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Development of Potential Woven Fabric Designs with Existing Loom-Set up

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ABSTRACT

Weaving factories in Ethiopia are sticking to limited types of product categories. It is analyzed that production of bed-sheeting and sheeting material covers more than 50% of the total product varieties. Besides, production of shirting, blankets & suiting in total covers only about 40%. Due to this, demands for basic product categories of shirting, suiting, dress materials, curtains and towels are not fulfilled with local factories product mix. Thus, the country is forced to import such products from different countries like: China, Italy, Turkey, India, Netherlands, United States, Taiwan, etc. for assessing the majorly imported product mix, three month import data has been taken from Ethiopian customs revenue authority and analyzed that for this 3-month period, a total cost of USD 566,329 has been withdrawn for purchasing the products. So, this paper tries to assess the machinery and loom conditions of the selected representative factories with main parameters of shedding mechanisms, make & model of the looms and active/working number of harness frames. Shedding contributes about 50%, 40% & 10% for tappet, dobby and jacquard mechanisms respectively & the number of harness frames in the looms ranges from 6 to 20 for both tappet and dobby looms respectively. Accordingly, with this machine set-up the potential woven fabric designs, which have application areas of shirting, dresses, suiting, towels & home furnishings have been studied in detail and more than 15 product designs have been suggested with details of required heald shafts, drafting procedures, lifting plans and specific application areas.

Keywords: loom set-up; product mix; production coverage; shedding mechanisms; woven fabric designs

INTRODUCTION

Land Ethiopia's government wants to diversify exports from agricultural product to strategic sectors like textile and garment manufacturing.

Ethiopia's long history in production of textile products began in 1939 by which the prior garment factory has been established. In the past years, the country's textile, and apparel industry have shown an increment with 51% and more than 65 international textile investment projects have started work. **[3]**

Woven fabric is any textile formed by weaving. Woven fabrics are often created on a loom, and made of many threads woven on a warp and a weft. Technically, a woven fabric is any fabric made by interlacing two or more threads at right angles to one another. **[1]**

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In woven fabric production, there are basically 2 types of mechanisms help for lifting the warp sheets and make the fabric designs more complex, dobby and jacquard mechanisms. The design complexity is entertained through the pattern repeats. Hence, the repeats determine end-use of the fabrics to be produced. **[4]**

For a textile company it is one of the strategies to be engaged in new product developments. This ensures that the company can become competitive in the global market. New product categories can be: innovative products, new product lines, addition product lines, improved products, customized products, etc. **[5]**

While considering a new woven fabric design for a firm, the technical sheets have to be filled for the requirements of: grey fabric width, reed width, threads count, warp & weft densities, number of ends for body & selvedges, reed count, width shrinkage for the finished fabric, etc. **[6]**

In a textile firm, for changing a sort/article, the loom set-up has to be changed and considered. Prior to set-up change, proper knowledge of the weave pattern has to be ensured which determines the structure, appearance, texture, etc of the fabric **[7].**

While discussing about woven textile product development, textile patterns have to be taken into consideration with main classifications of: plain weaves, describing a weave without decoration but can be make with color prints and embroidery on them, monotype pattern, with inclusion of one type of color during weaving and repeated patterns made with dobby and jacquard machines. **[8]**

In the country, only limited varieties of woven products are being produced. The types of woven articles most commonly produced are sheeting, abujedid, blanket, terry-towel, etc although the capacity of the looms is not limited to such types of products only.

So considering the above limitations, this research paper tries to study the existing loom conditions and machinery set-up, the current product types and fabric construction and accordingly the limitations on product diversifications is analyzed and the potential products that can be produced with the existing machinery condition and loom set-up are also studied in detail and state them along with drafting steps, the required number of harness frames, the lifting plan and the application areas.

MATERIALS & METHODS

For conducting the research, data have been collected from some selected weaving factories with inclusion of the necessary machinery parameters and products that the companies are currently producing. Accordingly, the existing status of the weaving factories in relation with their product mix has been shown in Table 1.

- ✓ Assessment of data available in selected weaving factories,
- ✓ The data from weaving factories have been analyzed,
- ✓ Currently produced woven product mix/varieties have been assessed,
- ✓ The potential product mix that can be produced with the existing machinery condition and loom set-up have been defined and analyzed,
- ✓ Putting and categorizing the potential products with the drafting procedures, lifting plans, required number of harness frames, their application areas, etc,
- ✓ Recommendation and suggestion of those potential products to be produced in the selected factories.

RESULTS AND DISCUSSIONS

For the research purpose, data of machinery conditions and product details have been taken from weaving factories found in Ethiopia. In these factories, a total of 929 looms are found and of which: 718 are Rapier looms, 32 are water-jet looms, 24 are projectile looms & 155 are air-jet looms.

Amongst the available looms listed above, 69% are of brand made (looms for 9 factories). The looms have a manufacturing year ranging from 1981-2014, among these about 54 % of the looms are manufactured in the year ranging from 2001-2014. When we see the shedding mechanisms 50% of the looms have a tappet shedding, 40% dobby shedding and 10% jacquard shedding mechanisms.

Table 1: Machinery condition and product category for selected weaving factories

Types of looms	No. of looms	Shedding mechanism	Max. harness frames	Make/model	Product types
Rapier	718	Tappet, dobby & Jacquard	20	Somet, dornier, vamatex picanol Staubli, comez Pantere4x	shirting, rib stop, sheeting Plain / twill blanket terry towel Kaki Cotton tape/ elastic band, narrow width fabrics
Air-jet	155	Tappet & dobby	12	Picanol Dornier	Bed sheet, Abujedid, Suiting,
Projectile	24	Tappet& dobby	12	Sulzer	Sheeting Canvas,

Water jet	32	Tappet& dobby	16	Tsudakoma	Sheeting

The number of harnesses in the looms ranges from 6 to 20 for tappet and dobby shedding mechanisms respectively and the number of weft accumulators in the looms ranges from 1 to 8.

In table 2, it has been tried to discuss the major types of products, which are currently produced in Ethiopia. When we see their production coverage: production of bed-sheeting and sheeting constitutes more than 50% of the total product varieties. Production of shirting, blankets & suits covers about 40 % of total product mixes, etc.

Table 2: Major product types and their current coverage in production

S.No.	Product type	Production coverage
1	Shirting	16%
2	Bed sheet	30%
3	Sheeting	24%
4	Blanket	18%
5	Suiting	7%
6	Others	About 5%

While trying to address major imported products, data has been taken from 06/08/2018 to 27/11/2018, i.e three months of data, has been taken from customs authority. Accordingly, in the tables: 3& 4, quantities and CIF value (in USD) have been analyzed for some major products like: Curtains and interior blinds; curtain or bed valances of cotton, towels, Shirting, Dresses & Suits. It is shown that with the stated three months of time, a total of 566,329 USD has been put in place. Out of this, shirting is the first, constituting about 258,737 $, followed by Suiting and Dresses with 139,435 & 96,686 USD respectively. So, after the research work is implemented, importing of the above stated products will be reduced since our locally owned weaving factories will be aware and capable of producing the same.

So, the existing situation of the looms shows that, although the machinery can produce products other than the above discussed, the factories are sticking to limited types of products only. This will limit the loom capacity utilization and hence the product mix of the factories is also small. But if their product varieties are more, it may enhance import-substitution of products with a fair price.

Below some potential fabric designs are analyzed in detail along with their draft, lifting plan and weave with their respective required number of harness frames and application areas.

Some of the potential product designs/categories to be developed with the existing machinery set-up are:

i. In **4 x 4 Mat weave** design, 4 heald shafts of dobby/tappet shedding mechanism are required. The application area is for Napkins, Table mats and towels. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through third heald, fifth warp yarn is drawn through third heald, sixth warp yarn is drawn through third heald, seventh warp yarn is drawn through fourth heald, eighth warp yarn is drawn through fourth heald, ninth warp yarn is drawn through fourth heald, tenth warp yarn is drawn through fourth heald, etc.
Lifting plan: with a weave repeat of 8, for the first pick, the first and third shafts must be raised, for the second pick, the second and third shafts must be lifted, for the third pick, the first and third shafts must be lifted, for the fourth pick, the second and third shafts must be lifted, for the fifth pick, the first and fourth shafts must be lifted, for the sixth pick, second and fourth shafts must be lifted, for the seventh pick, the first and fourth shafts must be lifted, for the eighth pick, second and fourth shafts must be lifted, etc.

ii. In **Bed ford cord weave** design, 6 heald shafts of dobby/tappet shedding mechanism are required. The application area is furnishing. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through first heald, the fourth warp yarn is drawn through third heald, fifth warp yarn is drawn through fourth heald, sixth warp yarn is drawn through third heald, seventh warp yarn is drawn through fourth heald, eighth warp yarn is drawn through third heald, ninth warp yarn is drawn through fourth heald, tenth warp yarn is

Table 3: Import data for major products [2]

Product type	Country (origin)	CIF Value (USD)
Curtains and interior blinds; curtain or bed valances of cotton	China	33976
	United Arab Emirates	556
	Taiwan, Province of China	12
	Israel	11,036
Towels	Netherlands	2141
	Argentina	85
	United States	11
	China	20674
	Belgium	1,304
	India	137
	Turkey	1037
	Italy	324
	India	177
Dresses	China	81635
	Indonesia	10,412
	Turkey	894
	Indonesia	3745
Shirting	China	236378
	Former Yugoslav Rep. Macedonia	250
	Turkey	21948
	India	160
Suits	United States	306
	China	44794
	Turkey	64534
	Thailand	5609
	Senegal	3757
	Pakistan	16,495
	Iraq	826
	Kenya	220
	Italy	2892

drawn through second heald up to twenty-second warp yarn is drawn through second heald, twenty-third warp yarn is drawn through first heald, etc.

Lifting plan: with a weave repeat of 4, for the first pick, the first, third, fourth and sixth shafts must be raised, for the second pick, the second, third, fourth and fifth shafts must be lifted, for the third pick, the first, fourth, fifth and sixth shafts must be lifted, for the fourth pick, the second, third, fifth and sixth shafts must be lifted, etc.

iii. In **WARP RIB IN PLAIN WEAVE** design, 2 heald shafts of tappet shedding mechanism are required. The application area is for furnishing. The description for the drafting, lifting plan and weave is stated below:

Drafting: a straight draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through first heald, etc.

Lifting plan: with a weave repeat of 2, for the first pick, the first shaft must be raised, for the second pick; the second shaft must be lifted, etc.

iv. In Stripes design, 2 heald shafts of tappet shedding mechanism are required. The application area is Shirting. The description for the drafting, lifting plan and weave is stated below:

Drafting: a straight draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through first heald, the fourth warp yarn is drawn through second heald, etc.

Lifting plan: with a weave repeat of 2, for the first pick, the first shaft must be raised, for the second pick, the second shaft must be lifted, for the third pick, the first shaft must be lifted, for the fourth pick; the second shaft must be lifted, etc.

v. In wavy twill weave design, 4 heald shafts of dobby/tappet shedding mechanism are required. The application area is for towels. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combination of straight and pointed draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through fourth heald, fifth warp yarn is drawn through first heald, sixth warp yarn is drawn through second heald, seventh warp yarn is drawn through third heald, eighth warp yarn is drawn through fourth heald up to thirteenth warp yarn is drawn through third heald, fourteenth warp yarn is drawn through second heald, etc.

Lifting plan: with a weave repeat of 4, for the first pick, the first and fourth shafts must be raised, for the second pick, the first and second shafts must be lifted, for the third pick, the second and third shafts must be lifted, for the fourth pick, the third and fourth shafts must be lifted, etc.

vi. In herring bone weave design, 8 heald shafts of dobby/tappet shedding mechanism are required. The application areas are for bed spread, bed cover and furnishings. The description for the drafting, lifting plan and weave is stated below:

Drafting: a straight draft is used, the first warp yarn is drawn through first heald, second warp yarn through the second heald, the third warp yarn through the third heald up to the eighth warp yarn through the eighth heald, etc.

Lifting plan: with a weave repeat of 8, for the first pick, the first, fifth, sixth and seventh shafts must be lifted, for the second pick, the first, second, fifth and sixth shafts must be raised, for the third pick, the first, second, third and fifth shafts must be lifted, for the fourth pick, the first, second, third and fourth shafts must be raised, for the fifth pick, the second, third, fourth and the eighth shafts must be lifted, for the sixth pick, the third, fourth, seventh and eighth shafts must be raised, for the seventh pick, the fourth, sixth, seventh and eighth shafts must be lifted, for the eighth pick, the fifth, sixth, seventh and eighth shafts must be lifted, etc.

vii. In DICE CHECK weave design, 8 heald shafts of dobby/tappet shedding mechanism are required. The application area is for shirting / Home furnishing. The description for the drafting, lifting plan and weave is stated below:

Table 4: Ranks of Majorly imported products [2]

Product types	Total CIF value (USD)	Rank	Grand total (USD)
Curtains and interior blinds; curtain or bed valances of cotton	45,580	4	566,329
Towels	25,891	5	
Shirting	258,737	1	
Dresses	96,686	3	

Suits	139,435	2

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through fourth heald, fifth warp yarn is drawn through first heald up to seventeenth warp yarn is drawn through fifth heald up to twentieth warp yarn is drawn through eighth heald up to thirty-second warp yarn is drawn through eighth heald, etc.

Lifting plan: with a weave repeat of 32, for the first pick, the first, second, third and fifth shafts must be raised, for the second pick, the first, second, fourth and sixth shafts must be lifted, for the third pick, the first, third, fourth and seventh shafts must be lifted, for the fourth pick, the second, third, fourth and eighth shafts must be lifted, for the thirty-second pick, fourth, sixth, seventh and eighth shafts must be lifted, etc.

viii. In 3/1 Twill -- Khaki Drill Cloth design, 4 heald shafts of dobby/tappet shedding mechanism are required. The application area is for Workmen Suiting. The description for the drafting, lifting plan and weave is stated below:

Drafting: a straight draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through fourth heald, fifth warp yarn is drawn through first heald, etc.

Lifting plan: with a weave repeat of 4, for the first pick, the first, second and third shafts must be raised, for the second pick, the second, third and fourth shafts must be lifted, for the third pick, the first, third and fourth shafts must be lifted, for the fourth pick, the first, second and fourth shafts must be lifted, etc.

ix. In 2 up, 1 down Twill check design, 3 heald shafts of dobby/tappet shedding mechanism are required. The application area is for shirting. The description for the drafting, lifting plan and weave is stated below:

Drafting: a straight draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through first heald, fifth warp yarn is drawn through second heald, etc.

Lifting plan: with a weave repeat of 3, for the first pick, the first and second shafts must be raised, for the second pick, the first and third shafts must be lifted, for the third pick, the second and third shafts must be lifted, etc.

x. In Fancy twill weave design, 8 heald shafts of dobby/tappet shedding mechanism are required. The application areas are for shirting& suiting. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn through the second heald, the third warp yarn through the third heald up to,the sixth warp yarn through the sixth heald, the seventh warp yarn through the first heald, eighth warp yarn through second heald, etc.

Lifting plan: with a weave repeat of 8, for the first pick, the third, fifth, sixth and seventh shafts must be lifted, for the second pick, the first, fourth, fifth and sixth shafts must be raised, for the third pick, the second, fourth, fifth and eighth shafts must be lifted, for the fourth pick, the third, fourth, seventh and eighth shafts must be raised, for the fifth pick, the first, sixth, seventh and the eighth shafts must be lifted, for the sixth pick, the first, second, fifth and seventh shafts must be raised, for the seventh pick, the first, second, third and fourth shafts must be lifted, for the eighth pick, the second, third, sixth and eighth shafts must be lifted, etc.

xi. In mock leno weave design, 4 heald shafts of dobby/tappet shedding mechanism are required. The application areas are for curtains and furnishings. The description for the drafting, lifting plan and weave is stated below:

Drafting: the first warp yarn is drawn through first heald, second warp yarn through second heald, third warp yarn through second heald, fourth warp yarn through first heald, fifth warp yarn through third heald, sixth warp yarn through fourth heald, seventh warp yarn through fourth heald, eighth warp yarn through third heald, etc.

Lifting plan: with a weave repeat of 8, for the first pick, the second and third shafts must be lifted, for the second pick, the first and second shafts must be raised, for the third pick, the first and second shafts must be lifted, for the fourth pick, the second and third shafts must be lifted, for the fifth pick, the first and fourth shafts must be lifted, for the sixth pick, the third and fourth shafts must be raised, for the seventh pick, the third and fourth shafts must be lifted, for the eighth pick, the first and fourth shafts must be lifted, etc

xii. In 8 X 12 Huck a Back weave design, 3 heald shafts of tappet shedding mechanism are required. The application area is for towels. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn through the second heald, the third warp yarn through the first heald up to the eighth warp yarn through the third heald, etc.

Lifting plan: with a weave repeat of 12, for the first pick, the first shaft will be raised, for the second pick, the second and third shafts will be lifted, for the third pick, the first and second shafts will be raised, for the fourth pick, the second and third shafts will be raised, for the fifth pick, first and second shafts will be lifted up to the twelfth pick, the second and third shafts will be lifted, etc.

xiii. In crepe weaves design, 5 heald shafts of dobby/tappet shedding mechanism are required. The application area is for towels. The description for the drafting, lifting plan and weave is stated below:

Drafting: here the first warp yarn is drawn through first heald, second warp yarn through second heald, third warp yarn through first heald, fourth warp yarn through third heald, fifth warp yarn through first heald, sixth warp yarn through fourth heald, seventh warp yarn through first heald, eighth warp yarn through fifth heald, etc.

Lifting plan: with a weave repeat of 8, for the first pick, the second, third and fourth shafts must be raised, for the second pick, the first and second shafts must be lifted, for the third pick, the second, fourth and fifth shafts must be lifted, for the fourth picks, the first and fifth shafts must be lifted, for the fifth picks, the second, third and fifth shafts must be lifted, for the sixth picks, the first and third shafts must be raised, for the seventh picks, the third, fourth and fifth shafts must be lifted, for the eighth picks, the first and fourth shafts must be lifted.

xiv. In Colour and weave effect design, 6 heald shafts of dobby/tappet shedding mechanism are required. The application areas are for Bed spreads and pillow covers. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through second heald, fifth warp yarn is drawn through third heald, sixth warp yarn is drawn through fourth heald up to twelfth warp yarn is drawn through sixth heald, etc.

Lifting plan: with a repeat of 12, for the first pick, the second, third and fourth shafts must be raised, for the second pick, the first, third and fourth shafts must be lifted, for the third pick, the second, third and fourth shafts must be lifted, for the fourth pick, the first, third and fourth shafts must be lifted, for the fifth pick, the first, second and sixth shafts must be raised up to for the twelvth pick, the third, fifth and sixth shafts must be lifted, etc.

xv. In Plain, Rib, and Twill combination design, 5 heald shafts of dobby/tappet shedding mechanism are required. The application areas are for shirting and other dress materials. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through first heald, the fourth warp yarn is drawn through first heald, fifth warp yarn is drawn through third heald, sixth warp yarn is drawn through fourth heald, seventh warp yarn is drawn through fifth heald, etc.

Lifting plan: with a repeat of 6, for the first pick, the first, third and fifth shafts must be raised, for the second pick, the second, third and fifth shafts must be lifted, for the third pick, the first, fourth and fifth shafts must be lifted, for the fourth pick, the second, fourth and fifth shafts must be lifted, for the fifth pick, the first, third and fourth shafts must be raised, for the sixth pick, the second, third and fourth shafts must be lifted, etc.

xvi. In Plain, mock-leno and Extra warp design, 6 heald shafts of dobby/tappet shedding mechanism are required. The application areas are for Window curtain. The description for the drafting, lifting plan and weave is stated below:

Drafting: a combined draft is used, the first warp yarn is drawn through first heald, second warp yarn is drawn through second heald, the third warp yarn is drawn through third heald, the fourth warp yarn is drawn through fourth heald, fifth warp yarn is drawn through second heald, sixth warp yarn is drawn through fourth heald, seventh warp yarn is drawn through fifth heald, eleventh warp yarn is drawn through sixth heald, etc.

Lifting plan: with a repeat of 12, for the first pick, the first, fourth and sixth shafts must be raised, for the second pick, the first, second and sixth shafts must be lifted, for the third pick, the first, fourth and sixth shafts must be lifted, for the fourth pick, the first, second and fifth shafts must be lifted, for the fifth pick, the first, fourth and fifth shafts must

be raised, for the sixth pick, the first, second and fifth shafts must be lifted, etc

CONCLUSIONS

From In general, in this research, the current status of locally owned weaving factories has been assessed. For that, loom machinery conditions and their current products have been analyzed. The analysis shows the factories are producing only limited type of products. But while seeing their loom features, i.e., the maximum available harness frames (according to shedding mechanisms) and the number of weft accumulators, there is a room for production of different designs. Based on that around 16 potential designs are developed & suggested. Detail descriptions are discussed with the type of draft, drafting procedures, the peg plan and specific application areas. So, the stated potential designs can be produced in the factories & in the near future importing of those products will not be there and hence foreign currency can be saved.

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Conflict of Interest

The author declares no conflict of interest.