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Sizing of Aircrew Clothing

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Abstract

Protective clothing assemblies worn by UK military aircrew involve a suite of clothing made up of multiple layers of garments with each garment layer designed to perform a specific role.

In order for these multi-layered clothing assemblies to function as a clothing system each layer is required to fit and integrate with the wearer, adjacent clothing layers and the workspace.

A unique method of applying anthropometric data to clothing sizing has now been developed by QinetiQ for UK MoD into a software program that improves the likelihood of garments fitting the intended wearers by drafting clothing sizing templates from the direct application of nude body anthropometric data, inclusive of allowances for mobility and underlying clothing bulk .

The system offers an opportunity to reduce the risk associated with clothing sizing by enhancing the quality control of a product using a process that has been proven, through fitting trials**,** to be more reliable than using traditional tailoring methodology by ensuring that clothing meets required size and shape specifications. Additional benefits include a visual presentation of anthropometric data, improved equipment scaling, high probability of garments fitting the intended wearers and the removal of the need of design contractors to interpret numerical data.

The system also supports a competitive tendering environment by providing information in a format that allows design contractors to concentrate on design, in the safe knowledge that when garments produced by different manufacturers or different design engineers within the same company and delivered to MoD, that all garments fit and integrate as required. The QinetiQ output can be applied to known populations of wearers or for individuals requiring bespoke tailoring.

Research Aims

Military aircrew are exposed to a range of flying and environmental hazards that require operators to wear multi-layered protective life support clothing assemblies. These assemblies comprise a series of individual garments, each offering protection against specific hazards and when worn as part of an assembly offer an all encompassing protection system that is required to integrate with the wearer and the operating environment.

An important aspect of the process of designing these garments is that of sizing. Historically, QinetiQ have been responsible for providing clothing size roll advice that is included in the design specification of aircrew garments. Unfortunately the format of this information requires a great deal of interpretation on the part of design contractors and is exacerbated when multiple contractors are involved; which can lead to problems relating to the quality of functional fit.

As a result of these issues, QinetiQ were tasked by MoD to investigate alternative ways of analysing and presenting anthropometric data; thereby improving the quality of functional fit, increasing the number of people accommodated in the size roll and increasing the probability of wearers fitting there predicted garment size.

The aim of this presentation is to describe the use of a novel clothing sizing software program. The software improves the data analysis, sizing process and presentation of aircrew clothing by providing both the procurer and clothing manufacturing contractors with clear information on clothing sizing. This enables functional garments to be designed that accurately relate to a predefined size specification.

By improving the quality of functional fit, aspects such as mobility, integration, bulk and thermal load are addressed.

Data Acquisition

The first stage of providing clothing size roll information is to collect appropriate body data of the target population. Traditionally this has been carried out by manually measuring the human body, a process that is commonly referred to as anthropometry.

This procedure involves the use of tape measures, callipers and an anthropometric measuring rig to collect up to 132 surface body measurements. Traditional anthropometry is a very labour intensive methodology that takes up to 40 minutes per subject in a survey environment, requires a team of trained measurers in very close contact with the subject and it is necessary to select the required body measurements prior to starting the survey.

To mitigate these issues, the use of 3D whole body scanning technology is being used as a means of gathering reliable and cost effective anthropometric data. The scan data also provides the opportunity to re-visit the data to extract new body measurement definitions as required.

In its standard form the scanner output is designed for use by the clothing retail trade who tend to use body measurements that are different to those used for military purposes. The scanner output is therefore required to be aligned with military requirements. This is achieved by reviewing the identification of anatomical points and considering their relevance to 3D scanner extracted measurements.

Data Analyses

Once the anthropometric data is acquired, it is analysed by plotting the population on a scatter plot graph. The data is plotted against a scale representing one body length and one body girth dimension that are selected based on the requirements of the target equipment. The selected "xy" co-ordinate measurements are referred to as "Control Dimensions" and are later used as a guide to select appropriate garment sizes for people as part of a selective fitting process.

The population on the graph is then grouped into specific sizes by overlaying a suitable grid that encompasses the majority of people. Historically the sizing increments of the grid have been based on an arithmetical progression comprising a common difference between sizes. Unfortunately, this approach penalises wearers at the lower end of every size by having a surplus of fabric whilst favouring all wearers of the larger sizes.

For these reasons a new size roll grid has been adopted that uses a geometric size progression. This results in the size increments increasing in proportion to one another and is represented as a percentage of the total size range. This approach offers an improved quality of fit on the target population across all sizes by varying the increments between sizes depending on the size of the wearer, reducing surplus fabric to a minimum.

Data Presentation

A list of subsidiary body measurements relating to a particular garment are then selected based on garment requirements. The subsidiary body measurements relating to the groups of people within each size box are analysed to determine the range of sizes of specific measurements for each sub-group of people from the population. By following a series of rules the resultant data can be presented in a numerical table that

represents the relevant nude body dimensions for each garment size based on a static nude subjects.

Current Issues

Historically, this has been the output format offered to MoD and used as part of the design specification to produce items of clothing. Unfortunately this method of data presentation requires a great deal of interpretation on the part of the manufacturing design contractor to convert the static nude body data into dimensions for dynamic functional garments.

Clothing design engineers are therefore required to add to the nude body measurements allowances for underlying clothing bulk and mobility. History has demonstrated that this is an inherently unreliable process as different design contractors (in a competitive environment), or even different design contractors within the same company are required to understand the process used to create the nude body numerical size roll and then second-guess the dimensions/shapes of other garments they are required to integrate with.

Allowing personnel interpretation can therefore lead to errors relating to garment fit which in extreme cases may result in the cancellation of expensive field trials. Problems encountered are likely to include people not finding garments that fit, or wearers not fitting their predicted garment size, leading to confusion for the wearer and difficulties in equipment scaling for MoD.

Clothing Sizing Software

In order to overcome the issues discussed previously, it was necessary to adopt a systems approach to clothing sizing. This was achieved by combining the various processes required to produce garment patterns and applying scientific sizing methodology with specific tailoring technique; both based on the direct application of anthropometric data offering a quality control tool for improving the sizing and fit of performance clothing.

The software program analyses anthropometric data to produce nude body numerical size roll tables. It then utilises the direct application of a selection of the nude body anthropometric data to generate garment “Sizing Templates”, recognising them as of male or female origin.

The anthropometry used by the software can be from either one individual (for bespoke) or from a range of sizes (for a size roll).

The problem of varying interpretations of numerical recommendations for individual garment layers of an assembly are eliminated by dealing with them as a system and presenting the information as visual images in the form of sizing templates showing size and shape information inclusive of allowances for underlying clothing bulk and wearer mobility. This concept allows the contractor to design clothing knowing that as long as the outline shapes of their finished garments stay within the profile of the sizing templates there will be no issues of fit.

By overlaying the various sizing templates from a size roll it is now possible to visually assess the validity of the decisions made during the data analyses phase by looking for unusual pattern shapes, anomalies can then be numerically validated. Once the size roll is accepted, sizing templates can be generated for whole assemblies all based on a common methodology.

The software program offers the opportunity to overlay finished manufacturing patterns inclusive of design detail over the sizing templates; thereby ensuring they meet the original size specification prior to starting the manufacturing process. Any differences in shape between the two drawings can then be agreed and approved.

The software output is in the form of electronic images of clothing sizing templates in an “HPGL.PLT” (Hewlett Packard Graphics Language – Plot file) format promoting a rapid two-way communication facility between QinetiQ, MoD and clothing design manufacturers. If an electronic format is not acceptable, printed copies can be generated for manual digitisation onto any commercial clothing design software package.

The sizing templates can be applied to any application were there is a requirement for functional protective clothing and can be used on requirements involving a single garment layer or for more complex clothing assemblies involving several garment layers that are required to be worn at the same time.

Validation of the system

Commercial design contractors were tasked to use the QinetiQ output as a basis to generate garment patterns inclusive of manufacturing and design detail; whereby the items of clothing were intended to represent various integrated multi-layered clothing assemblies.

Next, garments were produced to production standards which were then used to support a fitting trial involving male and female civilian subjects that represented a cross section of the UK military aircrew population.

It was found that the garments successfully fitted with all 52 subjects who each wore their predicted size and all were able to carry out a range of mobility tests while experiencing minimum disruption to comfort and mobility.

Summary

The clothing sizing system, described, has been developed to scientifically address a wide range of issues relating to the analyses, interpretation and presentation of anthropometric data. The system has successfully completed a period of validation and is ready to be applied to protective clothing applications.

The overall benefits of using this methodology are as follows:

- accurate garment sizing templates
- visual representation on the size and shape of numerical size rolls
- improve fit, mobility and integration of multi-layered protective clothing assemblies
- high probability of wearing the predicted garment size
- reduced number of special measure demands
- tariffs for ordering can be predicted with greater confidence
- quality control of finished clothing dimensions is monitored throughout
- time required to generate size rolls and first garment manufacturing patterns is reduced
- clothing manufacturers can be freed from sizing considerations to concentrate on design
- thermal insulation gaps are rationalised and controlled
- clothing bulk is minimised

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