Vol. 15 No. 1 Feb 2011

# Research Journal of Textile and Apparel

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# Visual Textures Combined with Metallic, Retro-Reflective and Stainless Steel Yarns in Semi-Transparent Fabrics

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## ABSTRACT

Fashion and technology of weaving fabrics have a wide range of industries that feel obliged to be renovated at the present time. Pre- and post-modified features, technological performances of fabrics, and aesthetic values are of great importance to fabric/yarn business. Self-cleaning, heat-keeping or heat-decreasing fabric for sanitary purposes are one of the new research fields in science, designing and technology. Functional fabrics are manufactured with high-tech fibers, different materials and finishing processes. Aesthetic fabrics are also made for fashions with high-tech fibers and threads, such as transparent and semi-transparent fabrics. Designers explore the limits of transparent and semi-transparent fabric effects using progressive fibers and yarn. The scope of this study is designing and producing transparent garment fabrics with new-tech metallic stainlees steel and retro-reflective fibers. Fourteen samples of woven fabrics were made, and visual effects related to type, number, density and structure were studied.

***Keywords:*** Transparent, Semi-Transparent, Weaving Design, Retro-Reflective Yarn, Stainless Steel Yarn, Fiber, Visual Effect

## 1. Introduction

Transparent and semi-transparent objects allow depth perception to be minimized and what is beneath them to be seen. While a transparent object tends to create an abstract emotion of existence in human beings, it also looks as if it were deprived way beyond space. This situation turns the transparent and semi-transparent items into objects that are remarkable, intriguing and captured between the real and unreal. The fashion industry is interested in potential transparency-induced illusions. Curator Milton Sonday, who held the succesful exhibition "Colour, Light, Surface" in New York at Cooper-Hewitt Museum in 1990, tries to attract attention to the theme that light passes over and through the fabric, creating visual effects, and emphasizes that it has simultaneously started to be explored by fabric designers all over the world (Colchester, 1996).

Textile designers create transparent effects through different interactions in fabrics, one of which is electronic iridescence of the computer screen.

Transparency implies both literal and metaphorical lightness, which can be achieved through the blending of different fibers, especially with the advent of new synthetic yarn. Or in other cases, this quality has been the hallmark of centuries-old traditional methods using only organic materials. From hand-woven to high-tech, remote islands to densely-populated industrial cities, artists are fascinated by the mystique of transparency. (McCarty & McQuaid, 1999).

Such effects still appear as interesting visual features. Yet traditional weaving techniques integrate into successful combinations of technological improvement by means of different materials and weaving techniques. Consequently different degrees of transparency and distinctive aesthetic values in transparency/semi-transparency and brightness of fabric are obtained. Colour,

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weave, fabric structure, fiber type, fiber number and density are designing parameters to contribute to the above-mentioned effects.

This study examines the visual effects of metallic, retro-reflective and stainless steel yarn in single- and double-layer, semi-transparent woven fabric. In view of the designs, weft yarn count per cm, weave and fabric structure are taken into account with different material and yarn qualities.

## 2. Materials and their Characteristics

Features of yarn used and the breakdown in fabrics are shown in Table 1.

Table 1. Material Properties of Warp and Weft Yarns in Sample Fabrics

| Fabric Sample Nr | Weft Yarn Type | | Warp Yarn |
|---|---|---|---|
| | Upper Face | Back Face | |
| 1 | 65/1 Nm Stainless Steel Yarn | 140/2 Denier Silk Yarn | 140/2 Silk Yarn |
| 2 | 50/1Nm Retro-Reflective | 140/2 Denier Silk Yarn | 140/2 Silk Yarn |
| 3 | 50/1Nm Retro-Reflective | 225 Denier Silk Yarn | 20/2 Ne Cotton 20/2 Ne Bam boo |
| 4 | 4 Nm Stainless Steel Yarn | 225 Denier Silk Yarn | 20/2 Ne Cotton |
| 5 | 4 Nm Stainless Steel Yarn | Fancy Yarn Coated Metal | 20/2 Ne Cotton |
| 6 | 150 Denier Metallic Yarn | 24/1 %95 Cotton %5 Silver Yarn | 20/2 Ne Cotton |
| 7 | Fancy Yarn coated 12 Micron Metal | 24/1Ne 95 Cotton, %5 Silver Yarn | 20/2 Ne Cotton |
| 8 | 50/1 Nm Retro-Reflective Yarn | 20 Nm Fancy Yarn with Nep | 20/2 Nm Bamboo 20/2 Ne Cotton |
| 9 | 50/1 Nm Retro-Reflective Yarn | 50/1 Nm Retro-Reflective Yarn | 20/2 Ne Cotton |
| 10 | 50/1 Nm Retro-Reflective Yarn | 50/1 Retro-Reflective Yarn | 20/2 Ne Cotton |
| 11 | 50/1 Nm Retro-Reflective Yarn | Fancy Yarn coated 12 Micron Metal | 20/2 Ne Cotton |
| 12 | 12 Micron Metallic Yarn | 12 Micron Metallic Yarn | 20/2 Ne Cotton |
| 13 | 150 Denier Metallic Yarn | 150 Denier Metallic Yarn | 20/2 Ne Cotton |
| 14 | 9.1, 4Nm Stainless Steel Yarn | 20/1 Ne Cotton | 20/2 Ne Cotton |

One of the weft threads is the retro-reflective yarn that is used in sportswear and accessories such as hats and shoes to increase visibility and distinctiveness of light-reflecting fabric. The fashion industry also produces reflective technical textiles for prêt-a-porter and haute-couture, proving that functional features can also be aesthetic. Textile designers Ann Richards's fabric may be given as a reference for this issue. It is used a polyester reflective yarn in her fabric which the name is Reflex. The polyester reflective yarn gives a gentle shimmer to the handwoven textile which varies according to the lighting conditions. The warp yarns used are silk/steel (65 per cent silk, 35 per cent stainless steel) and spun silk. The weft yarns are crepe silk and Reflecta, a polyester reflective yarn manufactured in Germany by Fuesers Garne GmbH. (Clarke & O'Mahoni, 2002).

The modern yarn technology creates materials which can be used in almost all sorts of fabric and therefore diversify retro-reflective textiles. Designers explore different fabric appearances with new yarn. The retro-reflective effect is obtained from thousands of glass beads that reflect the light back to its source. This means that the glass beads act as spherical lenses and return incoming light to the light source when the reflective layer is set in its focus point (Innonative Retro-Reflective, 2010).
In this study retro-reflective yarn used in semi-transparent fabrics numbered 2, 3, 8, 9, 10, 11 is examined the translucent and brilliant effect in the artificial light source in night and dark on the surface. For such reasons the above high-tech yarn is utilized to study the impact of transparency and reflectivity on fabric.

The use of metallic yarns to brighten fabric dates back to ancient times. It is, however, not until recently that yarn of copper, brass, platinium and stainless steel has been commonly used for fashion. Metallic yarn is a good example of recent technological fibers. Rigid and resistant to flexion, these materials can produce fabrics soft enough to match those made of other natural fibers. This study uses slit and twisted metallic yarn to increase visual effects in transparent and semi-transparent fabric. Aluminium-metalized PET polyester film was lacquered with protective epoxy resin to keep a shiny metalized surface. In case of gold and colors, appropriate quantities of metal complex dyestuffs are mixed with resin measured by an accurate electronic scale (Metallic Yarns for Textile Aplications, 2010).

The metal filaments used were steel composed of at least 11 % chrome in the metallic yarns. The basic factor to make steel resistant to high corrosion is a dense, thin and translucent oxide layer strongly adhered to the surface. Because of this thin amorphous layer, stainless steel is passive and becomes resistant to corrosion. The oxide layer emerges in an oxygen medium and is restored by mending itself even though it is affected by external processes such as cutting and wearing. (Baykal&Sığnak, 2009).

The highly extensive development of stainless steel fibers started in 1960. Its use as a textile fiber was an outgrowth of fiber research to meet aerospace requirements. Superfine-stainless-steel filaments (3-15 micrometers) are a bundle of 0.002-inch fine wires pickled in nitric acid and drawn to their final diameter. Metal yarns require special treatment to deaden yarn twists; otherwise, the yarns act like tiny coiled springs. The stainless-steel fibers are produced as both filament and staple. They can be used in complex yarn and can be woven or knitted. Only 1-3% staple fiber is needed to blend with other fibers to reduce static permanently. The limited use of stainless steel in clothing is attributed to its inability to be dyed (Kadolf & Langford, 2002). Slit metallic yarn increases brightness effect of the fabric.

## 3. Method

Fourteen woven garment fabrics were prepared to create impressions of transparency, semi-transparency, brightness and shimmer. It was thought that effects on designed fabrics would be obtained by a combination of metallic, stainless steel, retro-reflective yarns, different material and fabric structure, density and weave. Primarily, type and number of yarns used, density of weft and warp yarns were determined. Structures of fabric were then established. Using such data, densities of the fabrics were calculated in a way to obtain transparent and semi-transparent effects, with reports of weave draft, reed and armure being prepared.

Metallic, stainless steel and retro-reflective yarn were chosen as the main fabric materials. Linen,

cotton, silver-blended cotton, silk and nep polyester yarns were used as different materials.

The one layer/double face weaving structure was chosen to create brightness and shimmer when combining metalic, stainless steel and retro-reflective yarns with other threads.

Plain weave, panama and weft rib weave were chosen as they could best reflect effects of brightness and shimmer in designing fabric structures.

Table 2 shows weaving structures used in the sample fabrics, which were woven in a width of 100cm by a a shuttled automatic dobby loom (Sulzer Ruti) and a 22x50cm dobby hand loom.

## 4. Assessment of Fabrics

Fourteen different fabrics were woven within this research. On the fabrics that their warp and weft densities are different from each other, transparency and brightness effects were researched. The fabrics numbered 3, 4, 5, 6, 7, 9, 10, 13, 14 with a weft density 10 per cm, have a more dense transparency effect than the fabrics numbered 1,2,8,11,12 with a weft density of 15,18,14,17,19 per cm. However, at night and in the dark, under artificial light, the fabrics of a less weft density, have a less brightness and light effects than the fabrics of an intense weft density. Fabrics in this context are evaluated individually below.

Table 2. Material Properties of Warp and Weft Yarns in Sample Fabrics

| Fabric Sample Nr | Structure | Construction |
|---|---|---|
| 1 | Double layer, single layer | Plain, panama |
| 2 | Double layer, single layer | Plain, panama |
| 3 | Double layer,single layer, | Plain, panama |
| 4 | Double layer, single layer, | Plain, panama |
| 5 | Double layer,single layer | Plain, panama |
| 6 | Double layer, single layer | Plain, panama |
| 7 | Double layer, single layer | Plain, panama |
| 8 | Double layer, single layer | Plain, weft rib |
| 9 | Double layer, single layer | Plain, weft rib |
| 10 | Double layer, single layer | Plain |
| 11 | Double layer, single layer | Weft rip, plain |
| 12 | Double layer, single layer | Plain |
| 13 | Double layer, single layer | Plain |
| 14 | Double layer, single layer | Plain |

Table 3. Production Data of Sample Fabrics

| Fabric Sample Nr | Warp Density, End/ cm | Weft Density Picks/ cm | Reed Number | Fabric Dimension Width x Length (cm) |
|---|---|---|---|---|
| 1 | 7 | 15 | 50/3 | 22x 14 |
| 2 | 14 | 18 | 50/3 | 22x16 |
| 3 | 20 | 10 | 100/2 | 100x18 |
| 4 | 20 | 10 | 100/2 | 100 x 34 |
| 5 | 20 | 10 | 100/2 | 100 x 10 |
| 6 | 20 | 10 | 100/2 | 100 x 9 |
| 7 | 20 | 10 | 100/2 | 100x 49 |
| 8 | 20 | 14 | 100/2 | 100x24 |
| 9 | 20 | 10 | 100/2 | 100x 14 |
| 10 | 20 | 10 | 100 | 100x14 |
| 11 | 20 | 17 | 100/2 | 100 x 61 |
| 12 | 20 | 19 | 100 | 100 x 109 |
| 13 | 10 | 10 | 100 | 100 x 33 |
| 14 | 10 | 10 | 100 | 100x14 |

## 4. Assessment of Fabrics

Fourteen different fabrics were woven within this research. On the fabrics that their warp and weft densities are different from each other, transparency and brightness effects were researched. The fabrics numbered 3, 4, 5, 6, 7, 9, 10, 13, 14 with a weft density 10 per cm, have a more dense transparency effect than the fabrics numbered 1, 2, 8, 11, 12 with a weft density of 15, 18, 14, 17, 19 per cm. However, at night and in the dark, under artificial light, the fabrics of a less weft density, have a less brightness and light effects than the fabrics of an intense weft density. Fabrics in this context are evaluated individually below.

Fabric 1 is 140/ 2 denier silk in both warp layers with stainless steel and silk yarn in the first and second weft layers respectively. The warp density of the fabric makes it shimmer due to stainless steel and silk yarns used in the weft (Figure 1).

Table 4. Different Visual Effects of Stainless Steel Yarn in Woven Fabrics

| Fabric Sample Nr | Visual Effects |
|---|---|
| 1 | Pufy, shimmering |
| 2 | Puffy,voluminous, shimmering |
| 3 | Puffy, tissue effect, light shimmering |
| 4 | Puffy,voluminous, shimmering |
| 5 | Puffy,voluminous, shimmering |
| 6 | Puffy, voluminous,shimmering |
| 7 | Puffy, voluminous,shimmering |
| 8 | Tissue, light shimmering |
| 9 | Light pufy, light shimmering |
| 10 | Puffy, light shimmering |
| 11 | Voluminous, shimmering |
| 12 | Light voluminous, shimmering |
| 13 | Light voluminous, shimmering |
| 14 | Puffy, voluminous, relief, shimmering |

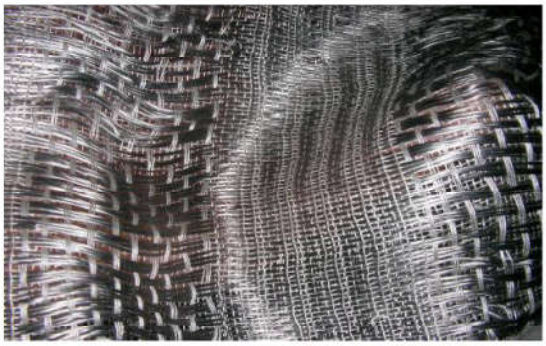
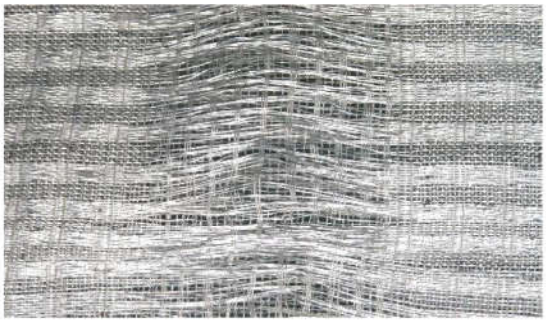


Fig. 1. Semi-Transparent Woven Fabric
(Warp: 140/2 Denier Silk; Weft: 4 Nm Stainless Steel Yarn, 140/2 Denier Silk)
Neslihan Yaşar, 2010

Fabric 2 consists of 50/1 Nm retro-reflective yarn in the first layer and silk in the second layer. The fact that 140/2 denier silk yarn is used in the warp makes it one of the two most transparent sample fabrics. Retro-reflective yarn makes the fabric brighter at night-time than in daylight (Figure 2).



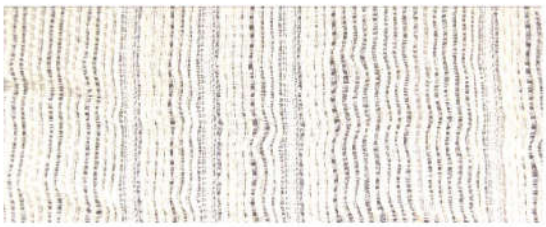
a) In daylight



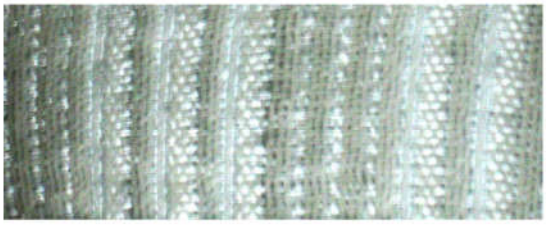
b) In a light source in the dark

Fig. 2. Semi-Transparent Woven Fabric
(Warp:140/2 Denier Silk; Weft:50/1Nm Retro-Reflective Yarn, 140/2 Denier Silk)
Neslihan Yaşar, 2010

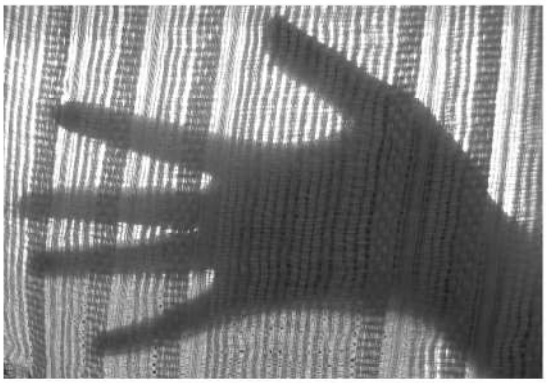
Fabric 3 exhibits brightness on the fabric surface even in daylight due to 50/1 Nm retro-reflective yarn used in the first layer. The silk in the second layer contributes to a certain degree of shimmer. The thinness of yarn and density of the weft make it semi-transparent (Figure 3).



a) In daylight



b) In a light source in the dark



c) Transparent appearance

Fig. 3. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: 50/1Nm Retro-Reflective Yarn, 225 Denier Silk)
Neslihan Yaşar, 2010

Fabrics 4, 5, 6 and 7 have the same technical features as Fabric 3 but they are made of different materials in the weft.

Stainless steel yarn is used for Fabrics 4 and 5, both of which have voluminous effects and shimmering surfaces because of the bag structure with a panama weave (Figures 4 and 5).



Fig. 4. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: 9.1 Nm Stainless Steel Yarn, 225 Denier Silk)
Neslihan Yaşar, 2010

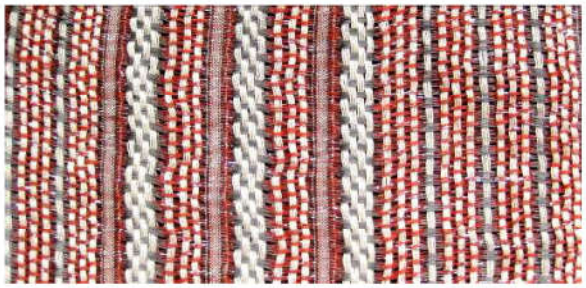


Fig. 5. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: 9.1 Stainless Steel Yarn, 225 Denier Silk)
Neslihan Yaşar, 2010



Fig. 6. Transparent appearance of Fabrics 4 and 5

The 150 denier metallic yarn for Fabric 6 gives the surface a sheen. Twisted metallic yarn make fabric 6 more tranparent than Fabric 7, whose surface brightness suffers as it is twisted and less dense, though it can increase dependent on the light source. The double-face bag structure and panama weave used for Fabrics 6 and 7 increase the degree of glitter (Figures 7 and 8).



Fig. 7. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: Metalic Fancy Yarn, 24/1 Cotton/Silver Yarn)
Neslihan Yaşar, 2010

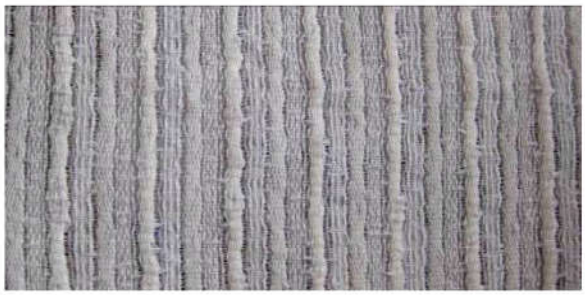


Fig. 8. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: 150 Denier Metalic Yarn, 24/1 Ne Cotton/ Silver Yarn)
Neslihan Yaşar, 2010



Fig. 9. Transparent appearance of Fabrics 7 and 8

Fabric 8 consists of 50/1 Nm retro-reflective in the first weft layer and 20 Nm nep polyester yarn in the second weft layer. The fabric with the warp of 20/2 Nm cotton and bamboo has little or no brightness in daylight while it can increase dependent on the light source at night-time. Its transparency is significantly less than other fabrics because of its structures and weaves (Figure 10).



a) In daylight



b) Transparent appearance

Fig. 10. Semi-Transparan Woven Fabric
(Warp: 20/2 Ne Cotton, 20/2Ne Bamboo; Weft: 50/1Nm Retro-Reflective Yarn, 20 Nm Fancy Yarn with Nep)
Neslihan Yaşar, 2010

Fabric 9 contains 17/1 Nm retro-reflective yarn in both layers, showing slightly varying shimmering effects in dailylight when brightness varies at night-time (Figure 11).



a) In daylight



b)In a light source in the dark



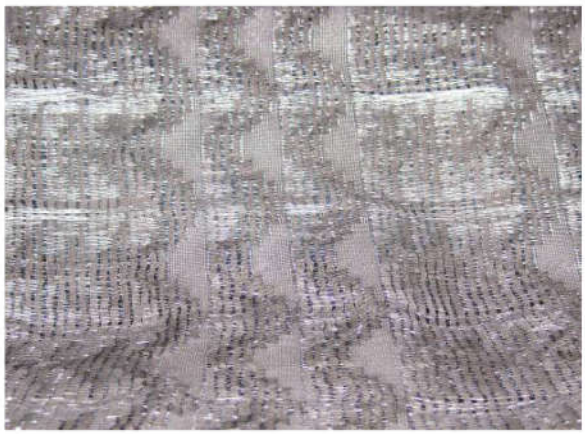
c) Transparent appearance

Fig. 11. Semi-Tranparent Woven Fabric
(Warp: 20/2 Ne cotton; Weft:50/1 Nm Retro-Reflective Yarn)
Nesrin Önlü, 2010

The weft density of the numbered 10 fabric, which is 10 per cm, is further than the fabrics numbered 12 and 11 with a weft density of 19,17 per cm owing to the density of its light transmission. Retro-reflective yarn used in the weft gives a shiny and bright appearance to fabric at night and in the dark under artificial light. At the same time, in the same condition transparency effect of the fabric changes according to the state of artificial light (Figure 12).



a) In daynight



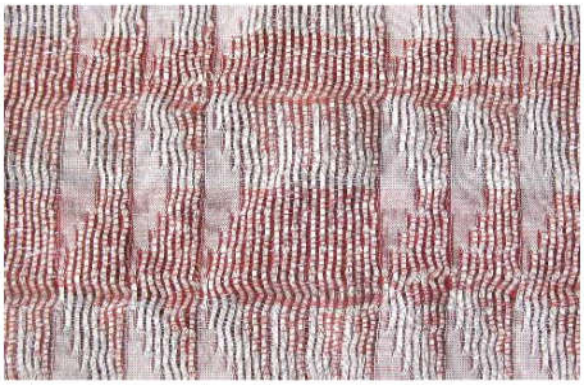
b) In a light source in the dark



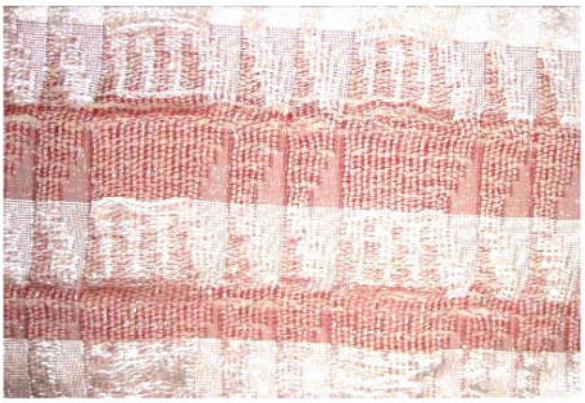
c) Transparent appearance

Fig. 12. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne cotton; Weft: 50/1 Nm Retro-Reflective Yarn)
Nesrin Önlü, 2010

Fabric 11 consists of 50/1 Nm retro-reflective yarn and fancy yarn which is coated with 12 micron metal in the weft. Surface brightness is much less due to retro-reflective yarn in daylight. The degree of shimmer can increase dependent on the light source at night-time (Figure 13).



a) In daylight



b) In a light source in the dark



c) Transparent appearance

Fig. 13. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne cotton; Weft: 50/1 Nm Retro-Reflective Yarn 12 micron metalic /fancy yarn)
Nesrin Önlü, 2010

Fabric 12 has 12 micron metallic/fancy yarn to form jewellery-like shimmer on the surface. There is less density in the warp and the weft tends to increase transparency in the fabric (Figure 14).



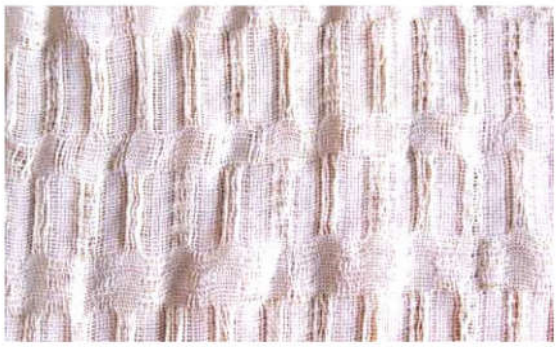
a) In daylight



b) Transparent appearance

Fig. 14. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: 12 Micron Metalic yarn)
Nesrin Önlü, 2009

The characteristics (weave, density, structure, warp yarn) of Fabric 13 are the same as Fabric 12's. However, it has 12 micron metallic yarn in the weft instead of 150 denier metallic yarn. Slit metallic yarn increases brightness effect of the fabric (Figure15).



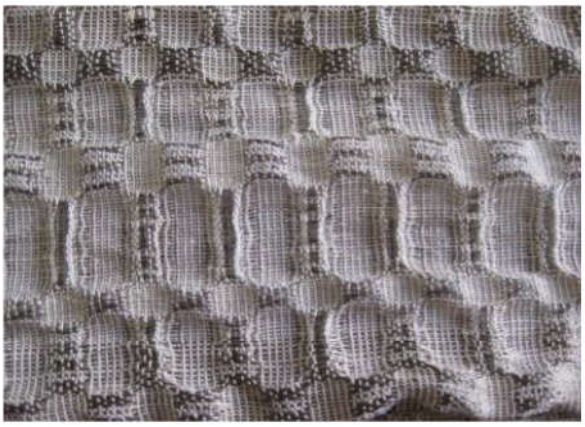
a) In daylight



b) Transparent appearance

Fig. 15. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne Cotton; Weft: 150 denier Metalic yarn)
Nesrin Önlü, 2009

9.1 Nm and 2 Nm stainless steel yarns give a shimmering, puffy and relief effect on the surface of Fabric 14 dependent on the single and double layer fabric structure. The use of 20/1 Ne cotton yarn as the weft on the back results in a different visual effect from the upper face. This semi-transparent fabric has a softer touch than other fabrics due to its low warp-weft density (Figure 16).



a) In daylight



b) Transparent appearance

Fig. 16. Semi-Transparent Woven Fabric
(Warp: 20/2 Ne cotton; Weft: 9.1 Nm , 2 Nm stainless steel yarn, 20/1 Ne cotton)
Nesrin Önlü, 2009

## 5. Conclusion

Transparent/semi-transparent fabric has a striking appearence due to the impression of spaciousness. As transparency makes fashions attractive, it remains to be a field worthy of further exploration. Fabrics and materials are constantly improved by latest technologies. This study concerns the transparent fabric effect which is shared by three different types of yarn. The warp contained threads made of natural materials such as cotton, bamboo and silk, and metallic, retro-reflective and

stainless steel yarn were used with cotton and silk. The consequent fabric effects were comprehensively studied.

Retro-reflective fabrics were utilized as the weft with a given density to create transparent effects and were given a slightly bright property in daylight as glass beads were also used. A densely bright and shimmering effect was obtained at night as the light was directly reflected. The fabrics exhibited varying degrees of transparency because brightness and shimmer varied dependent on the light source , the fabric structure and weave.

Brightness was the initial effect of fabrics woven by stainless steel and metallic yarn. The changing appearance of the fabrics created luminescent brightness. Patterns of different weaves were apt to increase illumination.

In conclusion, the shared feature of the fourteen semi-transparent fabrics for women's garments is that they have varying degrees of brightness, shimmer and illumination dependent on the light source and their fabric characteristics like yarn, weave, density and structure.

(This study was supported by Dokuz Eylül University, Branch Office of Scientific Researches.)

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ISSN 1560-6074


