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DESIGN OF COLD-PROOF CLOTHING: CONNECTION BETWEEN FUNCTIONAL AND AESTHETIC FACTORS

Zhang Zhetao[1], Gerasymenko Olena Dmytrivna[2]
[1] Postgraduate Student at the Department of Art and Fashion Design,
Kyiv National University of Technologies Design, Kyiv, Ukraine;
Department of Industrial Design,
Shaanxi University of Science and Technology, Xi'an, China,
e-mail: 2382001412@qq.com, orcid:0009-0008-0934-1924
[2]PhD in Design, Associate Professor, Associate Professor
at the Department of Art and Fashion Design,
Kyiv National University of Technologies and Design, Kyiv, Ukraine,
e-mail: gerasymenko.od@knutd.edu.ua, orcid: 0000-0001-8566-7215,
Scopus: 57474366800

Abstract. ***Purpose.*** *The purpose of the work is to study the design of cold-proof clothing, develop its classification and recommendations for creating a functional and aesthetic design to meet modern consumer requirements. Key aspects of design are analyzed, such as the choice of materials, artistic and compositional elements and adaptation of clothing to the needs of users.*

Methodology. *This study uses methods of analysis of scientific works, methods of comparative and system-structural analysis, interpretation and systematization of the results obtained.*

Results. *An analysis of literary sources was conducted on the development of clothing design for protection from the cold, material characteristics and consumer comfort. A classification of cold-proof clothing design was developed into four main categories: everyday, sports, work and for extreme conditions. For each category, recommendations on materials, structures and style are proposed that provide an optimal level of comfort and safety. Factors influencing the design of clothing for protection from the cold to achieve optimal comfort during use are identified: environmental factors, physiological and psychological comfort of consumers, ensuring functional and aesthetic requirements.*

Scientific novelty. *The work analyzes and systematizes the factors influencing the design of clothing for protection against the cold. The main requirements that such clothing must meet are determined and the importance of using multilayer materials with different characteristics, such as Gore-tex for the outer layer, woolen fleece for insulation and materials with silver ions for hygiene, is noted.*

Practical relevance. *The results of the study have practical application in the development of clothing design for protection against the cold, taking into account the physiological and psychological comfort of users, reducing the weight of clothing, increasing mobility and adaptation to various activities, including sports and work in extreme conditions.*

Keywords: clothing design, special clothing, clothing for protection against the cold, functional clothing, artistic and compositional elements, clothing requirements, innovative materials.

INTRODUCTION

With the improvement of people's living standards, outdoor sports have gradually become popular, and new concepts such as «normalised outdoor» and «light outdoor» have emerged. The outdoor sports group is growing, the related industry is booming, and consumers put forward higher requirements for outdoor clothing, equipment and the entire outdoor industry. With the continuous progress of science and technology and the increasing perfection of application systems, clothing design plays an important role in protecting human life and health and providing convenience through the application of special materials and professional structures. As the field of human outdoor activities expands, the demand for clothing worn in special environments is also increasing.

ANALYSIS OF RECENT RESEARCH

As the first choice of protective clothing worn during activities in low temperature environments, cold-proof clothing constructs a thermally comfortable microenvironment that maintains normal human activity by effectively insulating cold air [12]. In severe cold environments, cold-proof clothing places higher demands on properties such as thermal insulation, breathability, water resistance and durability. This is not only related to the comfort and activity efficiency of the wearer, but also directly related to the life safety of the user.

In the 21st centuries, with the rapid development of science and technology, the research on cold-proof clothing has made remarkable progress. The focus of research in this period was not only on material innovation and performance breakthroughs, but also on enhancing the user's wearing experience and improving comfort and convenience through optimised design. The appearance design of cold-proof clothing has also become more and more diversified and fashionable to meet consumers' pursuit of aesthetics and personalisation.

Authors Arens E. et al. [2] investigated the thermal comfort of 19 localised areas and the whole body under localised cooling and warming conditions. Li J. et al. [7] investigated the variation rates in thermal resistance and moisture permeability index of firefighter gear at natural openings, such as the collar, cuffs, hem, and ankles, under both open and tightened conditions. This evaluation aimed to assess the impact of ventilation through openings on the overall heat and moisture transfer of the clothing. Matusiak M. et al. [10] determined the thermal and humidity comfort indexes of cold-proof clothing by testing the air temperature and changes under the clothing and the temperature changes on the outer surface of the clothing caused by the heat generated by the human body.

Akshat T. M. et al. [1] argued that materials determine the function while setting the appropriate boundaries for the design of different clothing outer spaces. The ability to form varied shapes relies on the fabric itself, in addition to design tools and styling techniques. While thermal and physiological comfort is mainly influenced by the overall porosity and thickness of the fabric. Arumugam V. et al. [3] developed a novel polymeric fibre biaxial stretchable nonwoven paddings with good biaxial stretch and recovery properties as well as good thermal insulation.

The paper [18] investigates the application of smart materials in enhancing the thermal insulation and heat retention properties of cold-weather clothing. Researchers Wei Y. et al. analyzes the functional characteristics, applicability, and existing issues of these materials. It highlights key areas for future research, such as safety in usability and durability of performance, providing direction for the development of intelligent cold-weather apparel.

Cao Q. et al [4] argues that cold-proof clothing has a direct impact on the health and work efficiency of outdoor workers in winter. Consequently, they conducted research on a lightweight intelligent cold-proof material, analyzing its insulation and heating performance to enhance temperature adaptability, providing new insights for the design of cold-proof clothing. Ma L. et al [8] reviews five active heating modes for cold-proof clothing, evaluating their current research, limitations, and potential applications. It provides insights for optimizing temperature control algorithms and designing intelligent cold-proof garments, while emphasizing the need for more targeted heating solutions for different body areas.

PURPOSE

Based on an analysis of the features of use and taking into account consumer requirements, this study aims to propose a classification of cold-protective clothing and to develop recommendations for the design of functional and aesthetically attractive clothing that meets modern requirements.

RESULTS AND DISCUSSION

To develop clothing designs for extreme cold conditions, it is necessary to consider the definition of an intense cold environment. The researchers have developed a «cold degree scale» (Table 1), which divides the minimum

Table 1

Cold level scale

Cold Rating	Cold Name	Temperature Criteria (°C)
Grade 1	Extreme Cold	≥-40
Grade 2	Severe Cold	-40 – -30
Grade 3	Intense Cold	-30 – -20
Grade 4	Severe Frost	-20 – -10
Grade 5	Moderate Cold	-10 – -5
Grade 6	Mild Cold	-5 – 0
Grade 7	Slight Cold	0 – 5
Grade 8	Cool	5 – 10

temperature of the same day from below -40°C to 10°C into eight grades in order, and «severe cold» is the third grade, with temperatures between -30°C and -20°C [15]. In this paper, the term «cold environment» refers to the coldness of the wearer's working environment, which reaches «level 3» and is a common climatic condition in cold regions.

The human body is in a state of cold stress in a low-temperature environment, and the body dissipates heat rapidly, so if it is unable to maintain physiological heat balance, the human body will face the risk of freezing, frostbite, and even death [6]. Wearing modest and lightweight cold-proof clothing is an important means for the human body to defend itself against the threat of cold environments and to maintain the thermal balance of the muscles [17]. Clothing for cold environments we divided into four categories according to their wearing application occasions, namely, daily wear category, sports category, workwear category and extreme environment category as shown in Fig. 1.

For different categories of cold-resistant clothing, we have identified appropriate usage scenarios, according to which each category of clothing has different design features (Table 2).

Developing a clothing design that will be used in a cold environment, it is first necessary to consider the factors of the climatic environment, such as temperature, humidity, weather and other factors, which for a cold environment are mainly characterized by low temperatures, strong winds, snowfall, etc. In cold climatic conditions, the body loses heat mainly through three channels: convection, conduction and radiation. Convection is mainly related to the airtightness of the garment, which is controlled by the breathability and windproofness of the garment; conduction mainly lies in the

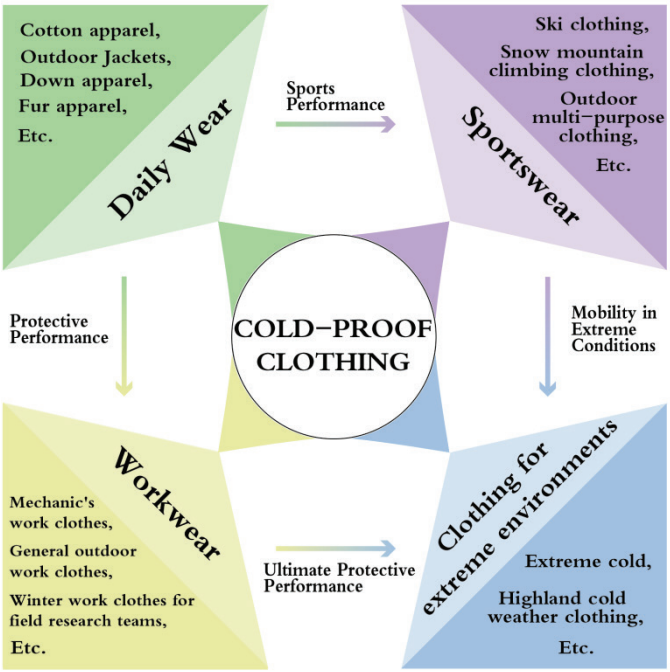

Fig. 1. Clothing classification table for cold environments

Table 2

Characteristics of cold-weather clothing

Category	Clothing Style	Application Scene	Clothing Characteristics
Daily category		Mainly used in cold climate environment, people's daily travel, outdoor activities wear	Daily category of cold-proof clothing style is increasingly diversified development, the main purpose of the design is to meet the user's aesthetic needs and warmth requirements
Sports category		Sportswear designed for users who play sports in cold environments, providing athletes with warmth on the premise of being able to better complete the corresponding sports programme.	In order to enable athletes to remain in good condition in cold environments, such clothing should first have good mobility, so that the wearer can be relaxed and unrestricted movement; for different sports there are corresponding functional designs, such as openings to adjust the breathability of the clothing, with the structure and space for the installation of sports protective gear, etc.; for the corresponding sports there are corresponding protective properties, such as cut-resistant performance for ice projects, abrasion resistance for outdoor projects, etc. For example, cut resistance for ice sports, abrasion resistance for outdoor sports, etc.
Workwear category		Workwear for users who work mainly in cold environments, with different design elements allocated according to the specific work environment and dress code requirements.	With basic labour protection ability and cold insulation performance; generally in the appearance of the design of the type of work, enterprises and other identifying information, such as special colours, corporate emblems, etc.; according to the user engaged in the work of the different features of the design of the corresponding styles and professional functional design, such as waterproof function, cold-proof function and so on.
Extreme environment category		Clothing specifically designed to cope with extreme cold conditions and to keep the wearer safe in harsh climatic conditions.	The first design element is to ensure that the physiological indicators of the wearer are normal, and in order to satisfy important design elements such as cold protection and warmth, the pursuit of mobility, aesthetics and other elements may be reduced.

thermal insulation performance of the garment; and the heat emitted by the human body mainly depends on the ability of the wearing garment to reflect and block thermal infrared rays [19]. Therefore, it is necessary to use the regulation of clothing design means to reduce the impact of environmental factors on the human body, through the regulation of temperature, airflow, humidity, radiation and other elements within the garment to meet the comfort requirements of the wearer's attire.

In cold climate regions, user demands for clothing go beyond mere insulation and extend to certain health care needs [14]. In severe cold environments, well-designed cold-proof clothing can help wearers cope with environmental stress, minimize negative impacts, and enhance emotional well-being. Therefore, the design of cold-proof clothing for cold environments should fully consider both the physiological and psychological needs of the users.

In clothing design, it is necessary to ensure the physiological health of consumers. Wearers are susceptible to the effects of low temperatures in cold environments, as this can lead to a drop in body temperature and a range of associated health issues [11]. Effective cold-proof clothing should provide sufficient insulation to help wearers maintain body heat and prevent cold-related health problems. High-performance insulation can reduce discomfort caused by the cold and improve overall quality of life during work or daily activities. Additionally, in harsh conditions, the weight of the clothing is linked to the wearer's fatigue levels; lightweight cold-proof clothing can alleviate the burden on the body, reducing fatigue. Furthermore, the breathability of cold-proof clothing is relevant to physiological comfort, as good breathability helps to expel excess heat and moisture, ensuring comfort and preventing skin irritation.

The color design of cold-proof clothing can have a potential influence on the wearer's emotional state and their psychological health. For instance, warm colors may evoke a sense of warmth, while cool colors can induce feelings of calm and relaxation. Appropriate color schemes can promote positive emotions in wearers. At the same time, the choice of materials for cold-proof clothing can contribute to a comfortable wearing experience, thereby alleviating stress from the environment. Moreover, well-fitted and appropriately designed cold-proof clothing can boost the wearer's confidence, contributing to psychological satisfaction and enhancing social interactions.

Due to the cold environment clothing needs to be filled with insulating material ensure the warmth of the clothing, clothing products in cold environments due to the filling of wadding is very bulky, such styles to a certain extent will form a constraint on the wearer's body, many large-scale movements in the work of the impact of the visual point of view of the bulky clothing silhouette will lead to the wearer's overall image of the aesthetics of the degree is reduced. In the selection of materials for this kind of clothing, we use materials with good elasticity and high warmth-keeping efficiency to reduce the bloatedness of the clothing as much as possible under the premise of meeting the requirements of warmth-keeping; in the design of the style, we mostly focus on shaping the wearer's body shape, and we try to ensure that the degree of aesthetics is as high as possible while fulfilling the basic needs of the clothing, so as to make the wearer have a better wearing experience and visual image.

For clothing in cold environments, warmth and windproof performance are the most important design requirements. The low temperature and cold wind in the cold environment have a great impact on the comfort of the garment and the physiological health index of the wearer, and the environmental factors will accelerate the dissipation of human body heat when working in the cold environment [5], and then the cold-proof clothing will become an important barrier to maintain the thermal balance of the wearer's body and to ensure the health of the wearer. Material selection is the first step in designing protective clothing for extreme cold temperatures (-20 °C) [9].

When choosing the material of the cold-proof clothing should be based on the climate characteristics of the wearing environment, the cold-proof and wind-proof nature of the garment material should be considered comprehensively. In terms of fabrics, materials with strong windproof and waterproof performance should be selected to prevent cold air from penetrating the garment and lowering the internal temperature of the garment, and at the same time to prevent rain and snow from wetting the garment in inclement weather; in terms of wadding, materials with strong long-lasting warmth should be selected to maintain the internal temperature of the garment and the core temperature of the wearer's body surface over a long period of time; in terms of lining, since the lining is close to the wearer's inner clothing, materials with good perspiration-expelling properties and good heat dissipation properties should be selected to ensure that the wearer's body surface temperature can be maintained.

When designing the style, silhouette shape and clothing construction of the cold-proof clothing, the influence of warmth and windproof factors in the style and structure of the garment should be considered comprehensively. Free silhouette shapes are better suited the wearer's basic needs for activity. However, it is worth avoiding a too loose silhouette, as it can cause a lot of heat loss. Reducing heat loss and improving the windproof of the cold-proof clothing can be achieved by separate elements are added to adjust the design and increase the elasticity of the design. Elements of the design for adjusting the fit, such as straps, straps, etc., will help the consumer adjust the breathability of cold-resistant clothing according to their own feelings. At the same time, such elements provide an opportunity to diversify the design of cold-resistant clothing and ensure compliance with fashion trends.

Functionality of clothing has always played an important role in clothing design, only a clear understanding of the function of clothing and its functionality, the designer can effectively carry out functional clothing design, multi-angle to meet the user design expectations. For cold-proof clothing designed for severe cold climates, it is essential to leverage various styles and structural combinations to fully utilize the advantages of the garment while meeting the functional design requirements. When planning the functional design of cold-proof clothing for extreme environments, the physiological, safety, and convenience needs of the wearer must be considered. The physiological needs address the basic functions of cold-proof clothing, such as insulation and temperature regulation, which influence different design aspects like structure and thickness to ensure coverage and warmth. Safety needs are critical, demanding protective features in the clothing to prevent harm during tasks, such as abrasion resistance

or impact protection. Lastly, convenience needs refer to the functional requirements that facilitate the wearer's daily activities and work, such as adding pockets for tools or adjustable components to enhance mobility based on specific work conditions.

Visual design, in particular the artistic and compositional characteristics of clothing, make the first impression on consumers, so the visual aesthetic design of cold-proof clothing is also of crucial importance. With the continuous progress of science and technology, design innovation, produced a lot of clothing personalised appearance design. It means, there is a wide range of clothing visual design decisions. The design of cold-proof clothing should not only fulfill an aesthetic function and present clothing models with various artistic and compositional characteristics. It should also be a functional design, not a purely decorative design, as the clothing should be visually aesthetic and comfortable for users, so that the appearance of the design and the functional design complement each other.

Working or living in cold environments can have adverse effects on the human body both physiologically and psychologically, and low temperatures can even cause damage to the human body, which can be serious and life-threatening. As a barrier for the human body to cope with the cold weather environment, clothing can effectively reduce or avoid the harm of the cold environment on the human body, and at the same time improve the efficiency of the wearer's outdoor work in the cold season [16]. Based on the theoretical foundation of previous research, this design practice takes the clothing for field activities in cold environments as an example to design a cold-proof clothing as shown in Fig. 2, and proposes a design strategy for the basic performance, additional functions and appearance design of the cold-proof clothing.

The aspect of clothing performance, first of all, to ensure the health and comfort of the wearer, according to the characteristics of the cold environment clothing with good cold and warmth and a certain degree of waterproof, but also with the warmth corresponding to the breathability, in the clothing produced by the heat and moisture concentration area of the breathable design, in order to promote the exchange of the site inside and outside of the hot and humid air, so as to achieve the balance of heat and moisture [13]. In terms of clothing materials, the fabric ratio is carried out according to the performance and comfort needs, and in general, the outer fabric uses materials with windproof, wear-resistant, waterproof and other characteristics, the middle layer uses materials that are light, moisture-absorbent, and good at keeping warm, and the inner layer uses skin-friendly, breathable materials and so on. The design practice plan is to use gray and orange Gore-tex fabrics for the outer layer, with a 180g wool flannel filling, and silver ion reflective fabrics for the inner layer and the skin-friendly fleece in the skin contact area. This combination ensures that the main outer fabric has good windproof, breathable, dirt-resistant and visual warning properties, the inner filler material has good heat preservation and sweat absorption capabilities, and the lining layer has a comfortable touch on the skin contact area, while at the

Fig. 2. Design Practice Rendering

Zhang Zhetao, Gerasymenko O. D. (2025). Design of cold-proof clothing: connection between functional and aesthetic factors. *Theory and practice of design. Culture and art*. 1(35). P. 497–505,
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same time enhancing the warmth of the garment with technological fabrics.

With regard to the appearance and structure of garments, the cold-proofing performance requires filling with good warmth-retaining wadding and wearing a warm inner layer inside the garment, which leads to a relatively heavy appearance and loose style. In order to minimise the loss of heat from the wearer's body, most cold-proof clothing are designed to provide good coverage, using as much style and construction as possible to cover the wearer's body, with removable hoods, windproof cuffs and extended hems. The windproof sleeves, which can be worn in the palm of the hand, and the slits in the hem ensure the garment's athletic performance. In order to ensure that the garment is breathable after exercise, the back of the garment is designed with active ventilation openings for adjusting the amount of ventilation. In terms of garment details, the buckle tabs, zip headers, pocket flaps and other garment components have been increased in size to make it easier for the user to handle the gloves when wearing them in cold environments.

CONCLUSIONS

This study investigated the features of clothing design for cold climates. The classification of cold-proof clothing for cold environments was proposed based on the features of its use and the priority characteristics that such clothing should have. The factors influencing the design of clothing for intensive cold environments were determined. In particular, cold-proof clothing should correspond to the climatic conditions of the environment in which it will be used. It was found that the key characteristics of clothing are thermal protection, windproofness, water resistance, lightness and breathability, which contribute to maintaining the body's thermal balance. Such clothing should provide physiological and psychological comfort for consumers, meet aesthetic and functional requirements. The analysis showed that materials are crucial for ensuring the functional properties of cold-proof clothing. Emphasis was placed on the use of multi-layer materials with different characteristics, such as Gore-tex for the outer layer, woolen fleece for insulation and inner fabrics with silver ions to preserve heat and hygiene. An important aspect is the adaptation of clothing to the conditions of user activity, such as sportswear, workwear or for extreme situations, which requires specific design solutions for each category. It was found that the design of cold-proof clothing should take into account the balance between protection, aesthetics and functionality in order to provide optimal conditions for work or active recreation in cold climates.

We have proposed an approach to the design of functional and at the same time aesthetically attractive cold-proof clothing that meets modern requirements. Based on the recommendations provided, a design of cold-protective clothing with additional elements, such as removable hoods, windproof cuffs and ventilation holes for temperature regulation, etc., was developed, which can be adapted to specific climatic and functional requirements.

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АНОТАЦІЯ

Чжан Чжетао, Герасименко О. Дизайн одягу для захисту від холоду: взаємозв'язок між функціональними та естетичними факторами

***Мета**. Метою роботи є дослідження дизайну одягу для захисту від холоду, розробка його класифікації та рекомендацій щодо створення функціонального та естетичного дизайну для задоволення сучасних вимог споживачів. Проаналізовано ключові аспекти дизайну, такі як вибір матеріалів, художньо-композиційні елементи та адаптація одягу до потреб користувачів.*

***Методологія**. У роботі виконано методи аналізу наукових праць, методи порівняльного та системно-структурного аналізу, інтерпретацію та систематизацію отриманих результатів.*

***Результати.** Проведено аналіз літературних джерел щодо розробки дизайну одягу для захисту від холоду, характеристик матеріалів та комфорту споживачів. Розроблено класифікацію одягу для захисту від холоду за чотирма основними категоріями: повсякденний, спортивний, робочий і для екстремальних умов. Для кожної категорії запропоновано рекомендації з матеріалів, конструкцій і стилю, що забезпечують оптимальний рівень комфорту та безпеки. Визначено фактори, що впливають на дизайн одягу для захисту від холоду для досягнення оптимального комфорту при використанні: фактори впливу навколишнього середовища, фізіологічний та психологічний комфорт споживачів, забезпечення функціональних та естетичних вимог.*

***Наукова новизна.** У роботі проаналізовано та систематизовано фактори, що впливають на дизайн одягу для захисту від холоду. Визначено основні вимоги, яким має відповідати такий одяг та відзначено важливість використання багатошарових матеріалів із різними характеристиками, таких як Gore-tex для зовнішнього шару, вовняний фліс для утеплення та матеріали з іонами срібла для гігієни.*

***Практична значущість.** Результати дослідження мають практичне застосування у розробці дизайну одягу для захисту від холоду з урахуванням фізіологічного та психологічного комфорту користувачів, зниженні ваги одягу, підвищенні мобільності та адаптації до різних видів діяльності, включаючи спорт та роботу в екстремальних умовах.*

Ключові слова: дизайн одягу, спеціальний одяг, одяг для захисту від холоду, функціональний одяг, художньо-композиційні елементи / artistic and compositional elements, вимоги до одягу, інноваційні матеріали.

АВТОРСЬКА ДОВІДКА:

***Чжан Чжетао**, аспірант кафедри мистецтва та дизайну костюма, Київський національний університет технологій та дизайну, Київ, Україна; Шеньсійський університет науки і технологій, Сіань, Китай, e-mail: 2382001412@qq.com, orcid:0009-0008-0934-1924.*

***Герасименко Олена**, доктор філософії, доцент, доцент кафедри мистецтва та дизайну костюма, Київський національний університет технологій та дизайну, Київ, Україна, e-mail: gerasymenko.od@knutd.edu.ua, orcid: 0000-0001-8566-7215, Scopus: 57474366800.*

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