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A Review on Comfort Properties of Functional Wear Apparels

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Abstract: ***Comfort properties are the very important part for the performance based fabrics. When compared to woven fabrics, knitted fabrics are more suitable for functional wear applications. The bi-layer and multilayered the use of fabrics in utilitarian applications is more appropriate. when compared to single layered fabrics. Performance based fabrics can protect against frozen or warm conditions. It is also found that these fabrics can offer a hygienic barrier, keeping infectious and toxic materials away from the body. The performance based fabrics are unique in certain aspects such as dimensional, physical, moisture and thermal properties. This paper presents a literature review of multilayer, physical, moisture and thermal comfort properties of performance based fabrics.***

Keywords: comfort, multi layer, moisture, physical, thermal

I. INTRODUCTION

Functional textiles are specialised textiles that serve a particular purpose. Aesthetics, mechanical failure resistance, garment producing ability, wearing comfortability, hygienic and safe attributes are all specialised fabrics. When studies are examined, it becomes clear that clothes is always used to describe comfort. Comfort is vague in its definition as it takes into account both quantifiable and subjective areas. The satisfying psychological and physical relationship of mankind with its environment is termed as comfort. Comfort is a key point in the textile technology. Figure 1 shows the heat and moisture vapour transmission through textile material [**1**].

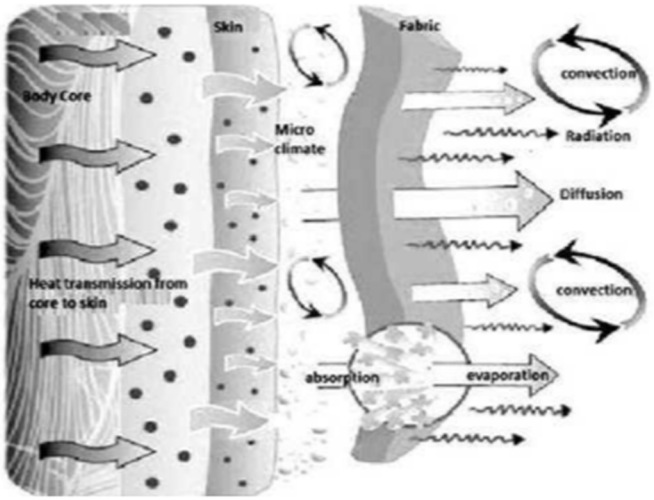

Figure 1: Heat and moisture vapour transmission through textile material
(Figure Source-Manshahia & Das 2014)

The human body regulates and strives to maintain a temperature of 37˚C in all varied situations. The body creates a lot of heat energy during strenuous activity, raising body temperature. In order to keep the body temperature at 37oC, heat must be transferred from the body to the environment. Also to reduce the very high temperature sweating is found in the human body. Due to this sweating process the human body experiences a reduced body temperature thus leaving the body cool. In this accord garments are to be designed to enable the human body to adapt itself to the varying climatic conditions [2]. Table 1 show that metabolic energy generation linked to many forms of physical activity.

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Table 1: Metabolic energy production associated with different types of physical activities
(Table Source-Holmer 2004)

Class	Average metabolic rate (W/m^2)	Examples
Resting	65	Sleeping, resting
Low	100	Spectators at sporting events, casual walking, shooting, curling, fishing
Moderate	165	Hiking, walking at a speed of 3.5 to 5.5 km/h, alpine skiing
High	230	Intermittent activities in ball games
Very high	290	Climbing, running or walking at a speed greater than 7 km/h, alpine skiing
Very, very high(2 hr)	400	Long-distance events in cross-country skiing protection against cold
Intensive work(15 min)	475	Sprint events in cross-country skiing
Exhaustive work(5 min)	600	Sprint events in skating

The two types of sweat produced by the human body are insensible (in the form of vapour) and sensible (in the form of liquid). In order to be comfortable, the sportswear worn next to the skin should permit both types of perspiration to pass from the skin to the exterior surface. [3]. Body heat generation with vigorous exercise approaches 1000 W. The body's core temperature rises when some of this heat dissipates. The skin's thermoreceptors detect a rise in temperature and cause perspiration to be produced to cool the body. Some of the body's heat-dissipating systems include sweat evaporation, enhanced skin flow, and blood flow. The dissipation of heat through evaporation, conduction, convection, respiration and radiation helps to keep the body in thermal balance by maintaining a stable core temperature [4]. Inappropriate clothing may hinder the body's capacity to release heat from the body. [5].

The body's core temperature is reported to be 37°C by Outlast Technologies, while skin temperature ranges from 31°C to 35°C in various body parts, including the abdominal region (35°C), head (34.4°C), shoulders and upper thighs (34.3°C), wrists (31.4°C), hands (31.6°C), ankles (30.8°C), and feet (30.8°C - 31.6°C). Even a slight temperature change can make people uncomfortable and have an impact on their work. It may be concluded that knowledge of body heat and sweat pattern is necessary to develop functional clothing with effective heat and moisture management. [6].

II. EFFECT OF FABRIC LAYERS OF CLOTHING SYSTEM

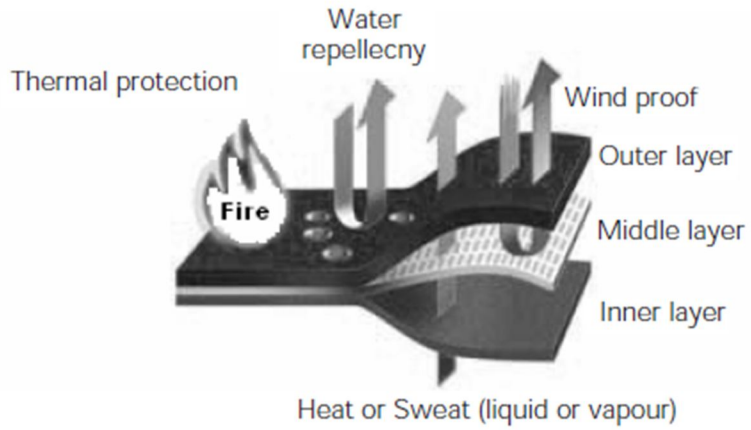

Figure 2: Multilayer clothing system
(Figure Source-http://hdl.handle.net/10603/9977)

This multilayer garment system is depicted in Figure 2. The multi-layered fabrics are made up of various layers of materials that might enhance the necessary comfort characteristics for particular end purposes. The functional characteristics of layered fabrics have been the subject of numerous research projects. The identification of heat and water transmission across several layered fabrics has been done using a mathematical model. [7]. The wicking coefficient of multilayered fabrics is higher than cotton fabrics, according to research on the wet ability qualities of polyester, cotton, and multilayered polyester/cotton fabrics to withstand human perspiration. [8]. For cushion applications, warp knit spacer textiles made of polyester multifilament and monofilament yarns were tested for pressure distribution, air permeability, and heat resistance. The author came to the conclusion that these spacer fabrics could be used in place of polyurethane foam, particularly when comfort and recycling are crucial considerations. [9]. The capacity of a fabric to be wet on its surface when in touch with liquid water, as occurs while sweating, was crucial in determining how quickly water vapour moves through layered materials. [10]. The water content builds up with time and is larger in the outside regions of battings than at the inner regions, according to research on heat and moisture transmission through garment assemblies made of porous fibrous battings sandwiched by inner and outer layers of thin covering fabric[11]. The liquid transfer from one layer of fabric to another layer and the liquid interaction between specific textiles in clothing methods have revealed that the amount of liquid transmitted greatly depends on the functionality of each fabric as well as how they come into touch with one another. [12].
The fabric is made of three layers, the middle layer of which, when submerged in water, absorbs and retains moisture. The fabric cools the wearer as the water evaporates from this layer, keeping the wearer dry thanks to its shell and lining [13]. The field sensor is a performance fabric that uses the capillary action principle and combines coarser denier yarn on the inside surface (in direct touch with the skin) with fine denier hydrophobic polyester yarn in a mesh construction on the outer surface. [14]. The material qualities of a specific layer, as well as those of the adjacent layers or even the entire combination, affect the moisture content of that layer. [15]. Bi-layer interlock knitted constructions are created using 100% cotton and 100% polypropylene spun yarn. A study was conducted to determine the behaviours of air, water, and heat in order to determine the suitability for sportswear. Compared to other 100% cotton fabrics, multilayered fabrics have much superior wicking coefficients. [16]. The thermal conductivity, air permeability, and moisture vapours have a significant impact on the layered materials used in clothing. [17]. To increase comfort and have a bigger impact on attributes like heat conductivity, air permeability, and moisture vapour transmission, multi-layered fabrics are used. [18].

III. EFFECT OF PHYSICAL CHARACTERISTICS ON CLOTHING SYSTEM

Physical and dimensional behaviour, micro denier fabrics have relatively higher properties compared to traditional denier materials [19]. Less absorbency of wetness in materials like polyester, polypropylene and polymer, natural and artificial fibre yarns is the right response to style wear for leisure sports [20]. Cotton or viscose plays a pivotal role in influencing mechanical properties like bursting strength or pilling properties. Polyester yarns exhibit superior mechanical properties compared to cotton or viscose [21]. The dimensional stability of knitted structures from the conventional yarns was good dimensional properties were observed [22]. Moisture management features of double layer knitted materials that are taken into consideration during the selection of right yarn linear density [23]. Air movement in the knitted fabric is directly influenced by yarn, fabric structure, yarn loop length and tightness factor of knitted fabric [24]. The comfort and handle value of knitted fabric is decided on the basis of fiber, yarn structure fabric dynamics, and finishing applications [25]. The loop height changes as the loop length course is modified, which changes the per unit length. The number of yarns used is a key factor in determining the fabric's weight. The course and wale densities are influenced by a number of variables, including course and wale spacing. To show the difference in stitch shape, different metallic yarns are used. [26]. Decrease in the density of the plated interlock when three knit yarns are utilized. A decrease in porosity and the length of loop is found when there is an increase in the thickness of the knitted fabrics [27]. The nature of knitted loop totally depends on the yarn’s physical aspects and mechanical procedures [28]. The loop lengths are shorter in values, the stretched strength was greater [29]. The yarn linear density, stitch length and fabric length were highly responsible for the fabric areal density [30]. The thickness was higher in the honeycomb than in single pique structure [31]. By increasing machine gauge and reducing stitch length, the fabric's thickness and porosity increase, increasing the fabric's mass per square metre. [32].

IV. EFFECT OF MOISTURE CHARACTERISTICS ON CLOTHING SYSTEM

The breathability and moisture management through thermo-physiological comfort, moisture properties consists of heat and moisture transport through the fabric. Moisture can be in either vapour or liquid form. A microclimate between the body and external environment is contributed by clothing. It also acts as a barrier for heat and vapour transfer between the skin and the environment [33].

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The perspiration of human body in two forms such as insensible (in vapour form) and sensible perspiration (in liquid form), both the types of perspiration are required for the human body to exhibit a comfortable feel [34]. The air permeability and moisture management properties of the commercial single jersey and rib knitted fabrics. The results indicated that the air permeability increased in relation to the mass of the fabrics [35]. The ability of woven and knit tri-layer materials to regulate moisture and heat. High air permeability, water vapour permeability, heat conductivity, wicking propensity, and quicker drying rates were all characteristics of fabrics made from bamboo charcoal, micro polyester, and Lyocell. [36]. Compared to casein fabrics, cotton fabrics demonstrated better one-way transport and maximum wetting radius values. [37]. The comfort and moisture-management capabilities of knitted fabrics made of milkweed and polyester for active wear. When compared to other textiles, the findings indicated that the plated fabric, which is comprised of 40% milkweed and 40% polyester, is an effective moisture management fabric. [38]. The implications of blend proportion on bamboo/cotton knit fabrics' moisture management properties. The findings showed that as bamboo content increased, wetting time, wetted radius, spreading speed, and OMMC all decreased but absorption rate increased. [39]. The effect of filament fineness on comfort characteristics of moisture management finished polyester knitted fabrics**.** The tests revealed that the fabrics containing 108 filaments in yarn yielded better wetting, higher wicking and optimum moisture vapour transmission [40]. The thermal comfort property of clothing should be assessed on the basis of moisture vapour pressure alteration within the clothing, surface temperature of the clothing and heat loss from the body [41]. The garment should possess the ability to release the moisture vapor held in the microclimate to the atmosphere in order to reduce the dampness on the skin [42]. Water vapour permeability plays a pivotal role in the case of little sweating or insensible perspiration or else very little sweating [43]. A good liquid transmission should be observed in the clothing to keep the body comfortable during heavy activity [44]. Wicking is an important property to keep up a feel of comfort during sweating conditions. Capillary theory is applied in this situation [45]. Moisture management properties were evaluated by blending of wool fiber with polyester and regenerated bamboo fiber. It was clearly indicated that blended fabrics possessed better moisture management properties than the fabrics without blending [46]. Fabrics with relatively higher thickness and mass per unit area indicated low moisture management properties [47].Study was conducted on the moisture management properties of bamboo-knitted fabrics. The study implied that there was an increase in the wetting time but a decrease in maximum wetted radius, rate of absorption, spreading speed and overall moisture management capacity [48]. The physical, moisture management and thermal transmission properties in double knit structures with completely different inlay tuck points [49]. A higher thermal physical phenomenon, air porousness, vapour porousness, wicking, wetness permeableness, drying rate and moisture management properties, lower thickness and mass per unit space. The less range of tuck sews showed higher thermal comfort properties [50]. Moisture management property of materials affected moisture diffusion and temperature distribution [51]. The micro denier polyester yarns both outer and inner layer of bi-layer knitted fabric shows a better moisture management properties, fabric thickness and fabric areal density affects the overall moisture management capacity. Micro denier polyester bi-layer fabrics quickly release the perspiration from the skin [52].

V. EFFECT OF THERMAL CHARACTERISTICS ON CLOTHING SYSTEM

The fabric being used should permit perspiration to pass or else it will cause some sense of discomfort. During sweating, if it is found that the clothing moisture transfer rate is slow, the relative and absolute humidity levels of the clothing microclimate will increase, thereby decreasing the rate of evaporation of sweat [53]. The amount of evaporated sweat and produced sweat is very low; moisture will be accumulated in the inner layer of the fabric system. Thus despite of change in the external environment and physical activity functional clothing must create a stable micro climate [54]. Heat and vapour transport, sweat absorption and drying ability are the major properties on which the thermal comfort of clothing depends [55]. The main functions of clothing are to protect the body from various environmental situations and to maintain appropriate body temperature. The ability of a fabric to keep a human body at its normal temperature under equilibrium conditions is known as thermal insulation. Fabric thickness is a major factor in thermal insulation, which is independent of the fibre type. [56]. Double layer fabric selecting the right yarn linear density is very important [57]. The absorbing nature of hydrophilic fibres like viscose is to prevent the spread of liquids including sweat [58].The thermal resistance of multi-layered fabrics increases when the mass per unit area increases [59]. Polyester blended wool and bamboo blended wool has improved comfort properties of the fabrics in comparison to 100% wool and 100% bamboo fabrics [60]. Better wicking ability was observed in cross section of bamboo fiber due to the presence of micro gaps and micro holes [61]. Better comfort, good extensibility, shape retention to the body and soft feel, as well lightweight, wrinkle resistance and ease of care can be checked on using the knitted fabrics [62]. The thermal comfort properties are affected when the bamboo fibre content is increased.

The thermal conductivity of knitted fabrics reduces as the content of bamboo fibre increases in the thermal radioactive properties of penguin down and yarn [63]. 70/30 % bamboo/ cotton double knit fabrics have the lowest water vapor resistance and thermal resistance values when compared to other double knit fabrics which consist of different raw materials [64]. There are signs of greater air permeability, water vapour permeability, wicking capacity, drying rate, and lower heat resistance in the inner layer of the bilayer knitted fabric constructed of microfiber polyester. [65]. Double layered knitted fabrics with different material combinations. It was observed that tencel-polypropylene was the most suitable for active sportswear [66].Raw materials, structural parameters and knitting pattern of the fabric were the factors on which thermal conductivity and thermal resistance depend upon [67]. Fabrics made by using yarn from cotton polyester and viscose are highly suitable for sportswear. These materials also exhibit high comfort [68]. The wicking characteristics of bi-layer fabric with one tuck point improvise the trend when there is a decrease in stitch density and thickness. It was also observed that the moisture absorbency of the bi-layer knitted structure increases with an increase in stitch density and tightness fabric [69]. Air permeability is a function of the thickness and surface porosity of the knitted fabrics, contrary to water vapour permeability [70]. Wicking as the liquid transport behaviour of fibrous assemblies and also wicking performs an important function in identifying the characteristics of fabrics [71]. Wetting and wicking behaviour affects the moisture and thermal comfort of clothing systems. The capillary pore distribution and bath ways as well as surface tension are utilized in identifying the wicking behaviour [72]. The moisture management behaviour of textile materials is difficult and solely depends on uncountable structural. The end use and application of the material depend upon the choice of the fibre, yarn and material properties and structures to attain acceptable moisture management properties and luxury [73]. The water vapour permeability, air permeability, thermal conductivity and thermal resistance of micro denier polyester inner and outer bi-layer knitted fabrics higher when compared to cotton/cotton, cotton/polyester, and cotton/polypropylene combinations. Micro denier polyester possesses excellent thermal properties [74].

VI. CONCLUSION

There is no discernible impact of the inner layer on thermal evaporation resistance in multilayered materials. Increased fabric weight and thickness as well as better evaporation characteristics are effects of the middle layer. In this competitive biosphere the major focus of top brands are customer satisfaction and performance based fabrics manufacture. The fibre selection depends upon the garment performance. The performance clothing totally relies upon the blended fabrics. The personal clothing is affected by both internal and external factors such as structure of the fabric, interaction between garment and skin. Fabrics made from new fibres and good yarn possesses characteristics like lightweight, good air transmission and also maintains a body heat at core temperature. Materials chosen for outdoor usages are checked for its heavy weight, coatdress, multi layer, protective against cold and wind, good moisture and thermal property. Woven and knitwear products are the recent trends for performance applications. It is viewed that the multi layer knitted fabrics provide good comfort properties when compared to single layer structure.

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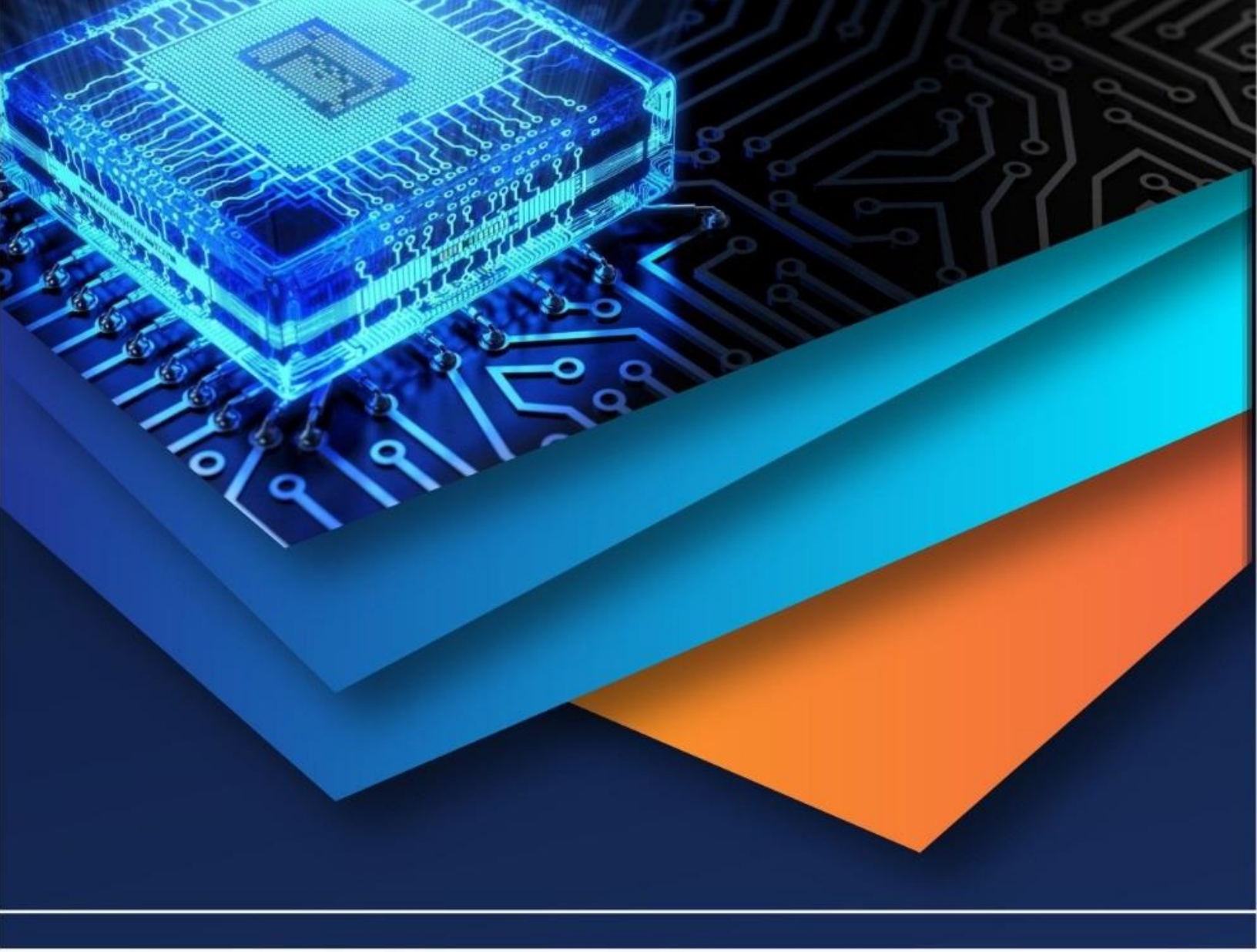

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