential relations to the material properties and the fabrication process.

References