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Apparel Design Safety and Production Criteria and Models

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Abstract
A safe apparel design and production (SADP) model was proposed as a system to guide the development of safe apparel. An objective analysis of user needs and examination of safe nutrients used in apparel design uncovered through related technical regulations/ standards induction and recall case analysis led to the development of apparel safety needs criteria. The criteria were then translated into apparel safety attributes and used in the development of the SADP model. A theoretical evaluation model remained to be developed for apparel safety purposes using multi-part disassembly. It is hierarchically structured in accordance with apparel safety attributes, and demonstrates how the apparel design safety criteria was used by a design team or an industry worker. By the introduction of the apparel design safety evaluation model, a further shift to pro-action and to the prevention of losses will be made possible. The research also demonstrates the application of the SADP model to a textile product design problem.

Key words: *apparel safety, safety attributes, design and production model, safety evaluation.*

Introduction

The residual toxic and harmful substances in textile and apparel associated with considerable amounts of chemicals consumed in textile production make chemical safety needs be taken into consideration in apparel design. A significant proportion of the part design used for children's clothes is reported hazardous to children according to foreign recall cases, accident reports and detection results [1, 2], which calls for the expansion of mechanical safety needs in apparel design. In addition, safety is a critical category in various textile and apparel technical regulations and standards. It can be seen that apparel design safety is of vital importance in mitigating the increasing incidence of recall cases and imparting protection to the wearer to avoid potential hazards. But apparel design with consideration of safety nutrients appears to be in its infancy. Apparel design safety requires a supportive management process helping the designer and firms to meet consumers' expectation for apparel safety in order to develop and protect competitive advantages in today's textile and apparel marketplace.

Apparel wearability is a basic qualifying 'ticket' for a product to enter the market, while functionality and safety as the higher order needs become more developed and the market more sophisticated. In fact, there have been technical regulations and standards to consider apparel safety, which aim to see that apparel must meet the requirements of the safety test in various countries. The formulation and comparison of apparel safety technical regulations and standards have been studied over the years. Safe design nutrients in garments were examined and organized into the three common sections of mechanical safety, combustible safety and chemical safety [3]. Mechanical safety requirements and test methods of children's garments in Chinese and Euramerican standards were compared [4]. Potential mechanical hazards of children's clothing were analyzed based on the fault tree method [5]. Pang conducted a safety risk assessment for textile and apparel by the application of the TS fuzzy neural network [6]. A risk assessment extended the tutorial for textile and apparel was described in a step-by-step way using test data from an inspection organization [7]. A risk assessment model based on SVM was developed for textile and apparel safety [8]. On the whole, evaluation techniques of apparel safety that integrate SVM technology and subjective judgment theory remain to be developed.

Although apparel design safety is important, there are few studies or methods for modelling a safe apparel design system. The preceding report showed that design processes incorporating safety are not well structured. Specifically it is not clear how system decomposition is related to design safety. A model for a safe apparel design system has not been developed to the degree it can be readily applied in apparel design practice. In the following, some preliminary ideas for addressing these issues are outlined.

This paper examines safety nutrients used in apparel design, presents a common system model that links design and production process, and demonstrates how the design model was used by a design team to work with industry management. One objective of this paper is to develop a comprehensive understanding of the state of the art of apparel design safety.

Specifically the following questions are to be answered.

- Question 1. What is apparel safety and its special significance for apparel design?

Table 1. *Regulations and standards of safety requirements of apparel.*

Items	China	US	Europe	Japan
Drawstrings / cords	■ GB/T 23155-2008 [9] ■ GB/T 22702-2008 [10] ■ GB/T 22704-2008 [11] ■ GB/T 22705-2008 [12]	■ ASTM F 1816-2004 [14] ■ CPSC Guidelines [15] ■ N.Y. Gen. Bus. Law Section 391.b [16] ■ Wisconsin State law ATCP 139 [17]	■ EN 14682-2007 [23] ■ BS 7907-2007 [24] ■ UK SI 1976 No. 21 [25] ■ Ireland SI 1976 No. 40 [26]	-
Choking	-	■ 16 CFR Part 1501.4[18]	-	-
Tension	■ GB/T 22704-2008 [11] Appendix B Appendix E	■ 16 CFR Part 1500.51 [19] ■ ASTM F963-11 [20]	■ BS7907-2007 Appendix B [24] ■ BS7907-2007 Appendix C [24] ■ EN 12586:2007 [27] ■ EN 71-1: 2005 [28]	-
Torque	■ SN/T 1932.8-2008 [13]	■ ASTM F963-11 [20]	EN 71-1: 2005 [28]	-
Sharp edges	-	■ 16 CFR Part 1500.49 [21]	-	■ Japanese products liability law [29]
Sharp points	-	■ 16 CFR Part 1500.48 [22] ■ ASTM F963-11 [20]	-	■ Japanese products liability law [29]
Button strength	■ GB/T 22704-2008 [11] Appendix C	-	-	-
Plastic pipe around cords safety	■ GB/T 22704-2008 [11] Appendix D	-	-	-
Material combustibility	■ GB 17591-2006 [30]	■ 16CFR Part 1609 [31] ■ 16CFR Part 1610 [31] ■ 16CFR Part 1615 [31] ■ 16CFR Part 1616 [31] ■ 16CFR Part 1611 [31]	■ EN 14878: 2007[32] ■ England-The nightwear[33] (safety regulations) 1985 ■ England-The nightwear (safety: (amendment) regulations 1987 [33] ■ Netherlands-Covenant on the fire safety of nightwear [34]	■ Fire protection law[35]
Content of toxic and harmful substances	■ GB 18401-2003 [35]	■ FHSA: the Federal Hazardous Substances Act (section 1500.83-1500.85) [36] ■ 16CFR Part 1303 [33]	■ EU Directive 76/769/EEC [16] ■ German - Consumer goods law [16] ■ England - The dangerous substances and preparations [16] ■ France - Formaldehyde in textile (commodity act) regulation [16] ■ Netherlands - Formaldehyde in textile (commodity act) regulation [16] ■ Finland - Degree on maximum amount of formaldehyde in certain textiles [16] ■ Austria - BGBL Nr.194/1990[16] ■ Switzerland - Daily necessities regulations [16] ■ Denmark - Imports and sales restriction act on nickel products [16] ■ Sweden - Chemical and biological organisms regulations: 1998:8: [16] ■ G/TBT/N/SWE/51 [16]	■ Harmful substances act for household products,9/26/1974 [35]

- Question 2. Is there a means to relate safety demand indicators to apparel attributes?
- Question 3. What is the relationship between design safety criteria and apparel attributes?
- Question 4. What should a model be for integrating safety into the conventional design and production process for the apparel industry?
- Question 5. How does the evaluation model work for a safe apparel design system?

The other objective of this paper is to discuss challenges and issues in the systematic design safety of apparel and to discuss potential solutions to these issues. It is noted that the safe design of apparel appears to be a relatively new application, and therefore the scope of applications is extended to other textile objects as well. In fact, except for different apparel, the safe apparel design model can be used with other textile objects, e.g. toys, smoothers, baby strollers etc, from a viewpoint of safety.

The remainder of this paper is organized as follows:

- **Section 2** briefly discusses the definition of safety and its significance for apparel design.
- **Section 3** discusses safety needs criteria and apparel attributes.
- **Section 4** discusses apparel design safety criteria and the evaluation model.
- **Section 5** develops a safe apparel design and production (SADP) model that incorporates safety aspects.
- **Section 6** summarizes the present authors' ideas of solutions to these issues and concludes.

Safety and its significance for apparel design

Safety

Safe quality has no precise definition since it is a qualitative product attribute that is evaluated by a consumer through inspection and experience. It may be

closely defined as the "degree of risk" of the product. Nevertheless, in daily life, safety is widely used. It could be applied in functional aspects, or unpredictable, dangerous situations. However, safety is not limited to the domain of danger. In this paper, a working definition of safety is used. Safety is a discipline concerning the quality that a human may meet while he or she interacts with his or her environment. In short, danger is for risk, while safety is for quality. It is noted that safety is acquired from the following demand patterns: mechanical safety needs, chemical safety needs, flammable safety needs and external safety needs. Thus safety in the context of the design system is to design a system to meet human needs in the safety aspect. Therefore design sciences and technologies that are applied to functional and aesthetic aspects should be equally applied to the safety aspects.

Significance of safety for apparel design

Apparel differs from many vehicle or electronic appliances in that it has a significant impact on the behaviours of users in terms of handling performance or usability. It has been shown that a safer environment could contribute to increasing security, comfort and pleasure. Apparel and humans are closely related in such a way that apparel becomes a part of the necessary goods of humans like food. Safety in wearing clothing thus equals the security of human life. Although there is no report on a statistical analysis of the degree of importance that safety has in a consumer's clothing-buying decision, the fact that all textile and clothing industries in the world have inquired about safe technical regulations or standards for textile and clothing may sufficiently imply the importance of safe design in textile and clothing development.

User safety needs and apparel attributes

An objective analysis of user safety needs uncovered through technical regulations/standards and recall cases led to the development of design criteria based on the apparel safety categories. The safety technical regulations/standards review all of the safety requirements and safety test methods for apparel (see ***Table 1,*** page 33), setting the background knowledge supporting and promoting the design safety criteria and apparel attributes presented in ***Table 2***.

Table 2. *User safety needs and apparel attributes.*

User safety needs	Apparel attributes
A. Mechanical Safety Needs 1. Strangulation, entrapment /entanglement/tangle/ catch/trap/snag	■ The length and use requirements of drawstrings/cords from different areas in children's garments, including hood and neck area, chest and waist area, lower hems area, back area, sleeves area and other body parts
2. Choking/aspiration	■ Size, intensity, abrasion resistance of small parts like button, pullers, beards, snap, pom-poms and appliqué in Children's garments
3. Other injuries	■ The dimension of open in Children's garments ■ Intensity and abrasion resistance of sewing thread ■ Materials and thickness of package bags ■ Needle detection of metal fasteners ■ Zipper strength and bur ■ Bur of edges of metal/grass adornment ■ Hard or sharp objects residual in padding ■ Seam security, seam strength, binding security of snap, unrepaired thread end or floating ■ The management of needles, sharp weapons(e.g. scissors) and needle detection process in manufacture process ■ Safety use of other parts like hood, hat, neckties and magnetic material in Children's garments
B. Chemical Safety Needs 1. Residual poisonous and harmful substances	■ Formaldehyde content, color fastness to water, Acid color fastness to perspiration, Alkali color fastness to perspiration, Color fastness to dry friction resistance , Color fastness to saliva resistance, pH value, Abnormal taste, AZO Dye in fabrics, buttons, fasteners, embroidery, zipper and so on in garment parts
C. Flammable Safety Needs 1. Flammability issues	■ Fail to meet the flammability requirements for fabrics or padding
D. External Safety Needs 1. Qualification and authenticity issues of textile printing labels	■ Qualification of product identification and fiber composition in label/tag

Technical regulations/standards and recall cases supported the use of mechanical safety needs, flammable safety needs, chemical safety needs and external safety needs for the design safety needs categories [3]. The needs were then translated into apparel attributes and used in the development of safe apparel. Mechanical, flammable, chemical and external user safety need categories were used in the define step to develop specific design criteria guiding the development and evaluation of safe apparel (see ***Table 2***).

Mechanical safety needs

The mechanical safety needs category addressed the safety of drawstrings/cords, small parts and other possible sources in children's clothing. Many of these mechanical safety needs are interrelated and played multiple roles in developing the design criteria. The drawstrings/cords in children's clothing have potential mechanical hazards of strangulation from the hood of sweatshirts, jackets, windbreakers, sweaters and so on; and entrapment/entanglement/tangle/ catch/trap/snap hazards are usually caused by the waist/bottom drawstring and the toggles at the end of drawstrings.

In general, small parts like buttons, snaps, pom-poms and appliqué may be placed in infants' and children's mouth and cause choking/aspiration hazards for them. Also small parts with a projection part or assembly that a child can grasp with at least the thumb and forefinger or the teeth may be removed and cause choking/aspiration hazards for them. Furthermore other parts like hoods, sharp objects, magnetic material, and padding in children's garments may cause injuries to the wearer. Therefore safety quality items should be subjected to a tension test, abrasion resistance test or other safety test.

Chemical safety needs

The chemical safety needs of textile and apparel consist of residual poisonous and harmful substances in fabrics and supplementary materials being in the qualified safety scope, including formaldehyde content, colour fastness to water, acid colour fastness to perspiration, alkali colour fastness to perspiration, colour fastness to dry friction resistance, colour fastness to saliva resistance, pH value, abnormal taste, and AZO dye. The residual poisonous and harmful substances

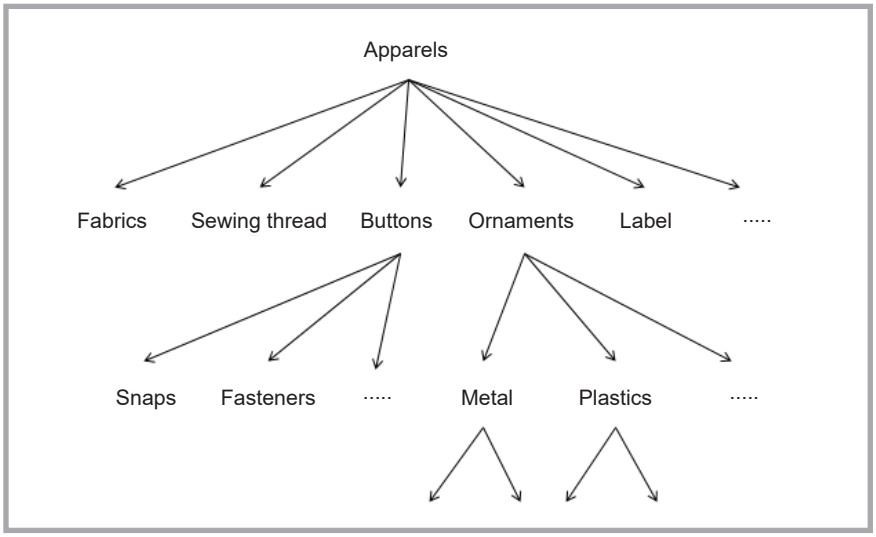

Figure 1. *Evaluation instances for safety apparel system decomposition.*

may penetrate into the skin along with sweat and cause unintended hazards to wearers, especially striking children particularly hard because of their delicate skin and weak immune systems. Many textile and apparel that contain toxic or harmful substances may cause stimulation, poisoning, sensibilization, and carcinogenicity for the wearer. Chemical safety performance means that the indexes of residual poisonous and harmful substances does not comply with related safety technological regulations/standards which ensure body health or property safety.

Flammable safety needs

Flammable issues are caused from failing to meet the flammable requirements for fabrics or padding of textile and apparel in related technological regulations/standards. Such fabrics or padding readily catch fire and blaze up if they contact ignition sources, such as stove elements and candles, and then might cause burns for the wearer and do harm to their health.

External safety needs

External safety needs mean that the qualification and authenticity of textile printing label/tag instructions, including product identification, fiber composition labels, washing and nursing labels etc., have to conform to related safety technological regulations/standards. It might also be noted that there can be different instructions in labels/tags for groups of textile and apparel in one country, and purpose and requirements of labels/tags can also vary. Therefore these labels/tags lack high level consistency, addressing their own characteristics in different countries. As a consequence, it is quite difficult to follow all of technical regulations/standards for labels/tags in different countries. For textile and apparel there exist external risks which might threaten person and property safety if the external safety needs are not meet correctly and reasonably.

Model for evaluating apparel design safety criteria

Evaluation is essential for any design process. The goal of evaluation is to give a detailed assessment of whether customers' needs are met. These needs consist of four categories, i.e. mechanical, chemical, flammable, and external safety needs. It is noted that the evaluation of a design

Table 3. *Evaluation model of safe design criteria.*

Criteria	Sub-criteria	Indicators
(C1) Mechanical safety	(S.1.1) The length and use requirements of drawstrings/ cords	(I.1.1.1) Drawstring, functional or decorative cord, elastic cord, shoulder strap, halter neck cord, tied belt or sash, stirrup and loop in children's garments
	(S.1.2) The size, intensity, abrasion resistance of small parts	(I.1.2.1) Buttons, snaps and knots (I.1.2.2) Zipper sliders, zipper pullers, pull tabs, rings and toggles at the end of drawstrings (I.1.2.3) Decorative small parts: pom-poms, appliqué, heated patch, crochet tassel, small pieces of fabric in the hem of clothing, spangles and beads (I.1.2.4) Touch and close fastener, fringe, bows, feather, label, badge, tabs
	(S.1.3) The use requirements of other parts	(I.1.3.1) Hood, filling materials, sharp objects, neckties, garment with integral feet, magnetic material and embroidery (I.1.3.2) The dimension of open (I.1.3.3) Intensity and abrasion resistance of sewing thread (I.1.3.4) Materials and thickness of package bags (I.1.3.5) The instruments used in manufacture like needles, sharp weapons(e.g. scissors) , stone washing or metal detection process (I.1.3.6) Seam security, seam strength, binding security of snap, unrepaired thread end or floating
(C2) Chemical safety	(S.2.1) Formaldehyde content, colour fastness to water, acid colour fastness to perspiration, alkali colour fastness to perspiration, colour fastness to dry friction resistance, colour fastness to saliva resistance, pH value, abnormal taste, AZO dye	(I.2.1.1) Fabrics: knots, bows, pom-poms, appliqué, heated patch, crochet tassel, small pieces of fabric and so on (I.2.1.2) Buttons, fasteners, embroidery, zippers, spangles and beads (I.2.1.3) Sewing thread
(C3) Flammable safety	(S.3.1) Flammability requirements	(I.3.1.1) Fabrics (I.3.1.2) Padding
(C4) External safety	(S.4.1) Qualification requirements	(I.4.1.1) Qualification of product identification (I.4.1.2) Fibre composition in label/tag (I.4.1.3) Washing and nursing label

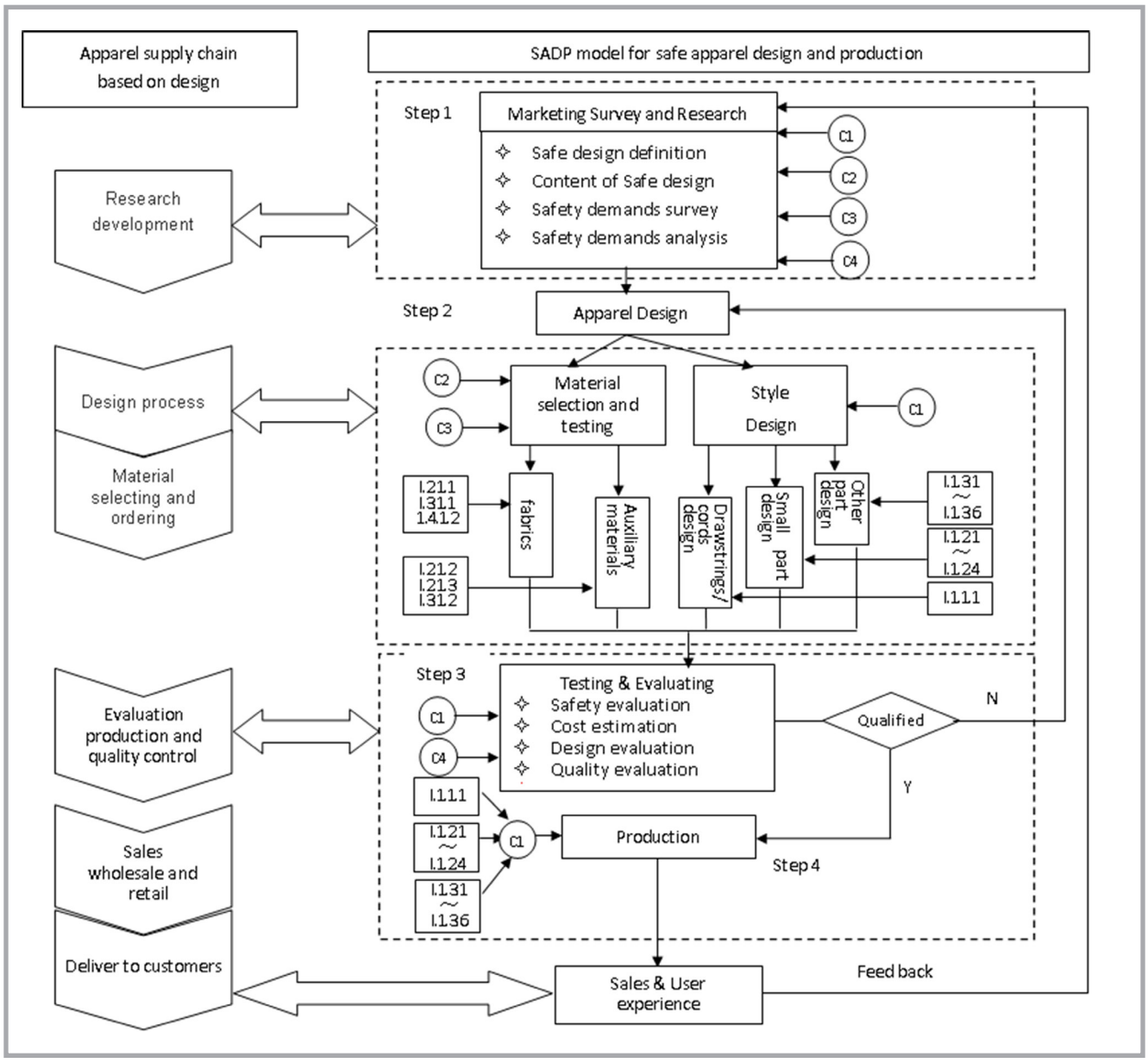

Figure 2. *SADP model for safe apparel design and production.*

may be skipped over in a very special and yet rare case. The evaluation criteria are a means of grouping measurable aspects and are associated with the safety requirements. These criteria are divided into sub-criteria for greater clarity, which in turn give rise to evaluation indicators that make up the final hierarchical level of the safety requirements (***Table 3***). Thus the model consists of four criteria, six sub-criteria and nineteen indicators. The four criteria of the model define safety management requirements for an apparel design and production project: mechanical, flammable, chemical and external safety. Each criteria is divided into sub-criteria. The necessary information for the development of the model was principally drawn from previous sources (***Table 1***).

The design criteria were used to review the ideations and management competencies for the contribution of the safe design model developed in this paper to a safe apparel system. However, in this evaluation model, after the safety elements are determined, there is no further assessment of the integrated apparel safety, which is shown in ***Figure 1***. It might be thought that such an assessment has been ensured by those in the design and production stage as showed in ***Table 3***. This might not be true. In fact, one of the limitations of the safe design evaluation model is how to estimate the consumer's and/or the designer's satisfaction with the outcome from the design safety criteria.

Design and design process incorporating safety

Results of a content analysis of safety requirements of textile and clothing led to the development of need identification and design criteria for the competitive textile and clothing during the safety step. A successful design hinges on the designer's understanding of the end user needs and the ability to translate them into apparel attributes (see ***Table 1***). These apparel attributes guided the ideate step of the design process. Design process reengineering was developed to explore possible design solutions for safe apparel. The safety quality of textiles and apparel involves a lot of items from design and production.

In this paper, safety was integrated into existing apparel design and production models to develop a safe apparel design and production (SADP) model. The SADP model, illustrated in ***Figure 2***, has four main steps:

(1) Marketing survey and research.
(2) Apparel design.
(3) Testing and evaluation.
(4) Production.

In step (1) of SADP, marketing survey and research, designers define safe design and analyze safe design contents and user safety needs. Designers need to understand the users' mechanical, flammable, chemical and external safety demands. Conducting research to satisfy these demands and generating design ideas are necessary in this step. At the end of this step, apparel design safety attributes should be decided.

Step (2), apparel design, includes "material selection and testing" and "style design". In material selection and testing, designers assess material safety based on the evaluation model of apparel safe design criteria (see ***Table 3***). Designers will phase out unsafe materials and use safer materials. Materials are defined as either fabrics or auxiliary materials (sewing thread, buttons, snap, zipper sliders, zipper pullers, pull tabs, rings, toggles, ornaments, labels etc.) used in apparel. For materials, non-flammable selected material, odorless and with no content of toxic and harmful substances, is necessary. For style design, designers must decide on up front safety for drawstrings/cords, small parts and other parts in apparel during the apparel's use. The apparel design process is essential to determine whether products can be marketable and producible. The apparel design step can help companies evaluate the design before they invest significant money and time on real production. If an apparel system is made from a mixture of different apparel parts, then decomposition processes are considered so that after decomposition, different parts can be evaluated according to different safety requirements.

Step (3) of SADP is a comprehensive test and evaluation. In material and design evaluation, apparel producers will evaluate safety, function, performance, fit, style, and estimate cost. If the apparel does not meet the requirements for these criteria, the design will be modified and re-evaluated. In current industrial divisions, most apparel manufactures do not produce the fabrics, dyes, and other apparel materials. Therefore collaboration with other industries, such as companies that produce fabrics or accessories for apparel are needed to reduce or eliminate harmful impacts during production. To assist with the prioritization of industry or company choices based on toxic compounds in their product offerings, an assessment of fabrics or accessories can be an insightful starting point and enable meaningful strategies for apparel manufacturer specializing in the chemical safety of materials. The HPLC or GPC method can be used to investigate the presence of toxic compounds in materials. In the SADP model, apparel designers and manufacturers will collaborate with other companies in the supply chain to maintain material safety.

Step (4) of SADP is production. Unlike other apparel production models, SADP considers safety in production. In addition to material safety and design safety, considerations regarding safety in production include sewing intensity and abrasion resistance, the instruments used in manufacture like needles, scissors etc., stone washing or the metal detection process, the binding security of snaps, unrepaired thread ends or floating. In a word, safety nutrients in apparel production need to be paid more careful attention .

The fundamental concept of the SADP model is that safety aspects are considered whenever designers and manufactures make decisions. The SADP model can be incorporated into the industry supply chain. Step (1) is related to research development in industry and step (2) is connected with material selection and ordering as well as style designing in industry. When designers or manufacturers select other manufacturers for outsourcing or collaboration, information about these manufacturers regarding safety issues will be easily obtained and considered. Step (3) is connected with the evaluation and quality control part in the supply chain. Step (4) can be connected to the production part of the supply chain in industry.

Conclusions

This paper examines the inductions of safety technical regulations/standards and recall cases in related fields, presents a common design criteria that link user safety needs with apparel attributes. Analysis of safety needs is a matter of the identification of possible hazards. Safety nutrients were examined and organized into the four parts of mechanical safety needs, chemical safety needs, flammable safety needs and external safety needs. The apparel attributes are defined to evaluate clothing's safety in terms of compliance with safety technical regulations/standards. The safe design criteria also provided a method for objective analysis of user safety needs concerning textile and apparel. Evaluation criteria remain to be developed that integrate the comprehensive multi-part disassembly and apparel safety attributes, and demonstrate how the apparel safe design criteria were used by a design team or an industry worker. By the introduction of an apparel safe design evaluation model, a further shift to pro-action and prevention of losses will be made possible. The safe apparel design and production (SADP) model developed in this paper can be used as a system to guide the development of safe textile and clothing design and production. The incorporation of safety concepts in a apparel design project has the potential to minimize recall rates and to reduce project costs. However, these concepts must be fully incorporated throughout the apparel design and production process. Attention should be paid to the initial design phase because of its greater impact on the reduction of recall cases. In response to this reality, a theoretical model has been developed for apparel safety purposes using multi-part disassembly. It is hierarchically structured in accordance with apparel safety attributes.

Summary and recommendations

The preceding discussion has shown that there have not been satisfactory answers to the questions raised in the introduction section. Design models incorporating safety are not well structured. Especially it is not clear how design system decomposition is related to safe design. Obviously it is necessary to develop a safe apparel design and production (SADP) model in order to implement completely and work more efficiently in practice.

In view of the above, it was concluded that a novel aspect of the present research is its explicit consideration of the safety indicators as an additional factor to take into account when evaluating the safety value of an apparel design

project. To facilitate support at various stages of the design process, partnering with industry on similar projects may be valuable. The research also demonstrates the application of the design safety model to a textile product design problem.

There is no doubt that good management is important for attaining high safety levels during the design and production stage. Managers should oversee design and production activities in such a way that it is planned, organized, monitored and checked, so as to assure acceptable safety levels. All designers and producers should have the necessary training and competence and should be consulted on apparel potential risk issues. Moreover coordination should exist between the different workers carrying out the project.

In addition, the low level of safety education and coexistence of designers of different nationalities originate communication barriers, not only among designers, but also between the management and designers. Cultural differences and professional training deficiencies hinder the prevention of unsafe apparels and may contribute for their occurrence. Therefore safety education is responsible for the popularization of the specialist knowledge of safe textile and apparel. Various channels to spread safe design expertise is needed in the textile and apparel design and production industry.

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References

1. Consumer Product Safety Commission, U.S. “Recalls and product safety news”, available at: http://www.cpsc.gov/en/Recalls/.
2. Consumer Affairs, Repax-Latest notifications, available at: http://ec.europa.eu/rapex.
3. Chen L, Wu X and Ding X. The definition of the defect for textiles and apparel defect in recall in China. In: *International Conference on Advanced Textile Materials & Manufacturing Technology*, Hangzhou, China, 15 October - 19 October 2008, pp. 1551-1555.
4. Chen L, Ding X and Wu X. Comparison of Mechanical safety Requirements and Test Methods of Children’s garments in Chinese and Euramerican standards. In: *International Conference on Textile Bioengineering and Informatics Symposium,* Shanghai, China, 28 May - 30 May 2010, pp. 1535-1539.
5. Zhou Y, Wu X, Chen L and Ding X. Analysis of potential mechanical hazards of children’s clothing based on fault tree method. In: *International Conference on Textile Bioengineering and Informatics Symposium*, Shanghai, China, 28 May - 30 May 2010, pp. 1528-1534.
6. Pang S, Zhou Y, Ding X and Wu X. Application of TS fuzzy neural network in safety risk assessment of textile and apparel. In: *Fuzzy Systems and Knowledge Discovery (FSKD) of Eighth International Conference.* Shanghai, China, 2011, pp. 414-418.
7. Zhou Y. Study on risk analysis and assessment of safety of import and export textile and apparel. MS Thesis, Donghua University, Shanghai, China, 2011.
8. Pang S. Study on safety risk assessment model of textile and apparel based on SVM. MS Thesis, Donghua University, Shanghai, China, 2012.
9. GB 23155: 2008. Requirements and test method—drawstrings and cords on children’s clothing in import and export.
10. GB/T 22702: 2008 Standard safety size for drawstrings on children’s upper wear.
11. GB/T 22704: 2008. Code of practice for the design and manufacture of children’s clothing to promote mechanical safety.
12. GB/T 22705: 2008. Safety specifications for cords and drawstrings on children’s clothing.
13. SN/T 1932.8: 2008. Rules for inspection on import and export garments—Part 8: Children’s garments.
14. ASTM F1816: 2009. Standard Safety Specification for Drawstrings on Children’s Upper Outerwear.
15. U.S. Consumer product safety commission (1999), Guidelines for drawstrings on children’s upper outerwear.
16. Chen L. Study on the Safety Requirements and Recall System of Textiles and Apparel in Domestic and Abroad and Countermeasures, MS Thesis, Donghua University, Shanghai, China, 2009.·
17. Wisconsin state law ATCP 139 : 2005. Wisconsin state law library.
18. 16 CFR Part 1501.4: 2009. Size requirements and test procedure.
19. 16 CFR Part 1500.51: 2009. Test methods for simulating use and abuse of toys and other articles intended for use by children 18 months of age or less.
20. ASTM F963: 2011. Standard consumer safety specification for toy safety.
21. 16 CFR Part 1500.49: 2009. Technical requirements for determining a sharp metal or glass edge in toys and other articles intended for use by children under 8 years of age.
22. 16 CFR Part 1500.48 : 2009. Technical requirements for determining a sharp point in toys and other articles intended for use by children under 8 years of age.
23. BS EN 14682: 2007. Safety of children’s clothing-Cords and drawstrings on children’s clothing-Specifications.
24. BS 7907: 2007. Potential mechanical hazard. Code of practice for the design and manufacture of children’s clothing to promote mechanical safety.
25. International drawstring requirements--Client guidance document (2007), Bureau Veritas Consumer Products Services, Paris, France.
26. Ireland SI No.40/1976. Industrial research and standards (Section 44) (Hood cords for children’s clothing) order, Irish Institute for Industrial Research and Standards.
27. BS EN 12586:2007. Child use and care articles - Soother holder - Safety requirements and test methods.
28. BS EN 71-1:2005+A4:2007, Safety of toys—Part 1:Mechanical and physical properties.
29. Law No.85: 1995. The product liability law, National Diet of Japan, Nagatachō, Chiyoda, Tokyo.
30. GB 17591: 2006. Flame retardant fabrics.
31. Shenzhen enter-exit inspection and quarantine bureau. *Analysis of technical regulations and standards applied in international textile market*. 1st ed. China: China standards press, 2005.
32. BS EN 14878:2007. Textiles-Buring behaviour of children’s nightwear-Specification.
33. Wang X. Technological regulations of domestic and foreign textile and garment, 1st ed. China: China standards press, 2004.
34. Safeguards consumer testing services (2007), Introduction of requirements for burning behavior of clothing in the Netherlands.
35. SN/T 1649: 2012. Rules for inspection on import and export textiles safety specification.
36. 16 CFR Part 1500 .83-1500.85:2009. Hazardous substances and articles Administration and enforcement regulations—Table of contents.

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