

Short Communications

Weaving 'figured - face flip face - fabric' using orthogonal weft tapestry weave

R G Panneerselvam^{1, a}, L Rathakrishnan² &
H L Vijayakumar³

¹Department of Weaving, Indian Institute of Handloom
Technology, Varanasi 221 002, India

²Rural Industries and Management, Gandhigram Rural Institute,
Gandhigram 624 302, India

³Army Institute of Fashion and Design, Bangalore 560 016, India

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The aim of this study is to evolve new compound weave structures by modifying and permuting the existing structures. Basic principles of orthogonal structure and weft tapestry structure have been studied. New 'Orthogonal Weft Tapestry (OWT)' weaves are evolved by combining these two weaves and the concepts involved in deriving the new weave have also been developed. The structure of 'Two in one' figured fabric available in the field has been analyzed. This fabric is renamed as 'Figured - Face Flip Face - Fabric (FFFFF)'. Suitability of OWT weave to produce diversified FFFFF has been interpreted. Superimposing the guide graphs for the preparation of weave graph has been worked out using MS Paint to weave this fabric using electronic jacquard. Methodology of making double punching graph for mechanical jacquard weaving is also explored. The feasibilities of weaving these structures are explored using heald-treadle and jacquard shedding devices either separately or in combination. Fabric samples have been developed using mechanical jacquard in handloom. The techno - ergonomics of weaving methods are compared and recorded. It is observed that FFFFF produced with OWT weave has got features like uniqueness in appearance, fascinating utility value, and possibilities of producing exclusive product range.

Keywords: Face flip face fabric, Figured fabric, Handloom fabric, Jacquard weave, Orthogonal weft tapestry

Most of the woven figured fabrics have a figure with two or more colour and weave effect on one side. The figure is same on the other side but the colours get interchanged with opposite weave effect [Fig. 1(a)]. Figured fabrics woven with the weaves like plain, twill sateen, double cloth and backed cloth become reversible and can be used on either side with the same figure. On the other hand, the fabrics woven

with weaves like extra warp and extra weft become non-reversible and could be used only one side. Experiments were conducted by fabric designing experts to produce figured fabric in the name of 'Two in one'¹, containing two layers of cloth having two different images one backing the other. The 'two in one' figured fabric displayed at the Folklore Museum of Indian Institute of Handloom Technology, Salem (TN) has elephant on one side and horse on other side [Fig. 1(b)]. The purpose of going for this type of fabric is to use the fabric, by reversing, one time looking with one image and next time with the other one. To quote an example, the single image on both the sides of one thick floor carpet which is used at least for a decade, give monotonous look. Instead, the carpet woven with the said 'two in one' concept will serve dual purpose. One is added thickness due to stitched double fabric and other is its double side usage with differently looking colour and image to break the monotonous. The principle of producing 'two in one' fabrics was based on only one weave that is figured self stitched double cloth¹.

In this study, the name 'Figured two in one fabric' has been changed to 'Figured - Face Flip Face - Fabric' to pronounce more technically. It means that both the sides of figured fabric could be used as face side, by flipping. The new weave structure namely 'Orthogonal Weft Tapestry (OWT)' is developed for producing FFFFF by combining orthogonal weave^{2, 3} and weft tapestry weave⁴. The new weave is developed to overcome some of the limitations of stitched double cloth weave used for producing 'two in one' fabric. The first limitation is the rough feeling of fabric when woven with coarser counts because of the twill and sateen weave bindings used in the figure and ground of both the layers. The second limitation

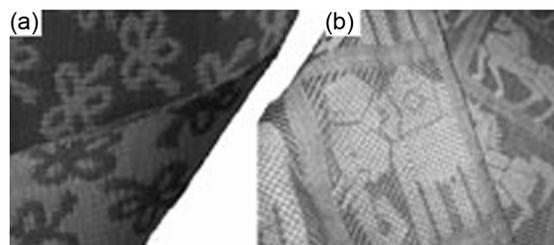


Fig. 1 – (a) Ordinary figured fabric, and (b) 'two in one' figured fabric

^a Corresponding author.
E-mail: rgpanneer61@gmail.com

is the lifting of huge number of ends for back picks. The other aim of the study is to have many more structures to produce diversified range of fabrics with different textures. The possibilities of weaving different orthogonal structures are experimented by weaving few samples in handloom⁵. Preparing jacquard graph for weaving this fabric is a unique one, based on the principle of superimposing which is done by the computer-aided graph designing using MS Paint⁶.

Experimental

Materials

Even though, orthogonal weave and weft tapestry weave have different weft set up, the warp setup is similar in both. The warp is in two series. One is stitching warp (st) mostly drawn in 2 healds to stitch the wefts alternately. The other one is separating warp (se) which separates the colour weft and keep them in the desired positions. These separating ends simply remain in between the wefts and are visible neither on the face side nor back side. The number of separating ends per repeat depends upon the number of weft colours used and requirement of their positions. The ratio between the stitching ends and separating ends can be 1:1 or 1:2 or 1:3 or 1:4 as per the compactness

required. These two series of warps have to be taken in two different beams. The stitching warp beam must be in moderately loose tension and the separating warp beam in regular tension. The number of wefts used is two or three or four or more as per the variety.

In orthogonal structure, the picks per set stay one above the other without any interchanging and without any colour importance throughout the width of fabric. For example, in three weft layered orthogonal structure, the first pick is on the top, the second is in the middle and the third one is at the bottom throughout the width of fabric without any interchanging which is indicated by 1 / 2 / 3, as shown in the third column - second row of Fig. 2. In weft tapestry structure, two or three or four differently coloured weft threads interchange completely between face and back of the cloth to produce design in different colours equal to number of wefts used. For example, in three colours weft tapestry, at any row of the fabric, in one part of the design, the first colour pick is on the face, the second colour pick is in the middle and the third colour pick is at the bottom which is indicated by 1 / 2 / 3. In the next part, the colour wefts get interchanged and placed in the order of 2 / 3 / 1. In the third place, the colour wefts again get interchanged to be in the order of 3 / 1 / 2. Thus, in the weft tapestry, both colour and their interchanging

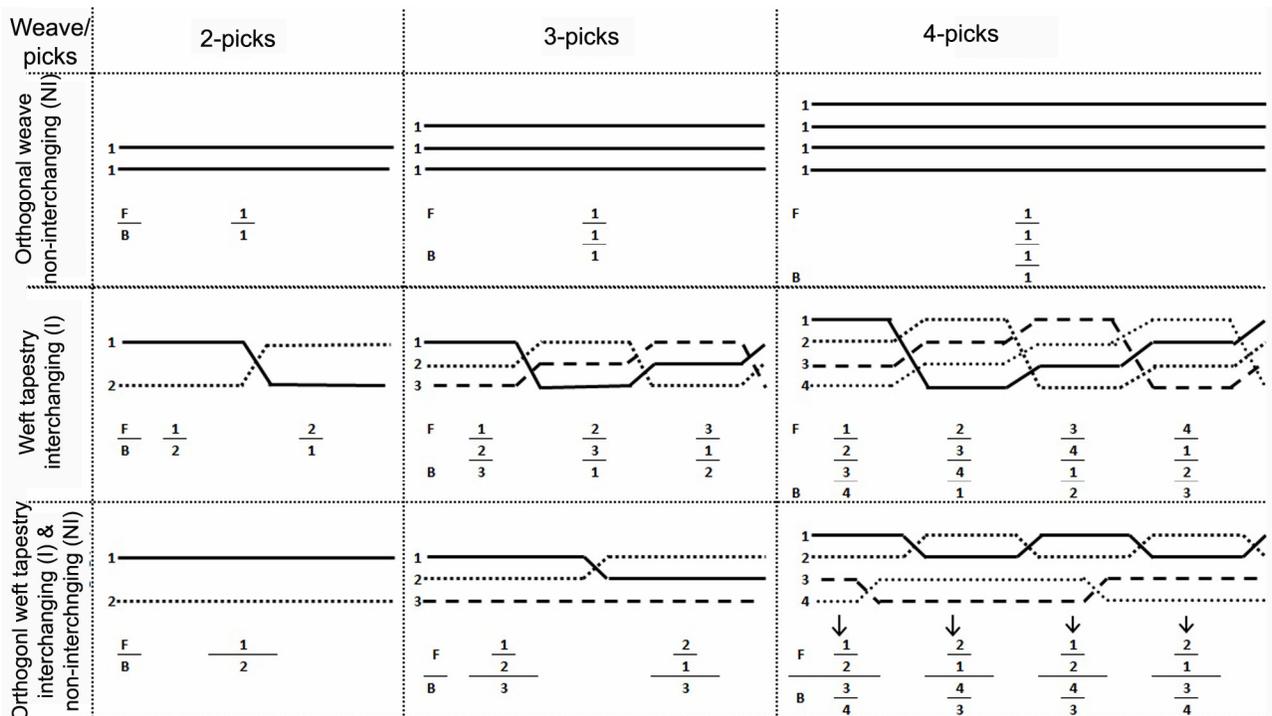


Fig. 2 – Comparison among orthogonal weave, weft tapestry weave and orthogonal weft tapestry weave

become equally important which is shown in the third column - third row of Fig. 2.

Complete interchanging principle of coloured weft in the weft tapestry and complete non-interchanging principle of orthogonal weaves are the two characteristics combined to form the new weave structure. The figured face flip face fabric is formed by combining the interlacements of four colour wefts of these two weaves. Out of four differently coloured picks, the first set of two picks is made to interchange only on the face side to form face layer figure. The other set of two picks is made to interchange only at the back side to form back layer figure. The first set of two face layer picks do not interchange with the second set of two back layer picks and thus forming independent two fabric layers one above the other. The separating warp (se) does the work of placing the weft in their respective positions. The stitching warp (st) does the work of stitching both the face and back layer together and also controlling of weft float. This results in forming two distinct face and back layer

having interchanging of colours in different places independently with each other. This concept is the base to form two different figures one on the face and other on the back. This is shown in the fourth column - fourth row of Fig. 2. The weft interlacing diagram of orthogonal weave, weft tapestry weave and orthogonal weft tapestry weaves formed with two picks, three picks and four picks are given in Fig. 2 in rows and columns respectively for complete understanding and comparison.

Methodology

Analysis of Four Picks OWT Weave

The weft interlacing diagram and the corresponding weaves of 4 picks orthogonal weft tapestry weave is given at Fig. 3. The warp is in two series namely stitching warp and separating warp arranged in 1: 3 order. The ends numbered 1 and 5 are stitching ends, stitching the set of four picks together in alternate plain order. The ends numbered 2, 3 and 4 are separating ends of one set. Out of four picks per

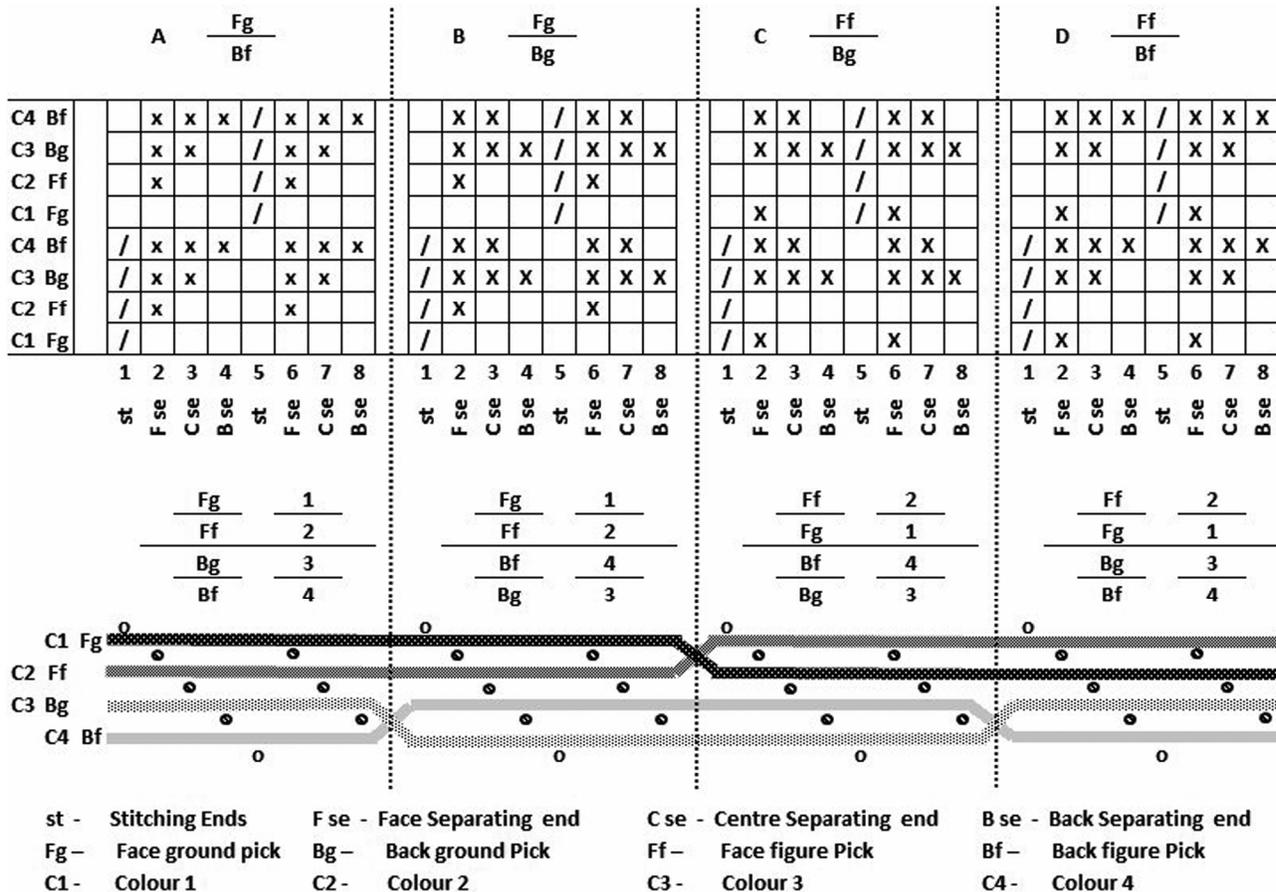


Fig. 3 – Four picks orthogonal weft tapestry structure; its weft interlacing diagram and corresponding four weaves of four different ‘superimposed figure parts’

set, the first and second picks are face picks forming ground and figure of the face image respectively. Hence, these two picks are named as Face-ground (Fg) and Face-figure (Ff). The colours of these two face picks are taken as C1 and C2. The third and fourth picks are back picks forming ground and figure of the back image respectively. Hence, these two picks are named as Back-ground (Bg) and Back-figure (Bf). The colours of these two back picks are taken as C3 and C4.

Out of three separating ends in each set, the first separating end separates the face picks Fg and Ff to form either ground or figure of the face image on face side. Hence, the first separating end is named as Face separating end (F se). The third separating end separates the back picks Bg and Bf to form either ground or figure of the back image at the back side. Hence, the third separating end is named as Back separating end (B se). The second separating end stays in the centre and separates the face picks and back picks to form two distinct layers one above the other. Hence, the second separating end is named as Centre separating end (C se). This arrangement results in forming two distinct face and back layer having interchanging of colours in different places independently with each other. This concept is the base to form two different figures one on the face and other on the back. The denting order is four per dent with one stitching end together with three separating ends. Stitching warp and separating warps are separately taken in two beams. The stitching warp beam is kept in slightly loose tension and separating warp beam is kept in moderate tension. The loose tension of stitching warp facilitates easy packing of picks and keep four picks one above the other in the cloth.

In any ordinary figured cloth produced by the structures like satin, double cloth and tapestry with single image, the ground and figure are independent. That is, the ground is ground on both face and back; the figure is figure on both face and back. But in any part of FFFFF produced by orthogonal weft tapestry, the ground and figure part of the face image get superimposed with the ground or figure of the back image. This results in formation of four different parts in the cloth. The weft interlacing diagram of four picks orthogonal weft tapestry (Fig. 3) shows the formation of these four different cloth parts, viz. Fg / Bf = A; Fg / Bg = B; Ff / Bg = C; and Ff / Bf = D with four different colour picks. Considering the first

pick as 1 & Fg, the second pick as 2 & Ff, third pick as 3 & Bg and fourth pick as 4 & Bf, all the four weaves A, B, C and D of four cloth parts are explained below:

- (i) Weave A in 8×8 corresponds to the cloth part where the ground of face image is on the top, below which is the figure of back image. The cloth effect is indicated by Fg // Bf and also by 1 // 4. The position of picks in this place is indicated by Fg/Ff // Bg/Bf and also by 1/2 // 3/4.
- (ii) Similarly, Weave B indicates Fg // Bg and also 1 // 3. The position of picks in this place is indicated by Fg/Ff // Bf/Bg and also by 1/2 // 4/3.
- (iii) Weave C indicates Ff // Bg and also 2 // 3. The position of picks in this place is indicated by Ff/Fg // Bf/Bg and also by 2/1 // 4/3.
- (iv) Weave D indicates Ff // Bf and also 2 // 4. The position of picks in this place is indicated by Ff/Fg // Bg/Bf and also by 2/1 // 3/4.

The set of these weaves A, B, C and D are meant for preparing weave graph in computer and directly used for operating electronic jacquard machines, wherein printing of weave graph and card punching are not required.

Another set of weave repeats E, F, G and H in 8×4 , are also derived from the weft interlacing diagram (Fig. 4) by separating the picks in two sets. One set is by taking only face picks Fg and Ff and another set is by taking only back picks Bg and Bf. The details of these four weaves are given below:

- (i) Weave E in 8×4 corresponds to the cloth part where the ground of face image is formed on the face side. The cloth effect is indicated by Fg. The position of picks in this place is indicated by Fg/Ff.
- (ii) Weave F indicates Ff. The position of picks in this place is indicated by Ff/Fg.
- (iii) Weave G indicates Bg. The position of picks in this place is indicated by Bf/Bg.
- (iv) Weave H indicates Bf. The position of picks in this place is indicated by Bg/Bf.

Out of these four weaves, the weaves E and F are meant for preparing the weave graph of face image. The weaves G and H are meant for preparing the weave graph of back image. These two weave graphs are used as punching graph for mechanical jacquard.

Graph Preparation for Electronic Jacquard

The procedure followed in the preparation of guide graphs, its superimposing and punching graph to

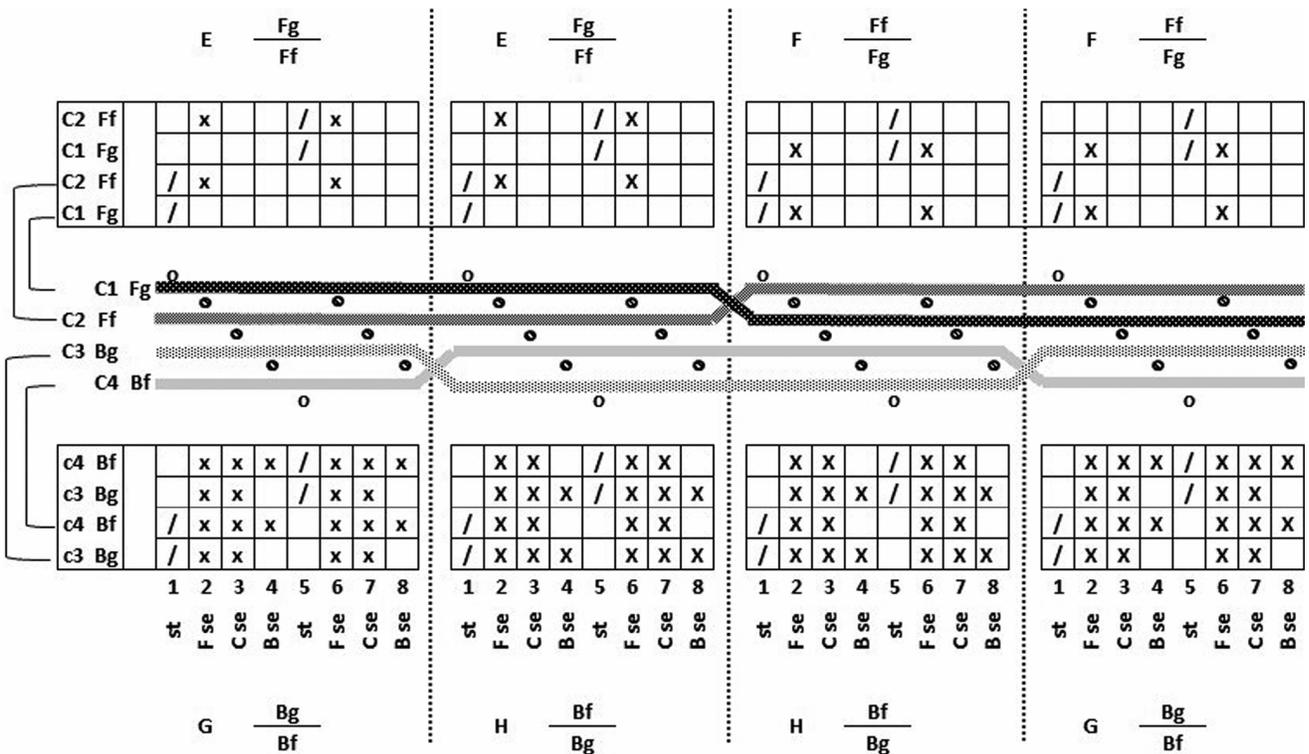


Fig. 4 – Four picks orthogonal weft tapestry structure; its weft interlacing diagram and corresponding four weaves of four different ‘separated figure parts’

weave FFFFF using electronic jacquard with straight tie and straight draft is described below. MS Paint is used for doing these works directly, following the principles of computer - aided graph designing.

Two figures which are totally looking different from each other are drawn one for face and other for back. For example, multi symmetrical image is taken for face [Fig. 5(a)] and diagonal image is for back [Fig. 5(b)]. Preparation of guide graphs for these two images is compulsory before going for the preparation of weave graph. As the basic weave of orthogonal weft tapestry repeats in 8 ends and 8 picks, the number of ends taken for preparation of guide graph is equal to one eighth (1/8) of the capacity of jacquard employed. The number of picks taken in the guide graph is also equal to one eighth (1/8) of the total picks to be woven. For example, if the capacity of the jacquard is 200 hooks and the total picks per repeat is also 200, two guide graphs of 25 ends × 25 picks (200 Hooks / 8; 200 Picks / 8) are prepared separately one for face image and other for back image in two colours.

Superimposing of the guide graph of face image with the guide graph of back image is essential for the preparation of weave graph. The guide graph of face

image shows the formation of only Fg and Ff in two colours. Similarly, the guide graph of back image shows the formation of only Bg and Bf in other two colours. By superimposing both the graphs, a final graph in 25 × 25 is obtained in four colours which represent the formation four different cloth parts as indicated in A, B, C and D viz. Fg / Bf; Fg / Bg; Ff / Bg; Ff / Bf. The superimposing is done in MS Paint by following the steps as described below:

Open new file in 25 x 25. Draw the graph of face image. Apply colour 1 in the ground and colour 2 in the figure. Save file as ‘face.bmp’ [Fig. 5(c)]. Open new file in 25 x 25. Draw the graph of back image. Apply colour 3 in the ground and colour 4 in the figure. Save file as ‘back.bmp’ [Fig. 5(d)]. Colour 1 indicates Fg. Colour 2 indicates Ff. Colour 3 indicates Bg. Colour 4 indicates Bf. The colour numbers 1-8 used in the explanation are indicated in the corresponding parts of all the figures.

Open ‘face.bmp’ file. Select all and copy. Open ‘back.bmp’ file, select colour 1 as back ground colour in the colour palette. Select ‘transparent selection’. Paste ‘face.bmp’ file over ‘back.bmp’ file. By doing so, colour 1 area (Fg) of face image get replaced by the corresponding area of back image

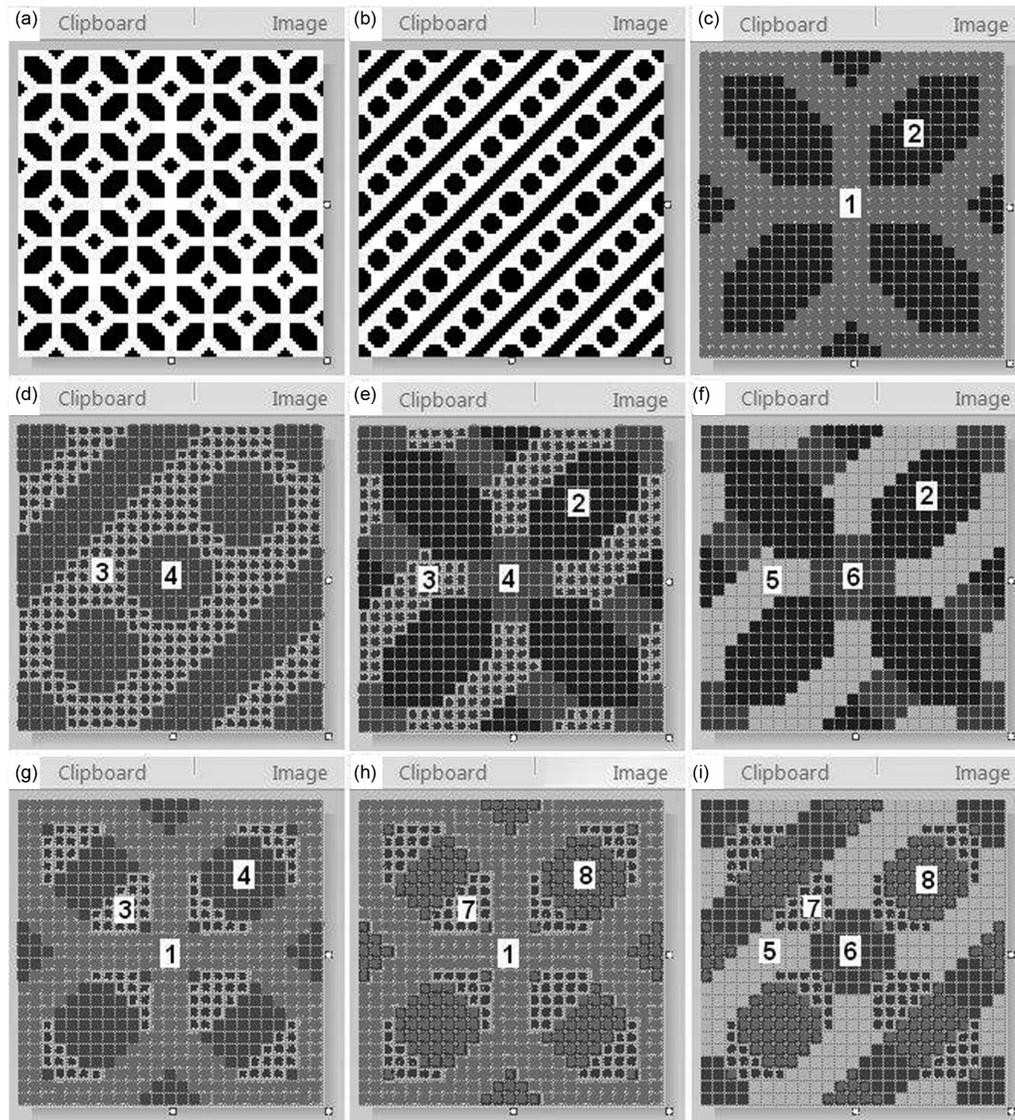


Fig. 5 – Different stages of preparing superimposed guide graph before the preparation of weave graph for electronic jacquard

in colours 3 (Bg) and 4 (Bf). Colour 2 (Ff) area of face image remains unaltered. Save the file as 'superimpose I.bmp' file [Fig. 5(e)]. Replace the colours 3 and 4 with colour 5 and 6 respectively. Save the file again. This 'superimpose I.bmp' is now in three colours – 2, 5 and 6 [Fig. 5(f)]. Colour 2 indicates Ff. Colour 5 together with colour 6 indicates Fg. Again colour 5 separately indicates the portions of Bg formed below Fg. Colour 6 separately indicates the portions of Bf formed below Fg. Hence, now, colour 5 indicates Fg / Bg. Colour 6 indicates Fg / Bf.

Open 'back.bmp' file again. Select colour 2 as back ground colour in the colour palette. Select 'transparent selection'. Paste 'face.bmp' file over

'back.bmp' file. By doing so, colour 2 (Ff) area of face image get replaced by the corresponding area of back image in colours 3 (Bg) and 4 (Bf). Colour 1 (Fg) area of face image remains unaltered. Save the file as 'superimpose II.bmp' [Fig. 5(g)]. Replace the colours 3 and 4 of 'superimpose II.bmp' file with colour 7 and 8 respectively. Save the file again. Select all and copy. This 'superimpose II.bmp' is now in three colours – 1, 7 and 8 [Fig. 5(h)]. Colour 1 indicates Fg. Colour 7 together with colour 8 indicates Ff. Again colour 7 separately indicates the portion of Bg formed below Ff. Colour 8 separately indicates the portion of Bf formed below Ff. Hence, now colour 7 indicates Ff / Bg. Colour 8 indicates Ff / Bf.

Open 'superimpose I.bmp' file which is in colour 2, 5 and 6. Select colour 1 as back ground colour in the colour palette. Select 'transparent selection'. Paste 'superimpose II.bmp' file (which is in colour 1, 7 and 8) over superimpose I.bmp file. By doing so, colour 1 (Fg) area of Superimpose II.bmp image gets replaced by the colours 5 and 6. Colour 7 and 8 of superimpose II.bmp image areas remain unaltered. Save the file as 'superimpose final.bmp'. This 'superimpose final.bmp' is in four colours 5, 6, 7 and 8 [Fig. 5(i)].

As stated earlier, colour 5 indicates the structure Fg / Bg produced by the weave B. Colour 6 indicates the structure Fg / Bf produced by the weave A. Colour 7 indicates the structure Ff / Bg produced by the weave C. Colour 8 indicates the structure Ff / Bf produced by the weave D.

The superimpose final.bmp graph of 25×25 in four colours is scaled / stretched eight times to make it to the size of 200×200 . The four weaves indicated at A, B, C and D are applied in the colour areas 5, 6, 7 and 8 respectively by using tools in the MS Paint. The final weave graph in 200×200 [Fig. 6(a)] is then directly used for electronic jacquard operation without any graph printing and card punching.

Graph Preparation for Mechanical Jacquard

Superimposing of graph is not required while preparing weave / punching graph for mechanical jacquard. Instead, two separate graphs are prepared, one for face image and another for back image. For example, if the capacity of jacquard is 200 hooks and the total picks per repeat is also 200, two guide graphs of $25 \text{ ends} \times 25 \text{ picks}$ ($200 \text{ Hooks} / 8$; $200 \text{ Picks} / 8$) are prepared separately, one for face image and other for back image in two colours [Figs 5(a) and (b)]. Both the graphs of 25×25 size are scaled / stretched

8 times in width way and 4 times in length way to make it to the size of 200×100 . This is because the basic weave is in 8×4 . Punching graph for face image is prepared by applying the weaves E and F respectively in the ground and figure of face image graph in 200×100 [Fig. 6(b)]. Similarly, punching graph for back image is prepared by applying the weaves G and H respectively in the ground and figure of back image graph in 200×100 [Fig. 6(c)]. One set of 100 cards are punched by punching all marks from the punching graph of face image and numbered serially as F1, F2, F3, F4,.....F100. Another set of 100 cards are punched by punching all marks from the punching graph of back image and numbered serially as B1, B2, B3, B4,.....B100. The cards are then laced in the order of 2: 2 sequence as F1, F2, B1, B2, F3, F4, B3, B4,.....F99, F100, B99, B100 and made as one set of 200 cards for weaving.

Loom Setting and Weaving

For weaving the sample, a loom is set with a jacquard of 200 hooks capacity and the harnesses are built in straight tie order. Two warp beams are prepared one for stitching ends and other one for separating ends. The ratio of total ends of stitching beam and separating beam is 1: 3 respectively. The ratio of length of warp taken in stitching beam and separating beam is 3: 1 respectively. The count of warp used for both the series is $2/20^s$. They are drawn through harness continuously in straight draft in the order of 1 stitching end and 3 separating ends. The ends are dented through 48^s reed with 2 ends per dent and gaited properly. The stitching warp beam is kept in moderately loose tension and the separating warp beam in normal tension. Weaving is carried pick by pick with four shuttles having four different colour wefts of same thickness. The count of

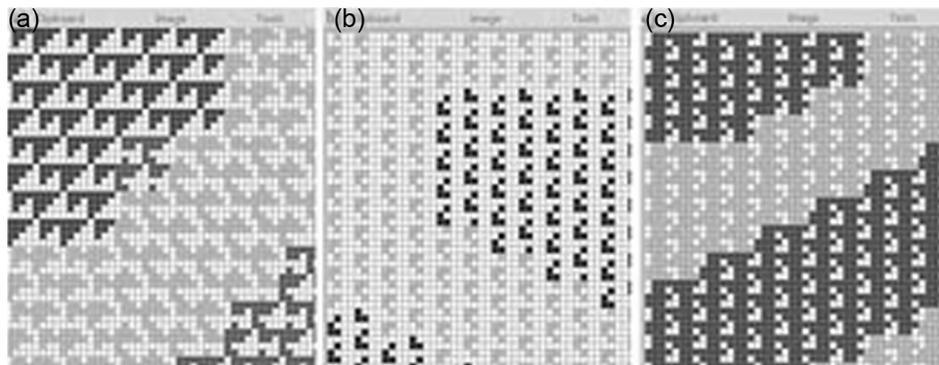


Fig. 6 – (a) Weave graph for electronic jacquard, (b) Weave / punch graph of face image for mechanical jacquard, and (c) Weave / punch graph of back image for mechanical jacquard

weft used is 2^s. The picks per inch in the fabric are 48, which include 12 picks of four varieties of picks (Fg, Ff, Bg and Bf picks).

Results and Discussion

The photo of FFFFF given at Fig. 7(a) is woven with the above loom set up. It is seen in the images shown in Figs 5(a) and (b). Two more photos of FFFFF are given at Figs 7(b) and (c). Figure 7(b)

shows a diagonal design on one face and an ogee design on other face. Figure 7(c) shows simple twill on one face and a diamond design on other face. The quality particulars of five different varieties of FFFFF are given in Table 1. The techno - ergonomics of weaving FFFFF with self stitched double cloth weave and weaving FFFFF with orthogonal weft tapestry weave are compared in Table 2.

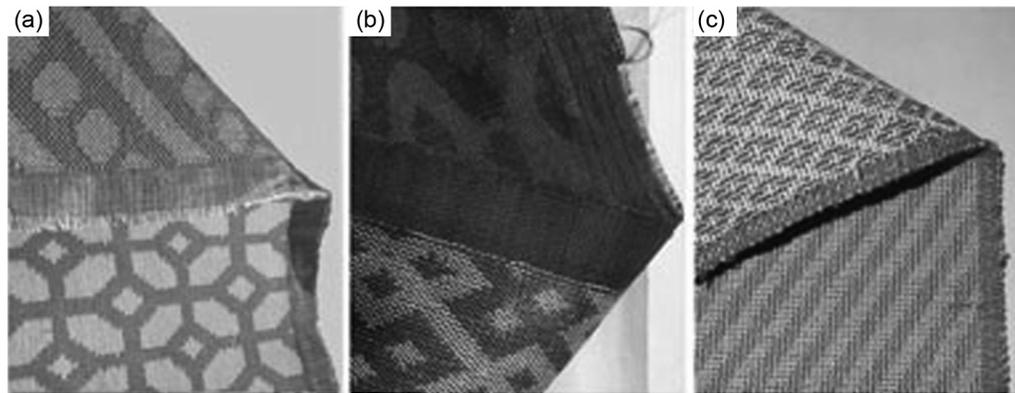


Fig. 7 – Three different FFFFFs

Table 1—Quality particulars of five different FFFFFs

FFFF fabrics	Count of warp		Ends / inch		Reed count - denting order	Count of weft	Picks / inch	Weight g /yd ²	Material	End use
	Se	St	Se	St						
1	2/20s	2/20s	42	14	24s - 4	4s (2 ply)	56	726	Cotton	Floor carpet, Door mat
2	2/40s	2/40s	54	18	32s - 4	10s (2 ply)	72	389	Cotton	Table cloth, Table mat
3	2/60s	2/60s	63	21	40s - 4	20s (2 ply)	84	242	Cotton	Room divider
4	2/120s	2/120s	96	32	60s - 4	48s (2 ply)	108	204	Woolen	Woolen shawl
5	20-22 D (2 ply)	20-22 D (2 ply)	123	42	80s - 4	20-22 D (4 ply)	128	114	Silk	Silk Shawl

Table 2—Comparison between FFFFF produced with self stitched double cloth weave and orthogonal weft tapestry weave

Self stitched double cloth weave	OWT weave
<ul style="list-style-type: none"> • Single cloth on both sides. • Ends per inch to be more. • Huge numbers of ends have to be lifted. • Imbalance lifting for alternate picks. • Binding marks are necessary. • Binding marks makes the fabric rough to feel • Binding marks reduces the solidity of figure. . • Introduction of wadding threads is difficult. • Increased figuring capacity of jacquard is required to increase the width of repeat. • No other possibilities of increasing the width of repeat from the given capacity of jacquard. • No possibility for increasing the weight and thickness of the fabric. 	<ul style="list-style-type: none"> • Weft tapestry on both sides, • Ends per inch could be less. • Lifting of huge number of ends does not arise. • Balance lifting for alternate picks. • No binding marks. • The fabrics are smooth and rubber like. • The appearance of figure is solid. • Introduction of wadding threads is easy. • Due to less ends per inch, the width of repeat increases for the given capacity of jacquard. • Special shedding techniques increase the width of repeat from the given capacity of jacquard. • Increasing the weight, thickness of the fabric and waste yarn utilization are possible.

The graph preparation of FFFFF is unique and intricate but can be carried easily by computer - aided graph designing methodology. As the actual weaves are used in the graph, the jacquard loom setting, drafting and graph punching have all become simple. From the table of quality particulars and comparison, it is evident that the OWT weave has got all the advantages to produce FFFF fabric in finer, medium and coarser quality range. There are also possibilities of producing FFFF fabric with OWT weave structure using different kinds of harnessing combined with heald system. The designers and manufacturers can very well adopt this weave to produce unique and innovative reversible product range like shawl, mufflers, jackets, floor carpets, door mats, table mats, table cloth, room dividers, door curtains. The study also extends to device new shedding, picking and weaving techniques to weave other varieties of FFFFF with many more advantages like increasing the figuring capacity of given jacquard, simple graphing with card punching and easy introducing of wadding threads both in warp and weft directions.

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