TASHKENT INSTITUTE OF TEXTILE AND LIGHT INDUSTRY

5320900-Design and Technology of Light Industry Products
(Textile Industry)

Bachelor's Degree

DIPLOMA PROJECT

Topic: Projecting Knitting Company specialized on producing 1,5 million outer wears for children

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Tashkent- 2018

TASHKENT INSTITUTE OF TEXTILE AND LIGHT INDUSTRY

«I approve»
Dean _____
"___" _____ 2018

DIPLOMA PROJECT TASK

Department: Technology of Textile Fabrics

Head of Department: Kadirova D.N.
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Adviser: Xanxadjaeva N.R.

Approved date: "30" of December 2017

Student Signature: Tashkent Institute of Textile and Light Industry
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Tasks for the preparation of the Diploma Project

To the student Riskalieva Firuza Murodali qizi

1. Project Topic Projecting Knitting Company specialized on producing 1,5 million outer wears for children

Approved by the order № 405-T of rector of the institute from 2017 year.

2. Term of protection of the final degree project: "12" of June 2018

3. Primary info about the Project: Projecting Knitting Company specialized on producing 1,5 million outer wears for children

4. Names of parts performed in the diploma project:

A) Technological Part

B) Special Part

C) Labor protection and Ecology Part

D) Economic Part

5. The list of mandatory descriptive - geometric materials:

Knit structure, form of producing garment, drafts, project of knitting company calculation tables.

6. Consultants of the parts of the Project Xanxadjaeva N.R., Maxmudov Yu., Davronov O.

7. Given date of the assignment "30" of December 2017

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INTRODUCTION

Actuality of diploma project: Uzbekistan's Textile industry is the most important multi-sectoral, investment and innovation-attractive sector of the economy. It contributes to obtaining effective results from large-scale production of economically viable and environmentally friendly goods, import substitution, and increase the country's export potential. In addition, the light industry plays a significant role in solving state tasks to improve the demographic situation and meets the important interests of many regions, not only in the city-forming but also in remote agricultural or mountainous regions. The industry contributes to the harmonious development of the territories of Uzbekistan, ensuring employment of the population and improving its well-being, helps in the formation and development of small businesses.

Among the tasks defined in the Strategy of Action for the five priority development directions of the Republic of Uzbekistan in 2017-2021, special attention is paid to increasing the country's export potential, increasing volumes and expanding the range of products supplied to international markets with high added value. For this purpose, emphasis will be placed on deep processing of raw materials, which will allow the industry to be brought to a qualitatively new level. [1]

During 2017, 15 projects for the amount of $ 178 million for the production of finished textile and sewing and knitting products are envisaged. It should also be noted the decree of the President of Uzbekistan Shavkat Mirziyoyev on December 21, 2016 "On the Program of Measures for the Further Development of the Textile, Garment and Knitting Industries at 2017-2019 years". In accordance with this important program document, up to 2020 132 investment projects are planned to be implemented, half of which will be financed through foreign investments and credits. The total cost of the project is about $ 2.2 billion. According to the program, 112 modern, high-tech productions will be created, the expansion, modernization and technological re-equipment of 20 productions will continue. All this will increase the export potential of the industry to $ 2.5 billion a year, and create more than 25 thousand jobs. [2]

In parallel with the textile industry, the fashion industry is also developing - it is a young and dynamic industry. Annually such important events as the Tashkent Fashion Week and "Bolajonlar-shirintoylar" - a show of designer children's clothes are organized. The development of children's fashion is important, since clothes from an early age have an impact on the harmonious development of the child. Within the framework of the festival, more than 450 sets of clothes will be presented. 42 collections of 60 designers were admitted to the show, 200 children from 2.5 to 13 years will take part in it.

At the same time, the presence of systemic problems, primarily related to the production of finished textile products, management of the industry, the distribution of resources and production capacities, and low skill levels, leads to low profitability of raw cotton production and processing, inadequate production and export of finished goods products. The Decree “On Measures for the Accelerated Development of the Textile and Sewing and Knitting Industries”, adopted by the President of the Republic of Uzbekistan, determined a set of priority measures to address existing problems, as well as to expand the production of high-quality textile products and its promotion to foreign markets.

This document defines such important areas for further reform of the textile industry as:

– increasing the share of the textile industry in the economy, increasing the volume and quality of the textile products produced in the country;

– Cardinal revision of the textile industry management system;

– further improvement of the system of standardization and certification in the field of the textile industry;

– wide introduction of advanced information and communication technologies into the industry;

– Implementation of a cluster model for the development of the textile industry;

– Ensuring the balance of the distribution of raw materials and the deployment of newly created enterprises in the industry in conjunction with the development of logistics and engineering infrastructure;

– wide introduction in the production process of advanced innovative technologies, know-how, design developments, localization of production of modern samples of accessories and accessories;

– cardinal improvement of the system of training, retraining and advanced training of personnel for the textile industry. [3]

It should be noted that this Decree is the most important step in the practical implementation of the Concept of Administrative Reform in the Republic of Uzbekistan, approved by Presidential Decree No. UP-5185 of September 8, 2017, which provides for further reduction of administrative influence, expansion of market mechanisms for managing sectors of the economy.

In particular, the Decree approved the Roadmap for the Accelerated Development of the Textile and Sewing and Knitting Industries in the Republic of Uzbekistan, which contains more than 20 measures to improve the system of management and training of personnel, modernization of production, technological process and development of textile industry infrastructure, enhancement of foreign economic activity, implementation of international standards in the textile industry.

The main aim of diploma project: Projecting knitting company specialized on producing 1,5 million outer wears for children in a year. It performs to project knitting section which is equipped with high-tech knitting machine, knitted panel inspection and mending section, sewing section and other area of auxiliary premises.

The chief tasks of diploma project:

1. Choice assortments of more demanded product and substantiate them
2. Choice of high-tech equipment and substantiate it.
3. Choice of knitted structure which are justified on foreign countries and our republic.
4. Choice of raw materials which are hygienic proper for producing children's outerwear.
5. Choice sequences of producing assortments and substantiate it.

I. TECHNOLOGICAL PART

I.1 CHOICE ASSORTMENTS OF PRODUCT AND ITS SUBSTANTIATION

In addressing the needs of the population for consumer goods occupy a significant place in the knitting industry enterprises. Prospects of development of knitwear production in comparison with other industries is characterized by the following features:

– a wide range of knitted products, but also the substitutability of their, products made of fabric (for example, stockings, gloves, sports apparel and others). Currently in our country is produced jerseys over 1500 assortments;

– opportunities meet the needs of the population elasticity, breathability, and others;

– ample opportunities during the knitting of knitting, to give the product a desired appearance and necessary properties;

– the possibility of using different textile raw materials: cotton, wool, staple fibers, natural and synthetic fibers, and chemical fibers;

– high level of technological development, compared with other branches of the textile industry;

– the highest level of technical and economic indicators of knitting production, in comparison with the weaving process.

A range of knitted products is quite wide and classified according to fiber composition, structure, finish, and purpose.

Depending on their purpose knit goods are divided into underwear, outerwear, hosiery, gloves, or kerchiefs.

Knitted articles of underwear and outwear are usually sewn from pieces of knitted fabric. Other types of garments are usually finished on the machine. Knitted underwear possesses high hygroscopicity, softness, elasticity and permeability to air and moisture.
It is usually manufactured from cloth made with a cotton-polyester (cotton - Lavsan) yarn, also used are plated fabrics, in which the face is made from silk yarn and the back from cotton. Knitted fabrics for outerwear are usually thicker

than those used for underwear; They hold their shape well and provide excellent warmth. Outerwear is manufacture primarily from cotton and wool yarn and artificial and synthetic fibers, including textured yarn. Knit goods may be manufactured from fibers of single type, from blended yarns obtained from a mixture of different fibers, or from several different yarns. Outerwear depending on finishing process can be as raw (unfinished), bleached, solid-dyed, or variegated. Likewise, other groups of knitwear, outwear can be produced by four differing processes: fully cut, stitch shaped cut, fully fashioned and integral.

The range of outerwear includes jackets, waistcoats, jumpers (pullovers), sweaters, coats, jackets, dresses, suits, skirts, shorts, blouses and overalls. Knitwear for women, men are roughly similar, there are some differences between children apparel and adults apparel.

Assortments of children apparel:

Blanket Sleeper - A full body, footed sleeping garment for a young child which is made of brushed or napped, knit man-made fibers, with a zipper extending from the neckline to one pant leg.

Creeper - An abbreviated, short sleeve babies' garment, with a snap crotch and without leg coverage which is designed for warm weather use and is usually of jersey, ribbed or interlock knit fabric.

Coverall - A full body garment designed to be worn alone. The item has blouse coverage above the waist and pants coverage below the waist. It is interchangeable for tariff purposes with the term "jumpsuit".

Divided Dress- A garment identical to a dress except for a divided skirt, culottes type division. The leg separation is not visible when the item is viewed from the front.

Infants' Set - Two or more different garments, and/or headwear, imported together, in the same sizes, which are intended to be worn together, in sizes newborn to 24 months.

Jomper - A fashion term for a hybrid garment which contains elements of a romper and a jumper. The item resembles a jumper except for a divided skirt, culottes type division below the waist.

Jumper - A sleeveless, dress-like garment, usually with extended or dropped armhole openings, designed to be worn with another upper body garment, such as a blouse or pullover. The garment construction is such that the item is not intended for use alone.

Jumpsuit - A full body garment which can be worn alone. The item has at least limited blouse coverage above the waist and pants coverage below the waist. It is interchangeable for tariff purposes with the term "coverall".

Overall - A garment identical to pants or trousers except for the addition of a significant front bib type rise which extends to the vicinity of the breast and chest sides.

Pinafore - An apron-like “dress” garment with open sides designed for use with other garments such as a shirt, blouse, or dress, and possibly bloomers or a diaper cover. It is usually intended for young girls in sizes newborn to 24 months and toddler sizes 2-4T.

Playsuit - A general term for a one-piece, abbreviated garment, intended to be worn alone as informal attire for casual wear use. The item has shirt type coverage above the waist and shorts type coverage below the waist. Rompers, sunsuits and washsuits are all considered playsuits for tariff purposes.

Popover - A fashion term for a pinafore. It is interchangeable for tariff purposes with term "pinafore".

Romper - An abbreviated one-piece garment designed to be worn alone. The item has shirt or blouse coverage above the waist and shorts coverage below the waist.

Scooter Skirt - A fashion term for a hybrid garment with a shorts type body and an additional fabric flap which is overlaid at the front. The fabric flap extends across the garment front, obscuring the leg separation and creating the visual impression, when viewed from the front, of a skirt.

Shortall - A garment identical to shorts except for the addition of a significant bib type rise which extends to the vicinity of the breast and chest sides.

Skeggings - A fashion term for pants style leggings with a sewn-in skirt or peplum at the waist.

Skirt - A lower body garment, with coverage, normally extending from the waist to the mid-thigh vicinity or below, which envelopes the wearer in an uninterrupted, continuous fabric sheath. Fashion may cause the body coverage of the garment to vary somewhat, however, it always covers the lower torso.

Skirtall - A fashion term for a garment which is identical to a skirt except for the addition of a significant front bib type rise which extends to the vicinity of the breast and chest sides.

Skort - A fashion term for a divided skirt or culotte. A lower body garment, which envelopes the legs in separate fabric sheathes. Imparts the visual impression of a skirt. The leg separation is not visible when the item is viewed from the front.

Sleep and Play - An infants' wear merchandising term, meaning apparel is suitable for use during babies' intermittent sleep and play periods. Such garments are usually made of finely knit jersey or interlock fabric and are not specifically constructed as sleepwear.

Stretchsuit - A full body coverall, usually footed, knit, with long sleeves, for young children, sizes newborn to 24 months.

Washsuit - An abbreviated one-piece garment designed to be worn alone, with limited upper body coverage above the waist and panty or shorts coverage below the waist. It is usually intended for young children in month sizes newborn to 24 months and toddler sizes 2-4T.

A waistcoat often called a vest in American English, and colloquially a weskit is a sleeveless upper-body garment. It is usually worn over a dress shirt and necktie and below a coat.

A cardigan is a usually collarless sweater or jacket that opens the full length of the center front.

It is widely accepted that as children grow subsequently, the demand to knitwear products for children will rise. Because of elasticity, breathability and lightness knitwear goods are satisfactory and suitable product for young generation. Furthermore, knitwear which are fashioned without stitch is the most convenient product for children. Because of its comfort and less expense, nowadays these kind of clothes take a special place in a new step of knitting development.

As the first product of diploma project is chosen children's waistcoat for wearing in the autumn-spring periods of the year (fig.1).

Front side Back side

Fig. 1 Children's waistcoat

As the second product of diploma project is chosen children's cardigan for wearing in the winter and autumn-spring periods of the year (fig.2).

Front side Back side

Fig. 2 Children's cardigan

I.2 CHOICE OF EQUIPMENT AND ITS SUBSTANTIATION

There is a great deal of opportunity to improve the technological process of manufacturing all kind of machines and all kind of knitwear production. Successful work in this direction is primarily creation of new knitting machines and improving the theory of production. When selecting machine there should be paid attention to the machine's productivity and the ability to tissue. In this case, Today, for many customers, the Stoll enterprise is the integrative link between the highly sophisticated technology in the area of developing and manufacturing flat knitting machines on the one hand and an innovative independent thinker and developer in the section of Fashion & Technology on the other hand. Stoll Software Solutions offers innovative software tools for more transparency, efficiency and economical pattern and knitting processes. Pattern programming, connectivity with machines and quick bug fixing are enabled by these software tools. The daily work becomes more comfortable, as well as the operation result of the knitter. With the CMS 502 HP can be simultaneously knitted Fully Fashion pieces. Carriage enable working width of 45"/114 cm, The 2 systems, the gauges E7, 12, 14, 16, 18. If necessary, the machine can be converted to a CMS 502 HP multi gauge or CMS 502 HP knit and wear configuration (fig.3).

Fig.3 STOLL CMS 502 HP

Accessories:

Additional yarn control units (CMS 502 HP+) Separate knot detectors for small and large knots with scale able setting of the desired parameters.

Additional yarn feeders- Machines with one carriage can utilize up to 32 yarn feeders. Also for coarse or abrasive yarns.

ASCON® For measurement of stitch length, controls external influences on yarn consumption.

Auxiliary take-down (for CMS 502 HP+ / CMS 502 HP+ multi gauge) Better wide fixing effect of the knitting piece.

Friction feed wheel Yarn delivery device for reduced, constant yarn tension. Standard equipment for Compact Class, Multi Gauge-Class and Knit&Wear-Class machines.

Plating kit consisting of improved plating yarn feeders and special yarn adapter. Colour and quality plating can be realized in better quality using the plating kit.

Features:

Battery back-up. Correct continuation of the knitting process after power failure.

CMS-needle. Pelerine spring-transfer needle with spring-loaded latch and conical hook. Ensures tight knitting and high running safety. Very low needle consumption.

Display slide with color monitor. Practical and clear: colour display 800x600 pixels and touchscreen. Enables to enter machine commands while maintaining eye contact to the fabric. (not for Economy Line models

Electronic selection system. No moving parts, no wear - that makes the Stoll selection systems maintenance-free and increases running stability. Two selection points for each system in each direction.

Friction feed wheels. These ensure a reduced, constant thread tension. An optimum yarn supply device for a maximum number of threads. (Not for all models standard equipment).

Knitting system control with flexible stitch and PTS Dynamic tension setting with step motors. Extremely quick adjustment of stitch tension with PTS (Power Tension Setting).

Main drive Programmable speed with flexible speed adjustment using starting bar. Variable stroke with Power-RCR system (Rapid Carriage Return). Especially useful at short strokes for narrow garments, binding off and narrowing.

Technical data of STOLL CMS 502 HP

Knitting Unit:	
Carriages | knitting systems	1x2
Drive:	
Max. knitting speed	1.2 m/s
Max. speed by empty rows	1.5 m/s
Needle bed:	
Nominal width | max. working width	45 (114) inches(cm)
Gauges:	E 7 – 18
Yarn guide:	
Yarn control units	14
Yarn carrier rail | yarn carrier	4 | 10
Dimensions | Weights:	
Length:	2370 mm
Width:	909 mm
Height:	2050 mm
Weight:	1028 kg
Power:	
Voltage connection	AC 230V +/-10%
Connection value, depending on operating status	1.7 KW

I.3 CHOICE OF KNITTED STRUCTURE AND ITS SUBSTANTIATION

The projecting models are designed for wearing in the winter and autumn-spring periods of the year. Human body is considered to be a complicated thermodynamic system which maintains thermal equilibrium with the environment by balancing the energy production and dissipation. The energy is produced continuously by metabolic activities and it must be continuously dissipated into the surroundings by dry heat loss (insensible perspiration) or latent heat loss (sensible perspiration), depending on ambient environmental conditions and individual's physical activity. Sensation of warmth-coolness and damp dryness, which depends on air permeability and capability to absorb and evaporate sweat, is primary determinants of thermal comfort. Clothing considered as the second skin should serve both as an effective transporter and barrier of heat to maintain the thermal balance with the surroundings. Therefore, thermal properties, air permeability and water vapor transmission properties of fabrics are very crucial for the human comfort. fiber ratio, yarn spinning method, fabric hairiness, fabric structure especially thickness and porosity. The transient transfer of heat energy depends on contact interface between fabric and skin, which, in turn, depends on many morphological and structural parameters like fiber morphology, yarn and fabric structure. Therefore, these products can be produced by following types of knitted structures – plat, purl, double jersey, plush, rib, also plain and float stitches.

A children's waistcoat is knitted from combination of a double- layer plain structure and a-jour structure. A bottom of the waistcoat consists of rib structure.

A double-layer plain knit - weft-knitted plain-based fabrics that show face stitches on the outside of both layers and reverse stitches on the inside. A double-layer plain knit fabric consists of rounds of tubular courses and is mainly produced on V- bed flat knitting machines, where the diameter of the fabric tube can easily be modified. Instead of knitting plain jersey fabric on both needle beds, a (knit miss) jersey jacquard fabric can be knitted on one needle bed and a 1 x 1 knit-miss jersey fabric on the other, or again, a jersey-based knop fabric on both needle beds.

There are many properties of a double- layer plain jersey fabric: heavy and firm, usually has almost no stretch in either direction, good shape retention and cut edges don't curl. It uses in producing tailored garments, such as jackets, suits or sheath dresses.

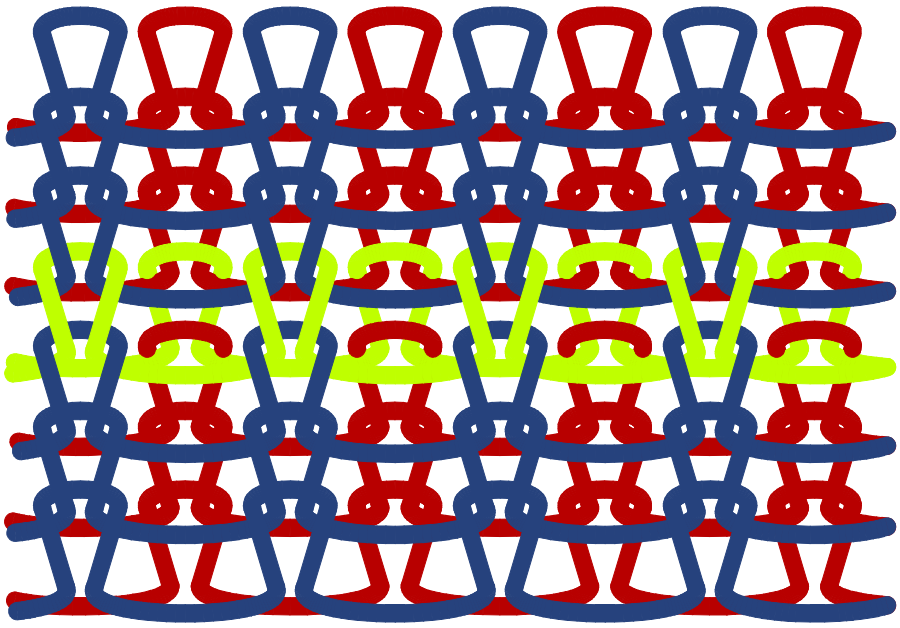

Fig. 4 Double-layer plain structure

RIB knit is a type of knit fabric created using two needles that has vertical textured lines. The vertical ribs are created with a certain number of knit stitches (more prominent) and a certain number of purl stitches (the groove between the ribs), repeated multiple times along the width of the fabric (which is usually made and sold in circular pieces, without any selvedge).

Depending on how many knits and purls, you can have different rib knit fabrics. A 2×2 rib knit will have a sequence of two knits and two purls.

Characteristics of rib knit:

1. It has a lot of crosswise stretch, even without any spandex content.
2. It usually recovers pretty well after being stretched.
3. Right and wrong sides are similar, but different: You can use either of the two as the right side, but choose one and stick with it.
4. It's stiffer than jersey and less smooth
5. When pulled, its edges don't curl like a jersey.
6. It perfectly hugs the body, highlighting shapes and curves.

This is the perfect type of knit fabric to be used for neckbands, collars, turtlenecks, cuffs, waistbands, wristbands. It's also great for any time you need a knit fabric that really highlights your shape.

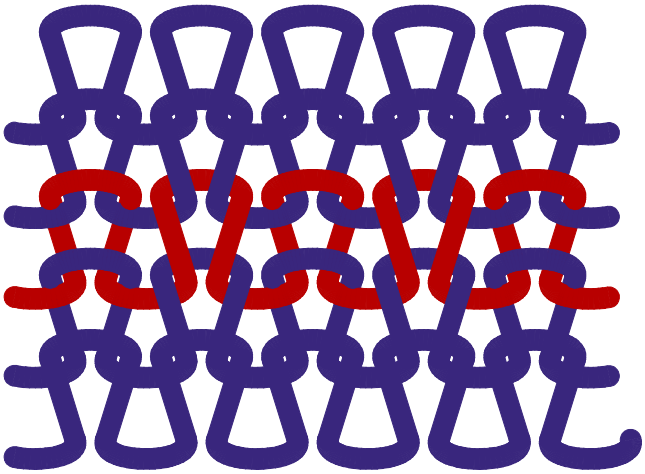

Fig. 5 Rib structure

A- jour stitch produces by transferring loops.

There are four main types of transfer stitches;

1. Plain needle loop transfers stitches, produced by transference of a loop from one needle to another in the same bed.
2. Fancy lacing stitches, produced by modification of the plain loop stitch.
3. Rib loop transfer stitches, produced by transferring a loop from one needle bed to the other.
4. Sinker loop transfer stitches.

Needle loop transfer on plain fabric is most commonly achieved on straight bar frames using specially-shaped, rack ably-controlled transfer points. In designs it is termed a lace stitch whereas in selvedge shaping it is termed fashioning. When crossing over transfer stitches or narrowing, it is possible to transfer a loop to the next-but-one adjacent needle. The method can be mechanically complex and slow. Only a few straight-bar rib frames were ever built. Although there are some electronic V-bed flat machines that have beds of loop transfer points, most use rib loop transfer needles and needle bed racking to achieve that purpose. The method can be mechanically complex and slow. In rib transfer method, at the first course, needles are knitting only in one bed. At the second course, an empty needle in the

opposite bed commences knitting, producing 1 x 1 rib, and at the third course, this needle transfers its loop to a needle knitting in the opposite bed. The rib loop transfer stitch is a very popular stitch. Modern automatic V-bed flat machines have special loop transfer needles, and individual needle selection and camming facilities for rib loop transfer from either bed, in addition to selection facilities for knit, tuck and miss.

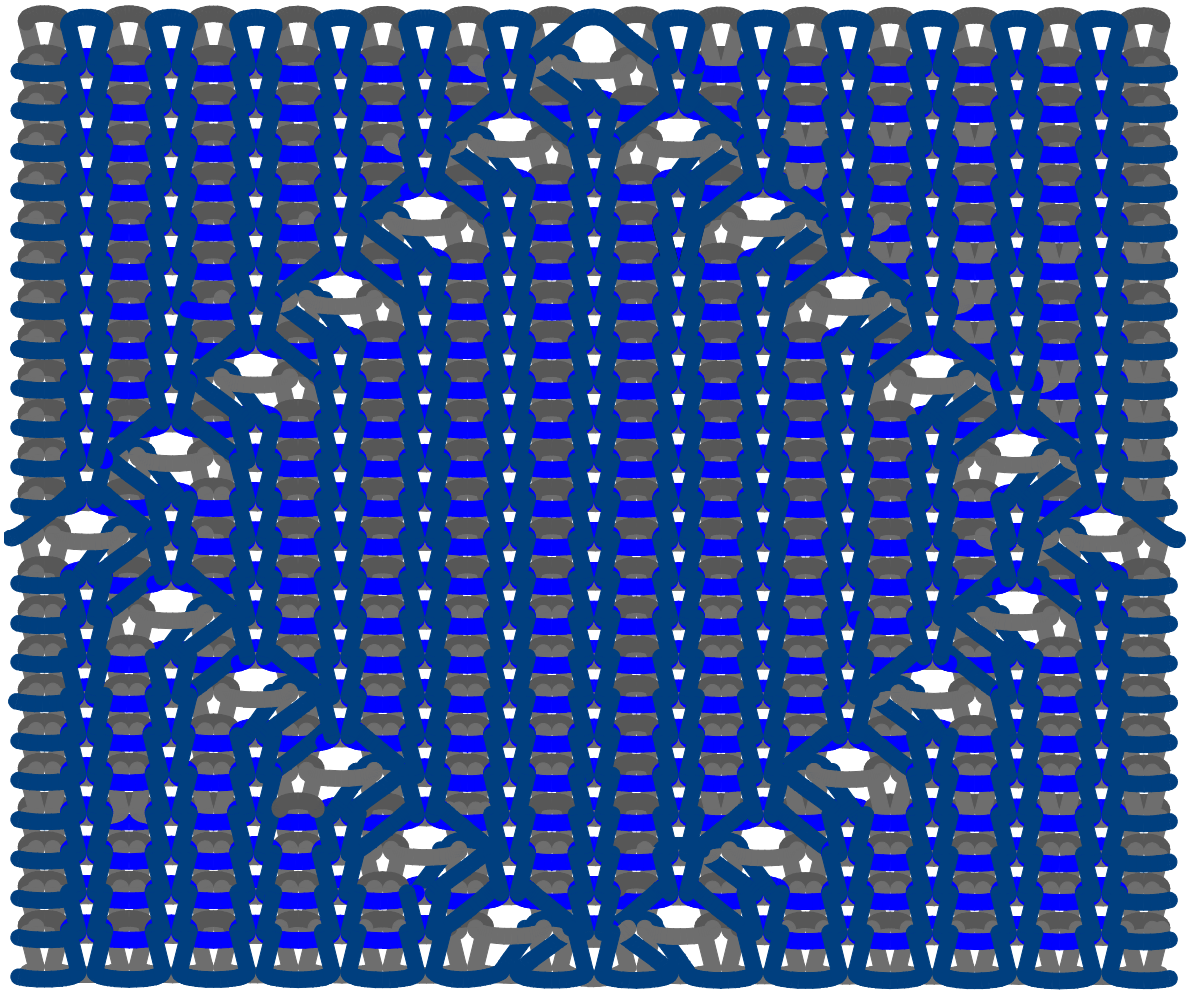

Fig. 6 A-jour structure

A children's cardigan is knitted from combination of a full and half jacquard structure, rib 1x1 structure. A bottom of the cardigan consists of rib 2x2 structure.

Apart from the woven fabric made with the help of jacquard loom, **jacquard knit** fabrics are also made, and jacquard fabric also refers to a rib-based, double jersey weft-knit fabric on which a figure or design appears in a different colour or texture. Jacquard fabrics are further sub-divided into flat-jacquard and blister fabrics. The flat jacquard patterns have equal number of loops in each wale of the

pattern knitting. It is not so with blister fabrics. A knitted Jacquard fabric is one produced on a rib or purl machine in which the coloured pattern has been produced by knitting and welting (miss-knitting) selected needles. While perforated cards and pattern wheels are other mechanical devices have been used to control needle actions, modern machines are invariably computer controlled. Jacquard knitting is recognisable by its reversibility because the fabric is truly double-sided and the back side does not show floats as expected compared to stranded knitting. A true double-sided jacquard knit will have pattern on both sides and will be double thick and jacquard knitting technique will have a dotted effect on the back side. The floats created by the colour switches will be confined to the inside of the fabric. The jacquard knitting involves more colours than other styles.

I.4 CHOICE OF RAW MATERIAL AND ITS SUBSTANTIATION

Jerseys, interlocks and rib knit fabrics can be made of natural fibers like cotton, wool, hemp, silk, bamboo or linen (just to name a few), or man-made fibers like rayon, modal, acetate, polyester, nylon or acrylic. A variety of natural and synthetic fibers is finding application in double-layered fabrics, active wear, innerwear and sportswear owing to unique characteristics and features of each fiber. While natural fibers are considered suitable for low activity levels, synthetic fibers are better suited for high activity levels. However, no single fiber or different fiber blends can ensure ideal clothing suitable for varied applications. Several researches have been directed towards the effect of fiber type, yarn variables such as yarn count, yarn twist and fabric structure on comfort properties of knitted fabrics. It has been reported that fiber type and fabric structure play a crucial role in determining the comfort properties of textile fabrics. The right type of fiber needs to be in the right place according to the fabric end use.

In this case, for projecting children's outerwear is chosen acrylic fiber.

Acrylic fiber is an artificial fiber that closely resembles wool in its character. According to the definition of the ISO (International Standards Organization) and BISFA (International Synthetic Fiber Standardization Office), fibers which contain a minimum of 85% acrylonitrile in their chemical structure are called "Acrylic Fibers". Acrylic fiber is composed of acrylonitrile and a monomer. The monomer is added to improve dye ability and the textile process ability of the acrylic fiber. Acrylic fiber is produced with two different systems: wet spinning and dry spinning. Acrylic fiber can be supplied as producer-dyed either by pigmentation of the dope or with jet dyeing systems. It can be used 100% alone, or in blends with other natural and synthetic fibers. **Properties of Acrylic Fiber:**

1. Easy to wash and good dimensional stability.
2. Resistance to damage by moths and chemical substances.
3. Excellent color-fastness and dye ability in brilliant colors.
4. Highly resistant to sunlight.
5. Lightweight, soft, and warm, with a wool-like touch.

I.5 CHOICE SEQUENCES OF PRODUCING ASSORTMENT AND ITS SUBSTANTIATION

Technological process - a series of interrelated, mutually beneficial operations that take place in a certain sequence, with the processing of raw materials into finished products. It is possible to have four knitted garments which look superficially similar but have been produced by four differing processes.

1. Fully cut
2. Stitch shaped cut;
3. Fully fashioned;
4. Integral.

Fully cut method - all required garment pieces are cut from the fabrics and sewn together to complete the garment.

Advantages:

- Higher production rate
- Fabric are on low cost than other methods
- Ease speed knitting of fabric

Disadvantages:

- Labor intensive
- Higher fabric waste
- Longer lead time
- Not widely used for wool

Applications: T-shirt, vest, underwear and etc.

Stitch shape cut method - Components of garments are knitted individually as rectangle poses according to size and cutting or trimming for side shaping, neck holes and arm holes.

Advantages: less labor intensive

Disadvantages:

- Higher fabric waste
- currently this method is not using

Applications: T-shirt, vest and etc.

Fully fashion method - portions of a garment are shaped at the selvedges by progressively increasing or decreasing the number of loops in the width of the fabric. Such narrowing and widening produces the shape of a piece of garment that would otherwise be generated by cutting.

Advantages:

- Little or no cutting wastage
- The edges of the garment pieces are sealed and not liable to fraying, so can be joined by simple non-bulky seams.
- Production is effective

Disadvantages: Low volume of production (Because time consuming wastage of time by increasing one decreasing of needle)

Applications: Sweater, cardigan, tights, stocking lingerie.

Integral method - Garments are produce as one piece. Sometimes end and the beginning of the garments must be joined together.

Advantages:

- Labor cost is low
- Low wastage
- Faster time to market by eliminating the need for sewing any components

Disadvantages: Different items in shape and size cannot make.

Applications: Socks, hose, gloves, woolen cap, pantyhose.

For producing children's outerwear from acrylic yarn was chosen fully fashioning method.

Fully fashioning is a method of shaping knitted structure by increasing or decreasing the numbers of wales or needles. Fully fashioned knitwear is manufactured through knitting the whole structure.

Warehouse of raw materials (warehouse arrangement) is a store room in knitting factory, where different types of yarns are kept. Yarn is the main raw material of sweater manufacturing. Yarn are thread which is manufactured from fiber. Based on different types of fiber, yarns used in sweater production which can be of different types such as: Pure acrylic, cotton, wool etc.

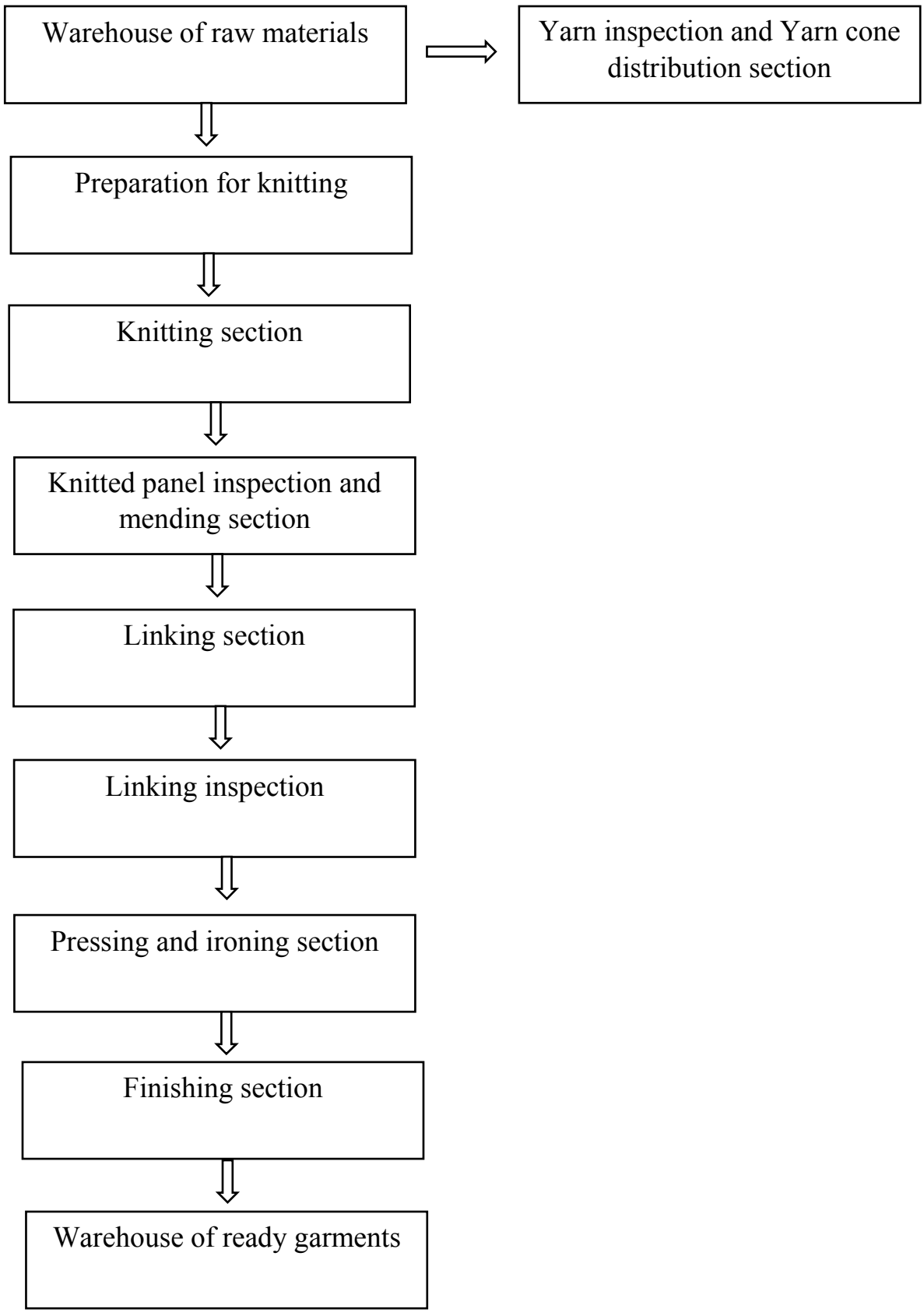

Fig.7 Sequences of producing children's outerwear

Yarn cone distribution section: after checking quality of yarns and sorting the defects distributor distributes yarn cone to knitting operator as per requirement. Normally the distributor is used that quantity of yarn to knit one dozens of waistcoat to one knit operator.

Knitting section: There are different types of technique to knit a waistcoat. Knitting operators knit the waistcoat according to design chart which is developed by designer/ a designer can make the design or developing by the design chart given by the buyer.

Knitted panel inspection: this is the process to check the different knitted panel. After knitting the different pieces of sweater, the knitting inspectors check the quality of knitted fabric on the basis of some criteria. These are- checking panel measurement, test the knitting tension, identification of knitting mistakes, style check, design check, spot check, foreign yarn mistake check etc.

In mending process: different operators for mending or repairing the defective sweater. This is manual process which is done by using needles and yarns.

Linking section: the working procedure of this section is to link the different panels to produce a complete sweater. In this section linking operator links the different panels by using linking machine or sewing them.

Linking inspection section: after linking the body parts, it will be inspected by the quality control team in the inspection section.

Pressing and ironing section: the objective of sweater ironing is to give permanent shape of the garments and to improve aesthetic value of the garments. It requires heavy stress for sweater pressing.

Finishing section: at this stage labeling, price tag attaching, folding, primary packaging, secondary packaging, final packaging, metal detecting and final inspection are done as per buyer requirement.

Finally, goods are ready for export and they will be forwarded to **warehouse of ready garments**. They will be kept there in fixed climate condition: in temperature 22° C and in humidity 65-67%.

I.6 CALCULATION OF TECHNOLOGICAL PARAMETERS

The main characteristics of the knitted fabric include the following technological parameters:

1. Yarn count or linear density of yarn
2. Width of loop A
3. Height of loop B
4. Density of loops on horizontal (Courses per cm)
5. Density of loops on vertical (Wales per cm)
6. Length of loop
7. Surface density (GSM- Gram per square meter)

Yarn count is the numerical expression which indicates or expressed the fineness or coarseness of yarn.

Stitch length/ length of loop is the length of yarn in a knitted loop. Stitch length is theoretically a single length of yarn which includes one needle loop half the length of yarn (half of a sinker loop) between that needle loop and the adjacent needle loops on either side of it. Loop length will affect the following parameters:

- Tightness factor;
- Fabric weight;
- Fabric width;
- Dimensional stability

Stitch density refers to the total number of loops in a measured area of fabric and not to the length of yarn in a loop (stitch length). Stitch density is the product of the courses and wales per unit length and is measured in units per square per centimeter. Stitch density = Courses per cm x Wales per cm

Surface density (GSM- Gram per square meter) means 'Gram per square meter' that is the weight of fabric in gram per one square meter. By this we can compare the fabrics in unit area which is heavier and which is lighter. The GSM of fabric is one kind of specification of fabric which is very important for a textile engineer for understanding and production of fabric.

The technological parameters of projecting products will be calculated by professor Dalidovich's method. Linear density of acrylic yarn T=31 tex×2 (№32/2), coefficient, depending on sort of yarn $\lambda = 1.6$

1. Calculation of technological parameters double-layer plain (tubular) structure:

Density of yarn: $$F = \frac{\lambda}{\sqrt{\frac{1000}{T}}} = \frac{\lambda}{\sqrt{N}} = \frac{1.6}{\sqrt{16}} = 0.4\ mm$$

Width of loop: $$A_{d-plian} = 5F = 5 * 0.4 = 2\ mm$$

Height of loop: $$B_{d-plain} = 0.865A = 0.865 * 2 = 1.7\ mm$$

Density of loops on horizontal: $$P_g = \frac{50}{A_{d-plian}} = \frac{50}{2} = 25\ loops$$

Density of loops on vertical: $$P_v = \frac{50}{B_{d-plian}} = \frac{50}{1.7} = 29\ loops$$

Length of loop: $$l_{d-plain} = \frac{78.5}{P_g} + \frac{100}{P_v} + \pi F = \frac{78.5}{25} + \frac{100}{29} + 3.14 * 0.4 = 7.8\ mm$$

The reduced length of loop $\mathbf{l_{reduced}}$, that is length of yarn consumed on each loops of facial side, taking into account the consumption of the yarn on the loops of back side. $l_{d-plain.reduced} = 2 * l_{d-plain} = 2 * 7.8 = 15.6\ mm$

2. Calculation of technological parameters rib 1x1 structure:

Density of yarn: $$F = \frac{\lambda}{\sqrt{\frac{1000}{T}}} = \frac{\lambda}{\sqrt{N}} = \frac{1.6}{\sqrt{16}} = 0.4\ mm$$

Width of loop: $$A_{rib1x1} = 4F = 4 * 0.4 = 1.6\ mm$$

Height of loop: $$B_{rib1x1} = 0.865A = 0.865 * 1.6 = 1.4\ mm$$

Density of loops on horizontal: $$P_g = \frac{50}{A_{rib1x1}} = \frac{50}{1.6} = 31\ loops$$

Density of loops on vertical: $$P_v = \frac{50}{B_{rib1x1}} = \frac{50}{1.4} = 36\ loops$$

Length of loop: $$l_{rib1x1} = \frac{78.5}{P_g} + \frac{100}{P_v} + \pi F = \frac{78.5}{31} + \frac{100}{36} + 3.14 * 0.4 = 6.6\ mm$$

The reduced length of loop: $$l_{rib1x1.reduced} = 2 * l_{rib1x1} = 2 * 6.6 = 13.2\ mm$$

Since the a-jour almost does not change the structure of the loops except for their slope, the calculation of parameters of a-jour does not differ from the calculation of the base knit structure's parameter. So,

$B_{d-plain} = B_{a-jour} = 1{,}7\ mm$ $l_{d-plain} = l_{a-jour} = 7.8\ mm$ and $l_{d-plain.reduced} = l_{a-jour.reduced} = 15.6mm$

3. Calculation of technological parameters rib 2x2 structure:

Density of yarn: $F = \frac{\lambda}{\sqrt{\frac{1000}{T}}} = \frac{\lambda}{\sqrt{N}} = \frac{1.6}{\sqrt{16}} = 0.4\ mm$

Width of loop: $A_{rib2x2} = 4F = 4 * 0.4 = 1.6\ mm$

Conditional density of loops on horizontal: $P_g = \frac{50}{A_{rib2x2}} = \frac{50}{1.6} = 31\ loops$

Density of loops on vertical: c=0.7 ÷ 0.865 $P_v = \frac{P_g}{c} = \frac{31}{0.865} = 36\ loops$

Height of loop: $B = \frac{50}{P_v} = \frac{50}{36} = 1.4\ mm$

Length of loop: $l_{rib2x2} = \frac{78.5}{P_g} + \frac{100}{P_v} + \pi F = \frac{78.5}{31} + \frac{100}{36} + 3.14 * 0.4 = 6.6\ mm$

The reduced length of loop: $l_{rib2x2.reduced} = 2 * l_{rib2x2} = 2 * 6.6 = 13.2\ mm$

4. Calculation of technological parameters double-full two-colour flat jacquard structure:

Density of yarn: $F = \frac{\lambda}{\sqrt{\frac{1000}{T}}} = \frac{\lambda}{\sqrt{N}} = \frac{1.6}{\sqrt{16}} = 0.4\ mm$

Height of loop:

B_b = height of loop on the back side $B_b = 2.5\ F = 2.5 * 0.4 = 1\ mm$

B_f = height of loop on facial side $B_f = 5\ F = 5 * 0.4 = 2\ mm$

Width of loop: $A_{2c.jacq.} = 5F = 5 * 0.4 = 2\ mm$

Density of loops on horizontal: $P_g = \frac{50}{A_{2c.jacq.}} = \frac{50}{2} = 25\ loops$

Density of loops on vertical:

On the facial side: $P_{v.f.} = \frac{50}{B_f} = \frac{50}{2} = 25\ loops$

On the back side: $P_{v.b.} = \frac{50}{B_b} = \frac{50}{1} = 50\ loops$

Length of loop:

On the facial side:

$l_{2c.jacq.f} = 1.57\ A + 2B_f + 3.14F = 1.57 * 2 + 2 * 2 + 3.14 * 0.4 = 8.4\ mm$

On the back side:

$$l_{2c.jacq.b} = 1.57\,A + 2B_b + 3.14F = 1.57 * 2 + 2 * 1 + 3.14 * 0.4 = 6.4\,mm$$

The reduced length of loop:

$$l_{2c.jacq.} = l_{2c.jacq.f} + 2l_{2c.jacq.b} = 8.4 + 2 * 6.4 = 21.2\ mm$$

5. Calculation of technological parameters double-half three-colour flat jacquard structure:

Density of yarn: $$F = \frac{\lambda}{\sqrt{\frac{1000}{T}}} = \frac{\lambda}{\sqrt{N}} = \frac{1.6}{\sqrt{16}} = 0.4\ mm$$

Height of loop:

B_b = height of loop on the back side $B_b = 3F = 3 * 0.4 = 1.2\ mm$

B_f = height of loop on facial side $B_f = 1.5B_b = 1.5 * 1.2 = 1.8\ mm$

Width of loop: $A_{3c.jacq.} = 4.4F = 4.4 * 0.4 = 1.76\ mm$

Density of loops on horizontal: $$P_g = \frac{50}{A_{3c.jacq.}} = \frac{50}{1.76} = 28\ loops$$

Density of loops on vertical:

On the facial side: $$P_{v.f.} = \frac{50}{B_f} = \frac{50}{1.8} = 28\ loops$$

On the back side: $$P_{v.b.} = \frac{50}{B_b} = \frac{50}{1.2} = 42\ loops$$

Length of loop:

On the facial side:

$$l_{3c.jacq.f} = 1.57\,A + 2B_f + 3.14F = 1.57 * 1.76 + 2 * 1.8 + 3.14 * 0.4 = 7.7\ mm$$

On the back side:

$$l_{3c.jacq.b} = 2.32A + 2B_b + 3.14F = 2.32 * 1.76 + 2 * 1.2 + 3.14 * 0.4 = 7.7\ mm$$

The reduced length of loop:

$$l_{3c.jacq.} = l_{3c.jacq.f} + 1.5l_{3c.jacq.b} = 7.7 + 1.5 * 7.7 = 19.3\ mm$$

I.7 CALCULATION OF RAW MATERIAL CONSUMPTION PER UNIT PRODUCT

The following indicators are most important for calculation of raw material consumption per unit product: number of needles, number of course, number of stitches, yarn length, weight per unit area

The first assortment - children's waistcoat is knitted from combination of a double- layer plain structure and a-jour structure by fully fashion method. A bottom of the waistcoat consists of rib 1x1 structure.

Calculation back and front side of waistcoat

Parameters of knit structures used for knitting children's waistcoat:

Rib 1x1 structure: yarn № 32/2, A=2 mm, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

Double- layer plain structure: yarn № 32/2, B=1.7 mm, l=7.8 mm, $l_{reduced}$ =15.6 mm

A-jour structure: yarn № 32/2, B=1.7 mm, l=7.8 mm, $l_{reduced}$ =15.6 mm

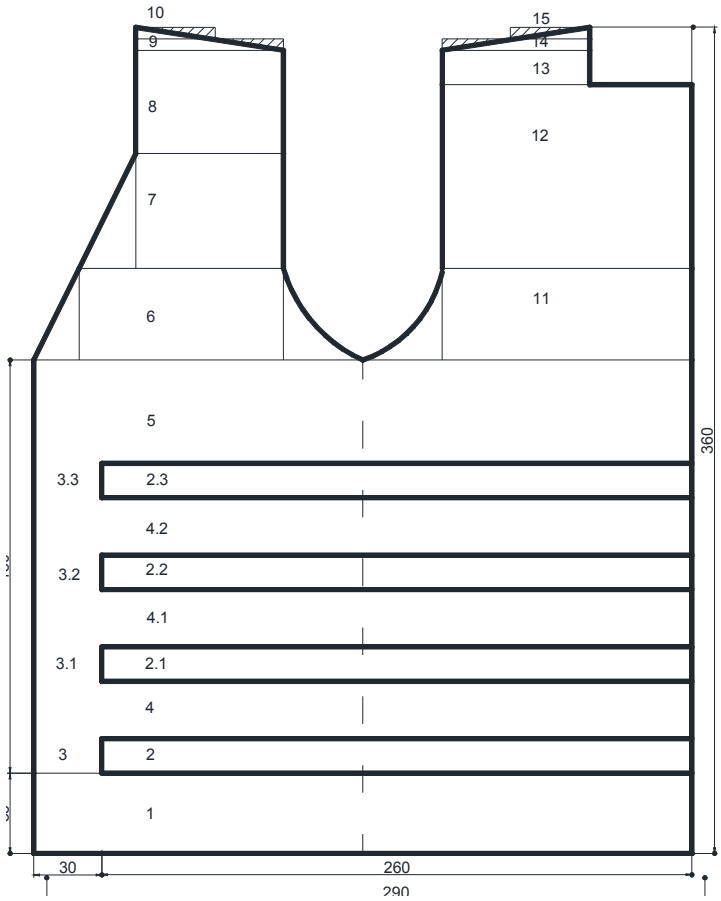

Fig. 8 Front and back side of children's waistcoat

1. Calculation number of needles:

$$I_1 = \frac{SH_1}{A} = \frac{290}{1.6} = 182\ needles \qquad I_1 = 364\ needles$$

$$I_2 = \frac{SH_2}{A} = \frac{260}{1.6} = 163\ needles \qquad I_1 = 326\ needles$$

$$I_3 = \frac{SH_3}{A} = \frac{30}{1.6} = 19\ needles \qquad I_1 = 38\ needles$$

$$I_4 = \frac{SH_4}{A} = \frac{290}{1.6} = 182\ needles \qquad I_4 = 364\ needles$$

$$I_2 = I_{2.1} = I_{2.2} = I_{2.3} = 326\ needles$$

$$I_3 = I_{3.1} = I_{3.2} = I_{3.3} = 38\ needles$$

$$I_4 = I_{4.1} = I_{4.2} = 364\ needles$$

$$I_5 = \frac{SH_5}{A} = \frac{290}{1.6} = 182\ needles \qquad I_5 = 364\ needles$$

$$I_6 = \frac{SH_6}{A} = \frac{130}{1.6} = 82\ needles \qquad I_6 = 164\ needles$$

On section-6 to form necklines and arm-holes number of needles reduced to 52 by one needle through each 2 course of front side of waistcoat. So, for two front sides of waistcoat needle reduces on each course by 4 needles.

$$I_7 = \frac{SH_7}{A} = \frac{90}{1.6} = 56\ needles \qquad I_7 = 112\ needles$$

On section-7 to form necklines number of needles reduced to 30 by one needle through each 2 course of front side of waistcoat. So, for two front sides of waistcoat needle reduces on each course by 2 needles.

$$I_8 = \frac{SH_8}{A} = \frac{65}{1.6} = 41\ needles \qquad I_8 = 82\ needles$$

$$I_9 = \frac{SH_9}{A} = \frac{65}{1.6} = 41\ needles \qquad I_9 = 82\ needles$$

$$I_{10} = \frac{SH_{10}}{A} = \frac{35}{1.6} = 22\ needles \qquad I_{10} = 44\ needles$$

$$I_{11} = \frac{SH_{11}}{A} = \frac{130}{1.6} = 82\ needles \qquad I_{11} = 164\ needles$$

On section-11 to form necklines number of needles reduced to 26 by one needle on through each 2 course of back side of waistcoat. So, for two back sides of waistcoat needle reduces on each course by 2 needles.

Between front side and back side 18 needles turned off to form necklines and armhole on each symmetric side.

$$I_{12} = \frac{SH_{12}}{A} = \frac{110}{1.6} = 69\ needles \qquad I_{12} = 138\ needles$$

$$I_{13} = \frac{SH_{13}}{A} = \frac{65}{1.6} = 41\ needles \qquad I_{13} = 82\ needles$$

$$I_{14} = \frac{SH_{14}}{A} = \frac{65}{1.6} = 41\ needles \qquad I_{14} = 82\ needles$$

$$I_{15} = \frac{SH_{15}}{A} = \frac{35}{1.6} = 22\ needles \qquad I_{15} = 44\ needles$$

2. Calculation number of courses:

$$P_1 = \frac{D_1}{B_{rib1x1}} = \frac{35}{1.4} = 26\ courses \qquad P_7 = \frac{D_7}{B_{a-jour}} = \frac{50}{1.7} = 30\ courses$$

$$P_2 = \frac{D_2}{B_{rib1x1}} = \frac{15}{1.4} = 10\ course \qquad P_8 = \frac{D_8}{B_{a-jour}} = \frac{45}{1.7} = 26\ courses$$

$$P_3 = \frac{D_3}{B_{d-plain}} = \frac{15}{1.7} = 8\ courses \qquad P_9 = \frac{D_9}{B_{a-jour}} = \frac{5}{1.7} = 2\ courses$$

$$P_4 = \frac{D_4}{B_{d-plain}} = \frac{25}{1.7} = 18\ courses \qquad P_{10} = \frac{D_{10}}{B_{a-jour}} = \frac{5}{1.7} = 2\ courses$$

$$P_2 = P_{2.1} = P_{2.2} = P_{2.3} = 10\ courses \qquad P_{11} = \frac{D_{11}}{B_{a-jour}} = \frac{40}{1.7} = 24\ courses$$

$$P_3 = P_{3.1} = P_{3.2} = P_{3.3} = 8\ courses \qquad P_{12} = \frac{D_{12}}{B_{a-jour}} = \frac{80}{1.7} = 48\ courses$$

$$P_4 = P_{4.1} = P_{4.2} = 18\ courses \qquad P_{13} = \frac{D_{13}}{B_{a-jour}} = \frac{15}{1.7} = 8\ courses$$

$$P_5 = \frac{D_5}{B_{a-jour}} = \frac{45}{1.7} = 26\ courses \qquad P_{14} = \frac{D_{14}}{B_{a-jour}} = \frac{5}{1.7} = 2\ courses$$

$$P_6 = \frac{D_6}{B_{a-jour}} = \frac{40}{1.7} = 24\ courses \qquad P_{15} = \frac{D_{15}}{B_{a-jour}} = \frac{5}{1.7} = 2\ courses$$

3. Calculation number of stitches (in thousands):

$$m_1 = \frac{I_1 * P_1}{1000} = \frac{182x2 * 26}{1000} = 9.5\ loops$$

$$m_2 = \frac{I_2 * P_2}{1000} = \frac{163x2 * 10}{1000} = 3.3\ loops$$

$$m_3 = \frac{I_3 * P_3}{1000} = \frac{19x2 * 8}{1000} = 0.3\ loops$$

$$m_4 = \frac{I_4 * P_4}{1000} = \frac{182x2 * 18}{1000} = 6.6\ loops$$

$$m_2 = m_{2.1} = m_{2.2} = m_{2.3} = 3.3\ loops$$

$$m_3 = m_{3.1} = m_{3.2} = m_{3.3} = 0.3\ loops$$

$$m_4 = m_{4.1} = m_{4.2} = 6.6\ loops$$

$$m_5 = \frac{I_5 * P_4}{1000} = \frac{182x2 * 26}{1000} = 9.5\ loops$$

$$m_6 = \frac{(I_7 + 52) * P_6}{1000} = \frac{(56x2 + 52) * 24}{1000} = 3.9\ loops$$

$$m_7 = \frac{(I_8 + 30) * P_7}{1000} = \frac{(41x2 + 30) * 30}{1000} = 3.4\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{41x2 * 26}{1000} = 2.1\ loops$$

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{41x2 * 2}{1000} = 0.2\ loops$$

$$m_{10} = \frac{I_{10} * P_{10}}{1000} = \frac{22x2 * 2}{1000} = 0.1\ loops$$

$$m_{11} = \frac{(I_{12} + 26) * P_{11}}{1000} = \frac{(69x2 + 26) * 24}{1000} = 3.9\ loops$$

$$m_{12} = \frac{I_{12} * P_{12}}{1000} = \frac{69x2 * 48}{1000} = 6.6\ loops$$

$$m_{13} = \frac{I_{13} * P_{13}}{1000} = \frac{41x2 * 8}{1000} = 0.7\ loops$$

$$m_{14} = \frac{I_{14} * P_{14}}{1000} = \frac{41x2 * 2}{1000} = 0.2\ loops$$

$$m_{15} = \frac{I_{15} * P_{15}}{1000} = \frac{22x2 * 2}{1000} = 0.1\ loops$$

4. Calculation yarn length (m):

$l_{rib1x1.red} = 13.2\ mm \quad l_{d-plain.red} = 15.6\ mm \quad l_{a-jour\ red} = 15.6\ mm$

$L_1 = l_{rib\ 1x1\ red.} * m_1 = 13.2 * 9.5 = 125\ m$

$L_2 = l_{rib\ 1x1\ red.} * m_2 = 13.2 * 3.3 = 44\ m$

$L_3 = l_{d-plain\ red.} * m_3 = 15.6 * 0.3 = 5\ m$

$L_4 = l_{d-plain\ red.} * m_4 = 15.6 * 6.6 = 103\ m$

$L_2 = L_{2.1} = L_{2.2} = L_{2.3} = 44\ m$

$L_3 = L_{3.1} = L_{3.2} = L_{3.3} = 5\ m$

$L_4 = L_{4.1} = L_{4.2} = 103\ m$

$L_5 = l_{a-jour\ red.} * m_5 = 15.6 * 9.5 = 148\ m$

$L_6 = l_{a-jour\ red.} * m_6 = 15.6 * 3.9 = 61\ m$

$L_7 = l_{a-jour\ red.} * m_7 = 15.6 * 3.4 = 53\ m$

$L_8 = l_{a-jour\ red.} * m_8 = 15.6 * 2.1 = 33\ m$

$L_9 = l_{a-jour\ red.} * m_9 = 15.6 * 0.2 = 3\ m$

$L_{10} = l_{a-jour\ red.} * m_{10} = 15.6 * 0.1 = 2\ m$

$L_{11} = l_{a-jour\ red.} * m_{11} = 15.6 * 3.9 = 61\ m$

$L_{12} = l_{a-jour\ red.} * m_{12} = 15.6 * 6.6 = 103\ m$

$L_{13} = l_{a-jour\ red.} * m_{13} = 15.6 * 0.7 = 11\ m$

$L_{14} = l_{a-jour\ red.} * m_{14} = 15.6 * 0.2 = 3\ m$

$L_{15} = l_{a-jour\ red.} * m_{15} = 15.6 * 0.1 = 2\ m$

5. Calculation of weight per unit area (gr.):

$Q_1 = \frac{L_1}{N} = \frac{125}{16} = 7.8\ gr$

$Q_2 = \frac{L_2}{N} = \frac{44}{16} = 2.8\ gr$

$Q_3 = \frac{L_3}{N} = \frac{5}{16} = 0.3\ gr$

$Q_4 = \frac{L_4}{N} = \frac{103}{16} = 6.4\ gr$

$Q_7 = \frac{L_7}{N} = \frac{53}{16} = 3.3\ gr$

$Q_8 = \frac{L_8}{N} = \frac{33}{16} = 2.1\ gr$

$Q_9 = \frac{L_9}{N} = \frac{3}{16} = 0.2\ gr$

$Q_{10} = \frac{L_{10}}{N} = \frac{2}{16} = 0.1\ gr$

$$Q_2 = Q_{2.1} = Q_{2.2} = Q_{2.3} = 2.8\,gr \qquad Q_{11} = \frac{L_{11}}{N} = \frac{61}{16} = 3.8\,gr$$

$$Q_3 = Q_{3.1} = Q_{3.2} = Q_{3.3} = 0.3\,gr \qquad Q_{12} = \frac{L_{12}}{N} = \frac{103}{16} = 6.4\,gr$$

$$Q_4 = Q_{4.1} = Q_{4.2} = 6.4\,gr \qquad Q_{13} = \frac{L_{13}}{N} = \frac{11}{16} = 0.7\,gr$$

$$Q_5 = \frac{L_5}{N} = \frac{148}{16} = 9.3\,gr \qquad Q_{14} = \frac{L_{14}}{N} = \frac{3}{16} = 0.2\,gr$$

$$Q_6 = \frac{L_6}{N} = \frac{61}{16} = 3.8\,gr \qquad Q_{15} = \frac{L_{15}}{N} = \frac{2}{16} = 0.1\,gr$$

$$\Sigma Q = Q_1 + Q_2 + \ldots\ldots\ldots + Q_{14} + Q_{15} = 69.4\,gr$$

6. Calculation of additional needles:

$$I_9 = I_9 - I_{10} = (41 - 22)x2 = 19 * 2 = 38\,needles$$

$$I_{10} = 22x2 = 44\,needles$$

$$I_{14} = I_{14} - I_{15} = (41 - 22)x2 = 19 * 2 = 38\,needles$$

$$I_{15} = 22x2 = 44\,needles$$

7. Calculation of additional stitches (in thousands):

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{38 * 2}{1000} = 0.08\,loops$$

$$m_{10} = \frac{I_{10} * P_{10}}{1000} = \frac{44 * 2}{1000} = 0.09\,loops$$

$$m_{14} = \frac{I_{14} * P_{14}}{1000} = \frac{38 * 2}{1000} = 0.08\,loops$$

$$m_{15} = \frac{I_{15} * P_{15}}{1000} = \frac{44 * 2}{1000} = 0.09\,loops$$

8. Calculation yarn length of additional stitches (m):

$$L_9 = l_{a-jour\ red.} * m_9 = 15.6 * 0.08 = 1.2\,m$$

$$L_{10} = l_{a-jour\ red.} * m_{10} = 15.6 * 0.09 = 1.4\,m$$

$$L_{14} = l_{a-jour\ red.} * m_{14} = 15.6 * 0.08 = 1.2\,m$$

$$L_{15} = l_{a-jour\ red.} * m_{15} = 15.6 * 0.09 = 1.4\,m$$

9. Calculation weight per unit area of additional stitches (gr):

$$Q_9 = \frac{L_9}{N} = \frac{1.2}{16} = 0.08\ gr$$

$$Q_{10} = \frac{L_{10}}{N} = \frac{1.4}{16} = 0.09\ gr$$

$$Q_{14} = \frac{L_{14}}{N} = \frac{1.2}{16} = 0.08\ gr$$

$$Q_{15} = \frac{L_{15}}{N} = \frac{1.4}{16} = 0.09\ gr \qquad \Sigma Q = Q_9 + Q_{10} + Q_{14} + Q_{15} = 0.3\ gr$$

Calculation table of children's waistcoat

Table 1

Name of section:	Number of sections	Number of courses	Number of needles	Number of facial stitches, thousand	Length of yarn, m	Weight of sections, gr	Waste in cutting			
							Number of needles	Number of facial stitches	Length of yarn, m	Weight of sections, gr
Bottom	1	26	364	9.5	125	7.8				
Main section	2	10	326	3.3	44	2.8				
	2.1	10	326	3.3	44	2.8				
	2.2	10	326	3.3	44	2.8				
	2.3	10	326	3.3	44	2.8				
	3	8	38	0.3	5	0.3				
	3.1	8	38	0.3	5	0.3				
	3.2	8	38	0.3	5	0.3				
	3.3	8	38	0.3	5	0.3				
	4	18	364	6.6	103	6.4				
	4.1	18	364	6.6	103	6.4				
	4.2	18	364	6.6	103	6.4				
	5	26	364	9.5	148	9.3				
Arm- hole and neckline of front side	6	24	164	3.9	61	3.8				
Narrowing:	7	30	112	3.4	53	3.3				
	8	26	82	2.1	33	2.1				
	11	24	164	3.9	61	3.8				
	12	48	138	6.6	103	6.4				
Arm-hole of back side	9	2	82	0.2	3	0.2	38	0.08	1.2	0.08
	10	2	44	0.1	2	0.1	44	0.09	1.4	0.09
	13	8	83	0.7	11	0.7				
	14	2	82	0.2	3	0.2	38	0.08	1.2	0.08
Shoulder	15	2	44	0.1	2	0.1	44	0.09	1.4	0.09
Total:						69.4				0.3

Total consumption of raw materials per unit of production (gr):

Table 2

Name of details	Weight of details	Including		Waste in knitting	Total consumption of raw materials
		Net weight of details	Waste in cutting		
Back side and front side	69.4	69.1	0.3	1.2	70.6
By weight:			0.3 gr	1.2 gr	70.6 gr
By percentage:		97.9%	0.4%	1.7 %	100%

The second assortment - children's cardigan is knitted from combination of a rib 1x1 structure and two and three coloured jacquard structure by fully fashion method. A bottom of the waistcoat consists of rib 2x2 structure. Collar of cardigan knitted from combination of rib 2x2 and double-layer plain structure.

Calculation front side of cardigan:

Parameters of knit structures used for knitting front side of cardigan: A=1.6 mm

Rib 2x2 structure: yarn № 32/2, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

Double- full two - coloured jacquard structure: yarn № 32/2, B=2 mm, l=21.2 mm

double-half three - colour jacquard structure: yarn № 32/2, B=1.8 mm, l=19.3 mm

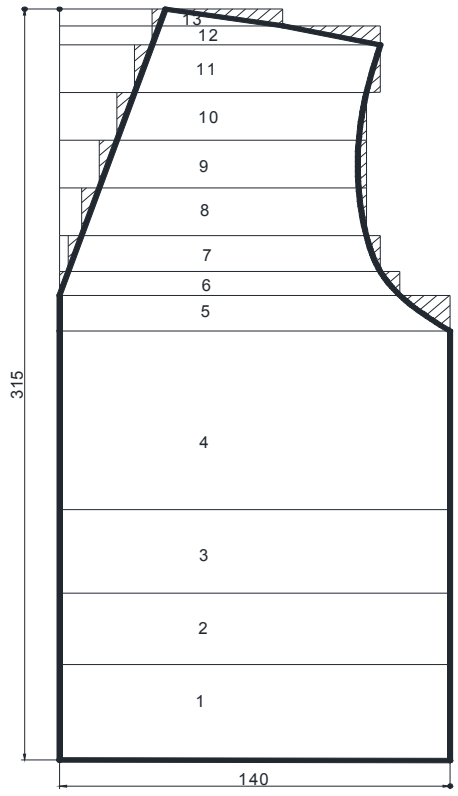

Fig. 9 Front side of children's cardigan

1. Calculation number of needles:

$$I_1 = \frac{SH_1}{A} = \frac{140}{1.6} = 86\ needles$$

$$I_2 = \frac{SH_2}{A} = \frac{140}{1.6} = 86\ needles$$

$$I_3 = \frac{SH_3}{A} = \frac{140}{1.6} = 86\ needles$$

$$I_4 = \frac{SH_4}{A} = \frac{140}{1.6} = 86\ needles$$

$$I_5 = \frac{SH_5}{A} = \frac{140}{1.6} = 86\ needles$$

$$I_6 = \frac{SH_6}{A} = \frac{122}{1.6} = 76\ needles$$

$$I_7 = \frac{SH_7}{A} = \frac{115}{1.6} = 72\ needles \qquad I_7 = 72 - 4$$

$$I_8 = \frac{SH_8}{A} = \frac{110}{1.6} = 68\ needles \qquad I_8 = 68 - 8$$

$$I_9 = \frac{SH_9}{A} = \frac{110}{1.6} = 68\ needles \qquad I_9 = 68 - 12$$

$$I_{10} = \frac{SH_{10}}{A} = \frac{110}{1.6} = 68\ needles \qquad I_{10} = 68 - 18$$

$$I_{11} = \frac{SH_{11}}{A} = \frac{115}{1.6} = 72\ needles \qquad I_{11} = 72 - 22$$

$$I_{12} = \frac{SH_{12}}{A} = \frac{115}{1.6} = 72\ needles \qquad I_{12} = 72 - 28$$

$$I_{13} = \frac{SH_{13}}{A} = \frac{80}{1.6} = 50\ needles \qquad I_{13} = 50 - 28$$

2. Calculation number of course:

$$P_1 = \frac{D_1}{B_{rib2x2}} = \frac{40}{1.4} = 28\ courses \qquad P_7 = \frac{D_7}{B_{2c.jacq.}} = \frac{15}{2} = 8\ courses$$

$$P_2 = \frac{D_2}{B_{2\ c.jacq.}} = \frac{30}{2} = 16\ courses \qquad P_8 = \frac{D_8}{B_{2c.jacq.}} = \frac{20}{2} = 10\ courses$$

$$P_3 = \frac{D_3}{B_{3\ c.jacq.}} = \frac{35}{1.8} = 20\ courses \qquad P_9 = \frac{D_9}{B_{2c.jacq.}} = \frac{20}{2} = 10\ courses$$

$$P_4 = \frac{D_4}{B_{2c.jacq.}} = \frac{75}{2} = 38\ courses \qquad P_{10} = \frac{D_{10}}{B_{2c.jacq.}} = \frac{20}{2} = 10\ courses$$

$$P_5 = \frac{D_5}{B_{2c.jacq.}} = \frac{15}{2} = 8\ courses \qquad P_{11} = \frac{D_{11}}{B_{2c.jacq.}} = \frac{20}{2} = 10\ courses$$

$$P_6 = \frac{D_6}{B_{2c.jacq.}} = \frac{10}{2} = 6\ courses \qquad P_{12} = \frac{D_{12}}{B_{2c.jacq.}} = \frac{8}{2} = 4\ courses$$

$$P_{13} = \frac{D_{13}}{B_{2c.jacq.}} = \frac{7}{2} = 4\ courses$$

3. Calculation number of stitches (in thousands):

$$m_1 = \frac{I_1 * P_1}{1000} = \frac{86 * 28}{1000} = 2.4\ loops$$

$$m_2 = \frac{I_2 * P_2}{1000} = \frac{86 * 16}{1000} = 1.4\ loops$$

$$m_3 = \frac{I_3 * P_3}{1000} = \frac{86 * 20}{1000} = 1.7\ loops$$

$$m_4 = \frac{I_4 * P_4}{1000} = \frac{86 * 38}{1000} = 3.3\ loops$$

$$m_5 = \frac{I_5 * P_4}{1000} = \frac{86 * 8}{1000} = 0.7\ loops$$

$$m_6 = \frac{I_6 * P_6}{1000} = \frac{76 * 6}{1000} = 0.5\ loops$$

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{(72-4) * 8}{1000} = 0.5\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{(68-8) * 10}{1000} = 0.6\ loops$$

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{(68-12) * 10}{1000} = 0.6\ loops$$

$$m_{10} = \frac{I_{10} * P_{10}}{1000} = \frac{(68-18) * 10}{1000} = 0.5\ loops$$

$$m_{11} = \frac{I_{11} * P_{11}}{1000} = \frac{(72-22) * 10}{1000} = 0.5\ loops$$

$$m_{12} = \frac{I_{12} * P_{12}}{1000} = \frac{(72-28) * 4}{1000} = 0.2\ loops$$

$$m_{13} = \frac{I_{13} * P_{13}}{1000} = \frac{(50-28)*4}{1000} = 0.1\ loops$$

4. Calculation yarn length (m):

$l_{rib2x2.reduced} = 13.2\,mm \quad l_{2\ c.jacq.} = 21.2\,mm \quad l_{3\ c.jacq.} = 19.3\,mm$

$L_1 = l_{rib\ 2x2\ red.} * m_1 = 13.2 * 2.4 = 32\,m$

$L_2 = l_{2\ c.jacq.} * m_2 = 21.2 * 1.4 = 30\,m$

$L_3 = l_{3\ c.jacq.} * m_3 = 19.3 * 1.7 = 33\,m$

$L_4 = l_{2\ c.jacq.} * m_4 = 21.2 * 3.3 = 69\,m$

$L_5 = l_{2\ c.jacq.} * m_5 = 21.2 * 0.7 = 15\,m$

$L_6 = l_{2\ c.jacq.} * m_6 = 21.2 * 0.5 = 11\,m$

$L_7 = l_{2\ c.jacq.} * m_7 = 21.2 * 0.5 = 11\,m$

$L_8 = l_{2\ c.jacq.} * m_8 = 21.2 * 0.6 = 13\,m$

$L_9 = l_{2\ c.jacq.} * m_9 = 21.2 * 0.6 = 13\,m$

$L_{10} = l_{2\ c.jacq.} * m_{10} = 21.2 * 0.5 = 11\,m$

$L_{11} = l_{2\ c.jacq.} * m_{11} = 21.2 * 0.5 = 11\,m$

$L_{12} = l_{2\ c.jacq.} * m_{12} = 21.2 * 0.2 = 4\,m$

$L_{13} = l_{2\ c.jacq.} * m_{13} = 21.2 * 0.1 = 2\,m$

5. Calculation of weight per unit area (gr.):

$$Q_1 = \frac{L_1}{N} = \frac{32}{16} = 2\ gr \qquad Q_7 = \frac{L_7}{N} = \frac{11}{16} = 0.7\ gr$$

$$Q_2 = \frac{L_2}{N} = \frac{30}{16} = 1.9\ gr \qquad Q_8 = \frac{L_8}{N} = \frac{13}{16} = 0.8\ gr$$

$$Q_3 = \frac{L_3}{N} = \frac{33}{16} = 2.1\ gr \qquad Q_9 = \frac{L_9}{N} = \frac{13}{16} = 0.8\ gr$$

$$Q_4 = \frac{L_4}{N} = \frac{69}{16} = 4.3\ gr \qquad Q_{10} = \frac{L_{10}}{N} = \frac{11}{16} = 0.7\ gr$$

$$Q_5 = \frac{L_5}{N} = \frac{15}{16} = 0.9\ gr \qquad Q_{11} = \frac{L_{11}}{N} = \frac{11}{16} = 0.7\ gr$$

$$Q_6 = \frac{L_6}{N} = \frac{11}{16} = 0.7\ gr \qquad Q_{12} = \frac{L_{12}}{N} = \frac{4}{16} = 0.3\ gr$$

$$Q_{13} = \frac{L_{13}}{N} = \frac{2}{16} = 0.1\ gr$$

$$\Sigma Q = 2 * (Q_1 + Q_2 + \dots\dots\dots + Q_{12} + Q_{13}) = 2 * 16\ gr = 32\ gr$$

6. Calculation of additional needles:

Arm-holes:

$$I_5 = I_5 - I_6 = 86 - 76 = 10\ needles$$

$$I_6 = I_6 - I_7 = 76 - 72 = 4\ needles$$

$$I_7 = I_7 - I_8 = 72 - 68 = 4\ needles$$

$$I_8 = I_{10} = 68$$

$$I_{11} = I_{11} - I_{10} = 72 - 68 = 4\ needles$$

Shoulders:

$$I_{12} = I_{12} - I_{13} = 72 - 50 = 22\ needles$$

$$I_{13} = 50 - 32 = 18\ needles$$

Neckline: $I_6 = I_7 = I_8 = I_{10} = I_{12} = I_{13} = 4\ needles$

$I_9 = I_{11} = 6\ needles$

7. Calculation of additional stitches (in thousands):

Arm-holes:

$$m_5 = \frac{I_5 * P_5}{1000} = \frac{10 * 8}{1000} = 0.08\ loops$$

$$m_6 = \frac{I_6 * P_6}{1000} = \frac{4 * 6}{1000} = 0.02\ loops$$

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{4 * 8}{1000} = 0.03\ loops$$

$$m_{11} = \frac{I_{11} * P_{11}}{1000} = \frac{4 * 10}{1000} = 0.04\ loops$$

Shoulders:

$$m_{12} = \frac{I_{12} * P_{12}}{1000} = \frac{22 * 4}{1000} = 0.09\ loops$$

$$m_{13} = \frac{I_{13} * P_{13}}{1000} = \frac{18 * 4}{1000} = 0.07\ loops$$

Neckline:

$$m_6 = \frac{I_6 * P_6}{1000} = \frac{4 * 6}{1000} = 0.02\ loops$$

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{4 * 8}{1000} = 0.03\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{4 * 10}{1000} = 0.04\ loops$$

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{6 * 10}{1000} = 0.06\ loops$$

$$m_{10} = \frac{I_{10} * P_{10}}{1000} = \frac{4 * 10}{1000} = 0.04\ loops$$

$$m_{11} = \frac{I_{11} * P_{11}}{1000} = \frac{6 * 10}{1000} = 0.06\ loops$$

$$m_{12-13} = \frac{I_{12-13} * P_{12-13}}{1000} = \frac{4 * 8}{1000} = 0.03\ \text{loops}$$

8. Calculation yarn length of additional stitches (m):

Arm-holes:

$$L_5 = l_{2\ c.jacq.} * m_5 = 21.2 * 0.08 = 1.7\ m$$

$$L_6 = l_{2\ c.jacq.} * m_6 = 21.2 * 0.02 = 0.4\ m$$

$$L_7 = l_{2\ c.jacq.} * m_7 = 21.2 * 0.03 = 0.6\ m$$

$$L_{11} = l_{2\ c.jacq.} * m_{11} = 21.2 * 0.04 = 0.8\ m$$

Shoulder:

$$L_{12} = l_{2\ c.jacq.} * m_{12} = 21.2 * 0.09 = 1.9\ m$$

$$L_{13} = l_{2\ c.jacq.} * m_{13} = 21.2 * 0.07 = 1.5\ m$$

Neckline:

$$L_6 = l_{2\ c.jacq.} * m_6 = 21.2 * 0.02 = 0.4\ m$$

$$L_7 = l_{2\ c.jacq.} * m_7 = 21.2 * 0.03 = 1.6\ m$$

$$L_8 = l_{2\ c.jacq.} * m_8 = 21.2 * 0.04 = 0.8\ m$$

$$L_9 = l_{2\ c.jacq.} * m_9 = 21.2 * 0.06 = 1.3\ m$$

$$L_{10} = l_{2\ c.jacq.} * m_{10} = 21.2 * 0.04 = 0.8\ m$$

$$L_{11} = l_{2\ c.jacq.} * m_{11} = 21.2 * 0.06 = 1.3\ m$$

$$L_{12-13} = l_{2\ c.jacq.} * m_{11-13} = 21.2 * 0.03 = 1.6\ m$$

9. Calculation weight per unit area of additional stitches (gr):

Arm-holes:

$$Q_5 = \frac{L_5}{N} = \frac{1.7}{16} = 0.1\ gr \qquad Q_7 = \frac{L_7}{N} = \frac{0.6}{16} = 0.04\ gr$$

$$Q_6 = \frac{L_6}{N} = \frac{0.4}{16} = 0.03\ gr \qquad Q_{11} = \frac{L_{11}}{N} = \frac{0.8}{16} = 0.05\ gr$$

Shoulders:

$$Q_{12} = \frac{L_{12}}{N} = \frac{1.9}{16} = 0.1\ gr \qquad Q_{13} = \frac{L_{13}}{N} = \frac{1.5}{16} = 0.1\ gr$$

Neckline:

$$Q_6 = \frac{L_6}{N} = \frac{0.4}{16} = 0.03\ gr \qquad Q_9 = \frac{L_9}{N} = \frac{1.3}{16} = 0.08\ gr$$

$$Q_7 = \frac{L_7}{N} = \frac{0.6}{16} = 0.04\ gr \qquad Q_{10} = \frac{L_{10}}{N} = \frac{0.8}{16} = 0.05\ gr$$

$$Q_8 = \frac{L_8}{N} = \frac{0.8}{16} = 0.05\ gr \qquad Q_{11} = \frac{L_{11}}{N} = \frac{1.3}{16} = 0.08\ gr$$

$$Q_{12-13} = \frac{L_{12-13}}{N} = \frac{0.6}{16} = 0.04\ gr$$

$$\Sigma Q = 2 * 0.8 = 1.6\ gr$$

Calculation table front side of children's cardigan

Table 3

Name of section:	Number of sections	Number of course	Number of needles	Number of facial stitches, thousand	Length of yarn, m	Weight of sections, gr	Waste in cutting			
							Number of needles	Number of facial stitches	Length of yarn, m	Weight of sections, gr
Bottom	1	28	86	2.4	32	2	-	-	-	-
Main section	2	16	86	1.4	30	1.9	-	-	-	-
	3	16	86	1.7	46	2.9	-	-	-	-
	4	38	86	3.3	69	4.3	-	-	-	-
	5	8	86	0.7	15	0.9	10	0.08	1.7	0.1
Arm-hole	6	6	76	0.5	11	0.7	4	0.02	0.4	0.03
	7	8	68	0.5	11	0.7	4	0.03	0.6	0.04
	8	10	60	0.6	13	0.8	-	-	-	-
	9	10	56	0.6	13	0.8	-	-	-	-
	10	10	50	0.5	11	0.7	-	-	-	-
	11	10	50	0.5	11	0.7	4	0.04	0.8	0.05
Shoulder	12	4	44	0.2	4	0.3	22	0.09	1.9	0.1
	13	4	22	0.1	2	0.1	18	0.07	1.5	0.1
Neckline	6						4	0.02	0.4	0.03
	7						4	0.03	0.6	0.04
	8						4	0.04	0.8	0.05
	9						6	0.06	1.3	0.08
	10						4	0.04	0.8	0.05
	11						6	0.06	1.3	0.08
	12 - 13						4	0.03	0.6	0.04
Total:						16				0.8

Calculation back side of cardigan:

Parameters of knit structures used for knitting back side of cardigan: A=1.6 mm,

Rib 2x2 structure: yarn № 32/2, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

Rib 1x1 structure: yarn № 32/2, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

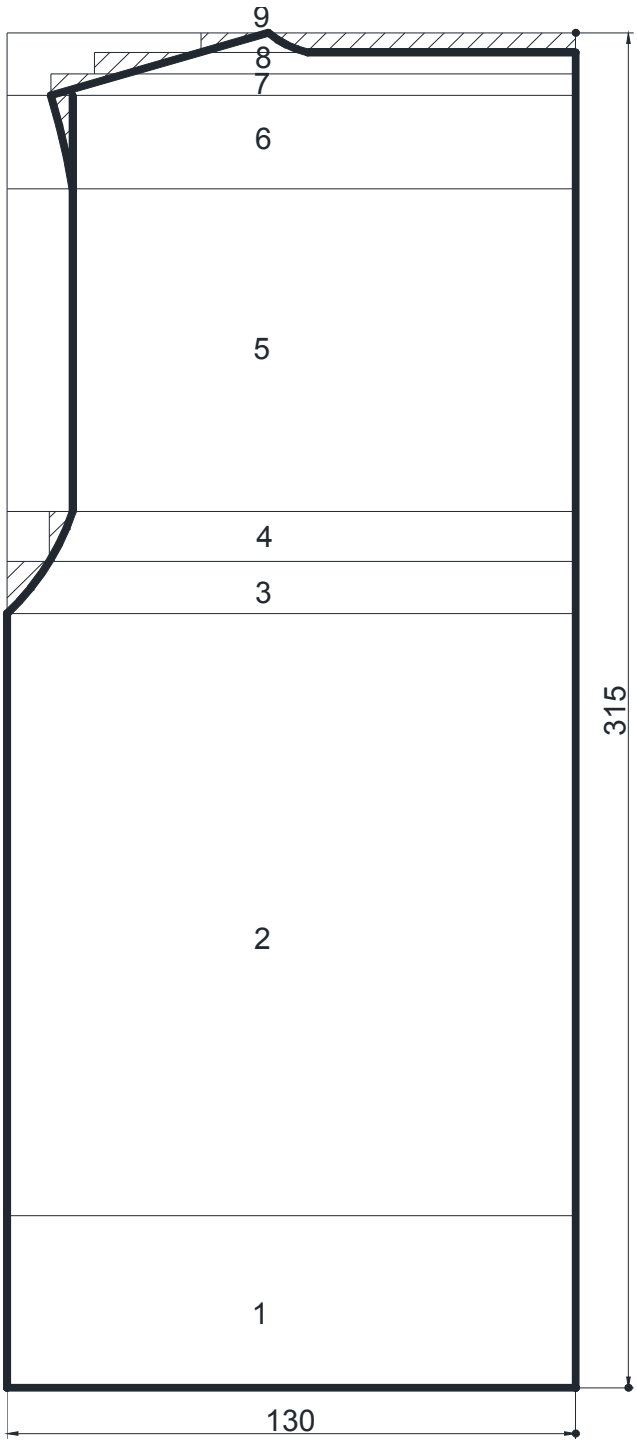

Fig. 10 Back side of children's cardigan

1. **Calculation number of needles:**

$$I_1 = \frac{SH_1}{A} = \frac{130}{1.6} = 82\ needles \quad x\,2$$

$$I_2 = \frac{SH_2}{A} = \frac{130}{1.6} = 82\ needles \quad x\,2$$

$$I_3 = \frac{SH_3}{A} = \frac{130}{1.6} = 82\ needles \quad x\,2$$

$$I_4 = \frac{SH_4}{A} = \frac{120}{1.6} = 76\ \text{needles} \quad x\,2$$

$$I_5 = \frac{SH_5}{A} = \frac{115}{1.6} = 72\ needles \quad x\,2$$

$$I_6 = \frac{SH_6}{A} = \frac{120}{1.6} = 76\ needles \quad x\,2$$

$$I_7 = \frac{SH_7}{A} = \frac{120}{1.6} = 76\ needles \quad x\,2$$

$$I_8 = \frac{SH_8}{A} = \frac{100}{1.6} = 62\ needles \quad x\,2$$

$$I_9 = \frac{SH_9}{A} = \frac{75}{1.6} = 46\ needles \quad x\,2$$

2. Calculation number of course:

$$P_1 = \frac{D_1}{B_{rib2x2}} = \frac{40}{1.4} = 28\ courses$$

$$P_2 = \frac{D_2}{B_{rib1x1}} = \frac{140}{1.4} = 100\ courses$$

$$P_3 = \frac{D_3}{B_{rib1x1}} = \frac{12}{1.4} = 8\ courses$$

$$P_4 = \frac{D_4}{B_{rib1x1}} = \frac{13}{1.4} = 10\ courses$$

$$P_5 = \frac{D_5}{B_{rib1x1}} = \frac{75}{1.4} = 54\ courses$$

$$P_6 = \frac{D_6}{B_{rib1x1}} = \frac{20}{1.4} = 14\ courses$$

$$P_7 = \frac{D_7}{B_{rib1x1}} = \frac{5}{1.4} = 4\ courses$$

$$P_8 = \frac{D_8}{B_{rib1x1}} = \frac{5}{1.4} = 4\ courses$$

$$P_9 = \frac{D_9}{B_{rib1x1}} = \frac{5}{1.4} = 4\ courses$$

3. Calculation number of stitches (in thousands):

$$m_1 = \frac{I_1 * P_1}{1000} = \frac{82x2 * 28}{1000} = 4.6\ loops$$

$$m_2 = \frac{I_2 * P_2}{1000} = \frac{82x2 * 100}{1000} = 16.4\ loops$$

$$m_3 = \frac{I_3 * P_3}{1000} = \frac{82x2 * 8}{1000} = 1.3\ loops$$

$$m_4 = \frac{I_4 * P_4}{1000} = \frac{76x2 * 10}{1000} = 1.6\ loops$$

$$m_5 = \frac{I_5 * P_4}{1000} = \frac{72x2 * 54}{1000} = 7.8\ loops$$

$$m_6 = \frac{I_6 * P_6}{1000} = \frac{76x2 * 14}{1000} = 2.1\ loops$$

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{76x2 * 4}{1000} = 0.6\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{62x2 * 4}{1000} = 0.5\ loops$$

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{46x2 * 4}{1000} = 0.4\ loops$$

4. Calculation yarn length (m):

$$l_{rib2x2.reduced} = 13.2\ mm \quad l_{rib1x1.reduced} = 13.2\ mm$$

$$L_1 = l_{rib\ 2x2\ red.} * m_1 = 13.2 * 4.6 = 61\ m$$

$$L_2 = l_{rib\ 1x1\ red.} * m_2 = 13.2 * 16.4 = 217\ m$$

$$L_3 = l_{rib\ 1x1\ red.} * m_3 = 13.2 * 1.3 = 17\ m$$

$$L_4 = l_{rib\ 1x1\ red.} * m_4 = 13.2 * 1.6 = 21\ m$$

$$L_5 = l_{rib\ 1x1\ red.} * m_5 = 13.2 * 7.8 = 103\ m$$

$$L_6 = l_{rib\ 1x1\ red.} * m_6 = 13.2 * 2.1 = 28\ m$$

$$L_7 = l_{rib\ 1x1\ red.} * m_7 = 13.2 * 0.6 = 8\ m$$

$$L_8 = l_{rib\ 1x1\ red.} * m_8 = 13.2 * 0.5 = 7\ m$$

$$L_9 = l_{rib\ 1x1\ red.} * m_9 = 13.2 * 0.4 = 5\ m$$

5. Calculation of weight per unit area (gr.):

$$Q_1 = \frac{L_1}{N} = \frac{61}{16} = 3.8\ gr$$

$$Q_2 = \frac{L_2}{N} = \frac{217}{16} = 13.6\ gr$$

$$Q_3 = \frac{L_3}{N} = \frac{17}{16} = 1.1\ gr$$

$$Q_4 = \frac{L_4}{N} = \frac{21}{16} = 1.3\ gr$$

$$Q_6 = \frac{L_6}{N} = \frac{28}{16} = 1.8\ gr$$

$$Q_7 = \frac{L_7}{N} = \frac{8}{16} = 0.5\ gr$$

$$Q_8 = \frac{L_8}{N} = \frac{7}{16} = 0.4\ gr$$

$$Q_9 = \frac{L_9}{N} = \frac{5}{16} = 0.3\ gr$$

$$Q_5 = \frac{L_5}{N} = \frac{103}{16} = 6.4\ gr$$

$$\Sigma Q = (Q_1 + Q_2 + \dots\dots\dots + Q_8 + Q_9) = 29.2\ gr$$

6. Calculation of additional needles:

Arm-holes:

$$I_3 = I_3 - I_4 = (82 - 76)x2 = 12\ needles$$

$$I_4 = I_4 - I_5 = (76 - 72)x2 = 8\ needles$$

$$I_6 = I_6 - I_5 = (76 - 72)x2 = 8\ needles$$

Shoulders:

$$I_7 = I_7 - I_8 = (72 - 62)x2 = 28\ needles$$

$$I_8 = I_8 - I_9 = (62 - 4)x2 = 32\ needles$$

$$I_9 = 12 * 2 = 24\ needles$$

Neckline:

$$I_9 = 68\ needles$$

7. Calculation of additional stitches (in thousands):

Arm-holes:

$$m_3 = \frac{I_3 * P_3}{1000} = \frac{12 * 8}{1000} = 0.1\ loops \qquad m_6 = \frac{I_6 * P_6}{1000} = \frac{8 * 14}{1000} = 0.1\ loops$$

$$m_4 = \frac{I_4 * P_4}{1000} = \frac{8 * 10}{1000} = 0.01\ loops$$

Shoulders:

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{28 * 4}{1000} = 0.1\ loops \qquad m_9 = \frac{I_9 * P_9}{1000} = \frac{24 * 4}{1000} = 0.1\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{32 * 4}{1000} = 0.1\ loops$$

Neckline:

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{68 * 4}{1000} = 0.3\ loops$$

8. Calculation yarn length of additional stitches (m):

Arm-holes:

$$L_3 = l_{rib\ 1x1\ red.} * m_3 = 13.2 * 0.1 = 1.3\ m$$

$$L_4 = l_{rib\ 1x1\ red.} * m_4 = 13.2 * 0.1 = 1.3\ m$$

$$L_6 = l_{rib\ 1x1\ red.} * m_6 = 13.2 * 0.1 = 1.3\ m$$

Shoulder:

$$L_7 = l_{rib\ 1x1\ red.} * m_7 = 13.2 * 0.1 = 1.3\ m$$

$$L_8 = l_{rib\ 1x1\ red.} * m_8 = 13.2 * 0.1 = 1.3\ m$$

$$L_9 = l_{rib\ 1x1\ red.} * m_9 = 13.2 * 0.1 = 1.3\ m$$

Neckline:

$$L_9 = l_{rib\ 1x1\ red.} * m_9 = 13.2 * 0.3 = 4\ m$$

9. Calculation weight per unit area of additional stitches (gr):

Arm-holes:

$$Q_3 = \frac{L_3}{N} = \frac{1.3}{16} = 0.08\ gr \qquad Q_6 = \frac{L_6}{N} = \frac{1.3}{16} = 0.08\ gr$$

$$Q_4 = \frac{L_4}{N} = \frac{1.3}{16} = 0.08\ gr$$

Shoulders:

$$Q_7 = \frac{L_7}{N} = \frac{1.3}{16} = 0.08\ gr \qquad Q_9 = \frac{L_9}{N} = \frac{1.3}{16} = 0.08\ gr$$

$$Q_8 = \frac{L_8}{N} = \frac{1.3}{16} = 0.08\ gr$$

Neckline:

$$Q_9 = \frac{L_9}{N} = \frac{4}{16} = 0.25\ gr$$

$$\Sigma Q = 0.7\ gr$$

Calculation table back side of children's cardigan

Table 4

Name of section:	Number of sections	Number of course	Number of needles	Number of facial stitches, thousand	Length of yarn, m	Weight of sections, gr	Waste in cutting			
							Number of needles	Number of facial stitches	Length of yarn, m	Weight of sections
Bottom	1	28	164	4.6	61	3.8	-	-	-	-
Main section	2	100	164	16.4	217	13.6	-	-	-	-
Arm-hole	3	8	164	1.3	17	1.1	12	0.1	1.3	0.08
	4	10	152	1.6	21	1.3	8	0.1	1.3	0.08
	5	54	144	7.8	103	6.4	-	-	-	-
	6	14	152	2.1	28	1.8	8	0.1	1.3	0.08
Shoulder	7	4	152	0.6	8	0.5	28	0.1	1.3	0.08
	8	4	124	0.5	7	0.4	32	0.1	1.3	0.08
	9	4	92	0.4	5	0.3	24	0.1	1.3	0.08
							68	0.3	4	0.25
Neckline	9									
Total:						29.2				0.7

Calculation sleeves of cardigan:

Parameters of knit structures used for knitting sleeves of cardigan: A=1.6 mm,

Rib 2x2 structure: yarn № 32/2, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

Rib 1x1 structure: yarn № 32/2, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

1. Calculation number of needles:

$$I_1 = \frac{SH_1}{A} = \frac{75}{1.6} = 46\ needles\ \ x\ 2 \qquad I_6 = \frac{SH_6}{A} = \frac{86}{1.6} = 54\ needles\ \ x\ 2$$

$$I_2 = \frac{SH_2}{A} = \frac{120}{1.6} = 76\ needles\ \ x\ 2 \qquad I_7 = \frac{SH_7}{A} = \frac{76}{1.6} = 48\ needles\ \ x\ 2$$

$$I_3 = \frac{SH_3}{A} = \frac{120}{1.6} = 76\ needles\ \ x\ 2 \qquad I_8 = \frac{SH_8}{A} = \frac{67}{1.6} = 42\ needles\ \ x\ 2$$

$$I_4 = \frac{SH_4}{A} = \frac{120}{1.6} = 76\ needles \quad x\,2 \qquad I_9 = \frac{SH_9}{A} = \frac{58}{1.6} = 36\ needles \quad x\,2$$

$$I_5 = \frac{SH_5}{A} = \frac{100}{1.6} = 62\ needles \quad x\,2 \qquad I_{10} = \frac{SH_{10}}{A} = \frac{47}{1.6} = 30\ needles \quad x\,2$$

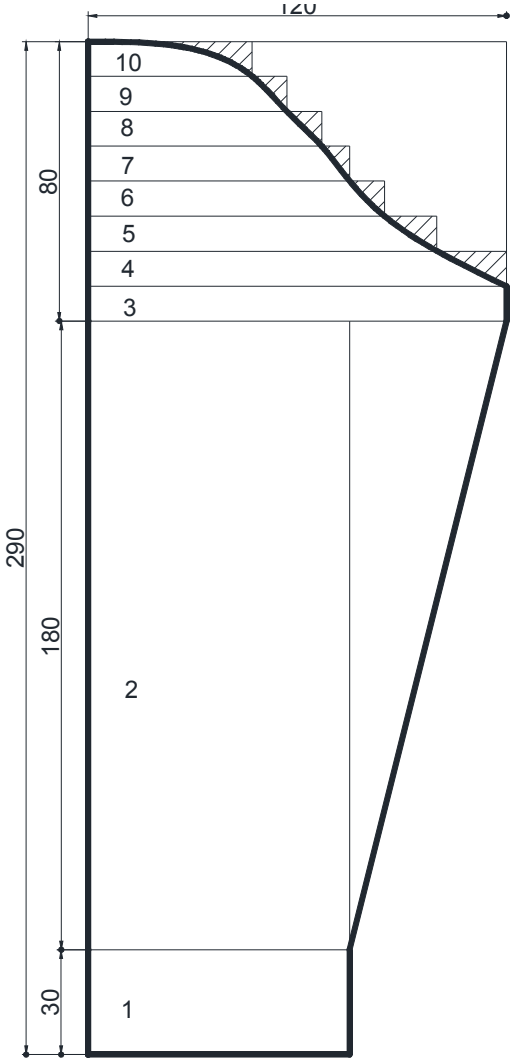

Fig. 11 Children's cardigan Sleeve

2. Calculation number of course:

$$P_1 = \frac{D_1}{B_{rib2x2}} = \frac{30}{1.4} = 22\ courses \qquad P_6 = \frac{D_6}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses$$

$$P_2 = \frac{D_2}{B_{rib1x1}} = \frac{180}{1.4} = 128\ courses \qquad P_7 = \frac{D_7}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses$$

$$P_3 = \frac{D_3}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses \qquad P_8 = \frac{D_8}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses$$

$$P_4 = \frac{D_4}{B_{rib1x1}} = \frac{13}{1.4} = 10\ courses \qquad P_9 = \frac{D_9}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses$$

$$P_5 = \frac{D_5}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses \qquad P_{10} = \frac{D_{10}}{B_{rib1x1}} = \frac{10}{1.4} = 8\ courses$$

3. Calculation number of stitches (in thousands):

$$m_1 = \frac{I_1 * P_1}{1000} = \frac{92 * 22}{1000} = 2\ loops$$

$$m_2 = \frac{(I_1 + 30) * P_2}{1000} = \frac{(92 + 30) * 128}{1000} = 15.6\ loops$$

*On section 2 sleeve is widening by increasing number of needles to 30 by one needle through each 4 course.

$$m_3 = \frac{I_3 * P_3}{1000} = \frac{152 * 8}{1000} = 1.2\ loops$$

$$m_4 = \frac{I_4 * P_4}{1000} = \frac{152 * 8}{1000} = 1.2\ loops$$

$$m_5 = \frac{I_5 * P_4}{1000} = \frac{124 * 8}{1000} = 1\ loops$$

$$m_6 = \frac{I_6 * P_6}{1000} = \frac{108 * 8}{1000} = 0.9\ loops$$

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{96 * 8}{1000} = 0.8\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{84 * 8}{1000} = 0.7\ loops$$

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{72 * 8}{1000} = 0.6\ loops$$

$$m_{10} = \frac{I_{10} * P_{10}}{1000} = \frac{60 * 8}{1000} = 0.5\ loops$$

4. Calculation yarn length (m):

$$l_{rib2x2.reduced} = 13.2\ mm \quad l_{rib1x1.reduced} = 13.2\ mm$$

$$L_1 = l_{rib\ 2x2\ red.} * m_1 = 13.2 * 2 = 26\ m$$

$$L_2 = l_{rib\ 1x1\ red.} * m_2 = 13.2 * 15.6 = 206\ m$$

$$L_3 = l_{rib\ 1x1\ red.} * m_3 = 13.2 * 1.2 = 16\ m$$

$$L_4 = l_{rib\ 1x1\ red.} * m_4 = 13.2 * 1.2 = 16\ m$$

$$L_5 = l_{rib\ 1x1\ red.} * m_5 = 13.2 * 1 = 13\ m$$

$$L_6 = l_{rib\ 1x1\ red.} * m_6 = 13.2 * 0.9 = 12\ m$$

$$L_7 = l_{rib\ 1x1\ red.} * m_7 = 13.2 * 0.8 = 11\ m$$

$$L_8 = l_{rib\ 1x1\ red.} * m_8 = 13.2 * 0.7 = 9\ m$$

$$L_9 = l_{rib\ 1x1\ red.} * m_9 = 13.2 * 0.6 = 8\ m$$

$$L_{10} = l_{rib\ 1x1\ red.} * m_{10} = 13.2 * 0.5 = 7\ m$$

5. Calculation of weight per unit area (gr.):

$$Q_1 = \frac{L_1}{N} = \frac{26}{16} = 1.6\ gr \qquad Q_6 = \frac{L_6}{N} = \frac{12}{16} = 0.8\ gr$$

$$Q_2 = \frac{L_2}{N} = \frac{206}{16} = 12.9\ gr \qquad Q_7 = \frac{L_7}{N} = \frac{11}{16} = 0.7\ gr$$

$$Q_3 = \frac{L_3}{N} = \frac{16}{16} = 1\ gr \qquad Q_8 = \frac{L_8}{N} = \frac{9}{16} = 0.6\ gr$$

$$Q_4 = \frac{L_4}{N} = \frac{16}{16} = 1\ gr \qquad Q_9 = \frac{L_9}{N} = \frac{8}{16} = 0.5\ gr$$

$$Q_5 = \frac{L_5}{N} = \frac{13}{16} = 0.8\ gr \qquad Q_{10} = \frac{L_{10}}{N} = \frac{7}{16} = 0.4\ gr$$

$$\Sigma Q = 2 * (Q_1 + Q_2 + \dots\dots\dots + Q_9 + Q_{10}) = 40.6\ gr$$

6. Calculation of additional needles:

$$I_4 = I_4 - I_5 = 152 - 124 = 28\ needles$$

$$I_5 = I_5 - I_6 = 124 - 108 = 16\ needles$$

$$I_6 = I_6 - I_7 = 108 - 96 = 12\ needles$$

$$I_7 = I_7 - I_8 = 96 - 84 = 12\ needles$$

$$I_8 = I_8 - I_9 = 84 - 72 = 12\ needles$$

$$I_9 = I_9 - I_{10} = 72 - 60 = 12\ needles$$

$$I_{10} = 34\ needles$$

7. Calculation of additional stitches (in thousands):

$$m_4 = \frac{I_4 * P_4}{1000} = \frac{28 * 8}{1000} = 0.2\ loops$$

$$m_5 = \frac{I_5 * P_5}{1000} = \frac{16 * 8}{1000} = 0.1\ loops$$

$$m_6 = \frac{I_6 * P_6}{1000} = \frac{12 * 8}{1000} = 0.1\ loops$$

$$m_7 = \frac{I_7 * P_7}{1000} = \frac{12 * 8}{1000} = 0.1\ loops$$

$$m_8 = \frac{I_8 * P_8}{1000} = \frac{12 * 8}{1000} = 0.1\ loops$$

$$m_9 = \frac{I_9 * P_9}{1000} = \frac{12 * 8}{1000} = 0.1\ loops$$

$$m_{10} = \frac{I_{10} * P_{10}}{1000} = \frac{34 * 8}{1000} = 0.3\ loops$$

8. Calculation yarn length of additional stitches (m):

$$L_4 = l_{rib\ 1x1\ red.} * m_4 = 13.2 * 0.2 = 3\ m$$

$$L_5 = l_{rib\ 1x1\ red.} * m_3 = 13.2 * 0.1 = 1\ m$$

$$L_6 = l_{rib\ 1x1\ red.} * m_6 = 13.2 * 0.1 = 1.3\ m$$

$$L_7 = l_{rib\ 1x1\ red.} * m_7 = 13.2 * 0.1 = 1.3\ m$$

$$L_8 = l_{rib\ 1x1\ red.} * m_8 = 13.2 * 0.1 = 1.3\ m$$

$$L_9 = l_{rib\ 1x1\ red.} * m_9 = 13.2 * 0.1 = 1.3\ m$$

$$L_9 = l_{rib\ 1x1\ red.} * m_9 = 13.2 * 0.3 = 4\ m$$

9. Calculation weight per unit area of additional stitches (gr):

$$Q_4 = \frac{L_4}{N} = \frac{3}{16} = 0.2\ gr$$

$$Q_5 = \frac{L_5}{N} = \frac{1}{16} = 0.1\ gr$$

$$Q_6 = \frac{L_6}{N} = \frac{1}{16} = 0.1\ gr$$

$$Q_9 = \frac{L_9}{N} = \frac{4}{16} = 0.3\ gr$$

$$Q_7 = \frac{L_7}{N} = \frac{1}{16} = 0.1\ gr$$

$$Q_8 = \frac{L_8}{N} = \frac{1}{16} = 0.1\ gr$$

$$Q_9 = \frac{L_9}{N} = \frac{1}{16} = 0.1\ gr$$

$$\Sigma Q = 2 * 1 = 2\ gr$$

Calculation table sleeve of children's cardigan

Table 5

Name of section:	Number of sections	Number of course	Number of needles	Number of facial stitches, thousand	Length of yarn, m	Weight of sections, gr	Waste in cutting			
							Number of needles	Number of facial stitches	Length of yarn, m	Weight of sections
Bottom	1	22	92	2	26	1.6	-			
Widening	2	128	92-152	15.6	206	12.9	-			
Direct section	3	8	152	1.2	16	1	-			
Arm- hole	4	8	152	1.2	16	1	28	0.2	3	0.2
	5	8	124	1	13	0.8	16	0.1	1	0.1
	6	8	108	0.9	12	0.8	12	0.1	1	0.1
	7	8	96	0.8	11	0.7	12	0.1	1	0.1
	8	8	84	0.7	9	0.6	12	0.1	1	0.1
	9	8	72	0.6	8	0.5	12	0.1	1	0.1
	10	8	60	0.5	7	0.4	34	0.3	4	0.3
Total:						20.3				1

Calculation collar of cardigan:

Parameters of knit structures used for knitting collar of cardigan: A=1.6 mm,

Rib 2x2 structure: yarn № 32/2, B=1.4 mm, l=6.6 mm, $l_{reduced}$ = 13.2 mm;

Double-layer plain structure: yarn № 32/2, B=1.7 mm, l=7.8 mm, $l_{reduced}$ = 15.6 mm.

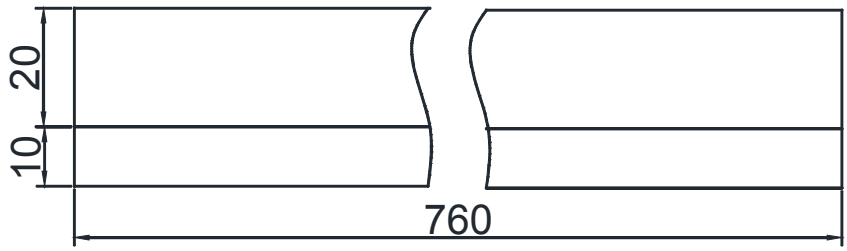

Fig. 12 Children's cardigan Collar

1. Calculation number of needles:

$$I_1 = \frac{SH_1}{A} = \frac{380}{1.6} = 238\ needles\ \ x\ 2$$

2. Calculation number of course:

$$P_1 = \frac{D_1}{B_{d-layer\ pl.}} = \frac{10}{1.7} = 6\ courses$$

$$P_2 = \frac{D_2}{B_{rib2x2}} = \frac{20}{1.4} = 14\ courses$$

3. Calculation number of stitches (in thousands):

$$m_1 = \frac{I_1 * P_1}{1000} = \frac{476 * 6}{1000} = 2{,}9\ loops$$

$$m_2 = \frac{I_2 * P_2}{1000} = \frac{476 * 14}{1000} = 6{,}7\ loops$$

4. Calculation yarn length (m):

$$l_{rib2x2.reduced} = 13.2\ mm \quad l_{d-layer\ plain} = 13.2\ mm$$

$$L_1 = l_{d-layer\ plain} * m_1 = 15.6 * 2.9 = 45\ m$$

$$L_2 = l_{rib\ 1x1\ red.} * m_2 = 13.2 * 6.7 = 88\ m$$

5. Calculation of weight per unit area (gr.):

$$Q_1 = \frac{L_1}{N} = \frac{45}{16} = 2.8\ gr \qquad Q_2 = \frac{L_2}{N} = \frac{88}{16} = 5.5\ gr$$

$$\Sigma Q = Q_1 + Q_2 = 8.3\ gr$$

Total consumption of raw materials per unit of production (gr):

Table 6

Name of details	Weight of details	Including		Waste in knitting	Total consumption of raw materials
		Net weight of details	Waste in cutting		
Back side	29.2	28.5	0.7	0.5	29.7
Front side (two)	32	30.4	1.6	0.6	32.6
Sleeves (two)	40.6	38.6	2	0.7	41.3
Collar	8.3	8.3	-	0.1	8.4
By weight:	110.1	105.8	4.3	1.9	112
By percentage:		94.5 %	3.8%	1.7%	100 %

I.8 CALCULATION OF ANNUAL PRODUCTION VOLUME

CALCULATION OF COE (KPO)

COE (Coefficient of operating equipment) represents constantly availability of equipment, taking into consideration the percentages of planned shutdowns of equipment for overhaul, medium maintenance, corrective maintenance and for technological cleaning.

$$COE(KPO) = 1 - \frac{a}{100}$$

There in: a= percentages of planned shutdowns of equipment

$a = a_1 + a_2 + a_3 + a_4$

a_1- percentage of overhaul shutdowns

a_2- percentages of medium maintenance shutdowns

a_3- percentage of corrective maintenance shutdowns

a_4- percentage of technological cleaning shutdowns

1. Calculation of percentage of overhaul shutdowns, a_1

- Overhaul time norm: 188 working hour
- Time interval of overhaul: once in 6 years
- The total number of workers in maintenance crew: 4 people
- The machine's operating mode: 2 shifts
- The working mode of maintenance crew: 1 shift
- The working hour of machines: 4055 hours

If every worker works 7.4 hours a day, subsequently maintenance crew work:

4*7.4=29.6 working hour.

Number of days for overhaul: 188 working hour/29.6 working hour=6.35 days

At the first shift: 6.35*7.4= 46.99 hours

At the second shift: 6*7.4=44 hours

Total hours for overhaul: 46.99+44=90.99 hours

$$a_1 = \frac{loss\ of\ time\ for\ overhaul * interval\ of\ maintenance * 100\%}{total\ working\ ours\ of\ machine}$$

$$= \frac{90.99 * 1 * 100}{6 * 4055} = 0.37\ \%$$

$a_1 = 0.37\%$

2. Calculation of percentage of medium maintenance shutdowns, a_2

- medium maintenance time norm: 110 working hour

- Time interval of medium maintenance: once a year

If every worker works 7.4 hours a day, subsequently maintenance crew work:

4*7.4=29.6 working hour.

Number of days for medium maintenance:

110 working hour/29.6 working hour = 3.7 days

Total hours for medium maintenance: 3.7*7.4= 27.38 hours

$$a_2 = \frac{loss\ of\ time\ for\ medium\ maintenance * interval\ of\ maintenance * 100\%}{total\ working\ ours\ of\ machine}$$

$$= \frac{27.38 * 1 * 100}{1 * 4055} = 0.67\ \%$$

$a_2 = 0.67\ \%$

3. Percentage of corrective maintenance shutdowns, $a_3 = 1 - 3\%$

Depending on the machine's condition, it will be taken 2 %

$a_3 = 2\ \%$

4. Percentage of technological cleaning shutdowns, a_4

- Technological cleaning time norm: 2 hours

- Time interval of technological cleaning: once in 3 months

- Number of days for technological cleaning: 4055/12=338 days

$$a_4 = \frac{loss\ of\ time\ for\ technological\ cleaning * interval\ of\ maintenance * 100\%}{total\ working\ ours\ of\ machine}$$

$$= \frac{2 * 1 * 100}{3 * 338} = 0.197\ \%$$

$a_4 = 0.197\ \%$

$a = a_1 + a_2 + a_3 + a_4 = 0.37 + 0.67 + 2 + 0.197 = 3.2\ \%$

$$COE\ (KPO) = 1 - \frac{a}{100} = 1 - \frac{3.2\%}{100} = 0.97\ \%$$

CALCULATION OF NORMALIZATION CARD FOR PRODUCING CHILDREN'S OUTERWEAR

Normalization card is calculated in the following order for children's waistcoat:

Table 7

Details:	Number of course			Number of carriage movement per minute	Machine time t_m, sec.
	in main fabric	add.	totally		
Back side and front side of waistcoat	230	5	235	26	542

Number of double carriage movement per minute:

$$n = \frac{60 * \vartheta * \eta}{2 * \left(\frac{И * 0.0254}{K} + 2C\right)} = \frac{60 * 1.2 * 0.85}{2 * \left(\frac{364 * 0.0254}{12} + 2 * 0.2\right)} = 26\ times$$

There in:

ϑ- linear speed of carriage – 1.2 m/c

η- coefficient of carriage slippage- 0.85

И - number of needles

K-gauge of knitting machine

C-carriage run out, 0.15-0.22 m

1. Machine time is calculated:

$$t_m = \frac{R_1 * z_1}{n_1} * \frac{60}{m} = \frac{235 * 2}{26} * \frac{60}{2} = 542\ second$$

There in:

R- number of knitting course

n- number of double carriage movement per minute

z- number of knitting system, participating in the interloping of one course

m- number of knitting system on the machine

2. Theoretical productive capacity of machine is calculated:

$$A_t = \frac{T_{sm}}{t_m} = \frac{3600}{542} = 7\ pcs.$$

3. Servicing norm of machine is calculated:

$$H_o = \frac{t_m + t_{bn}}{t_n + t_{bn}} * K_z = \frac{542 + 136}{34 + 136} * 0.85 = 3.4$$

$$K_z = 0.85$$

$$t_{bn} = t_m * 25\% = 542 * 25\% = 136\ second$$

$$t_n = t_{bn} * 25\% = 136 * 25\% = 34\ second$$

Accepted 3 pcs.

4. Knitter's workload on one machine is calculated:

$$K_z' = \frac{t_n + t_{bn}}{(t_m + t_{bn}) * K_z} = \frac{34 + 136}{(542 + 136) * 0.85} = 0.3$$

5. From interpolation, we get coefficient $K_c = 1.1$

6. K_a - The coefficient, expressing portion of machine time in operational time is calculated:

$$K_a = \frac{t_m}{(t_m + t_{bn}) * K_c} = \frac{542}{(542 + 136) * 1.1} = 0.73$$

7. K_b – The coefficient, expressing portion of operational time in working shift duration is calculated:

$$K_b = \frac{T_{sm} - T_b}{T_{sm}} = \frac{28800 - 900}{28800} = 0.96$$

8. Coefficient, expressing time usage is calculated:

$$КПВ\ (CTU) = K_a * K_b = 0.73 * 0.96 = 0.7$$

9. Practical productive capacity of machine is calculated:

$$H_m = A_t * КПВ = 7 * 0{,}7 = 4{,}9$$

Accepted 5 pcs.

10. Knitter norm for production children's waistcoat:

$$H_b = H_m * H_o = 5 * 3 = 15\ pcs.$$

Normalization card is calculated in the following order

for children's cardigan:

Table 8

Details:	Number of course			Number of carriage movement per minute	Machine time t_m, sec.
	in main fabric	add.	totally		
Front side x2	172	5	177	51	208 x2
Back side	226	5	231	41	169
Sleeve x2	214	5	219	44	149 x2
Collar	20	5	25	22	68
					951

Number of double carriage movement per minute for each details:

For front side:

$$n_1 = \frac{60 * \vartheta * \eta}{2 * \left(\frac{И_1 * 0.0254}{K} + 2C\right)} = \frac{60 * 1.2 * 0.85}{2 * \left(\frac{86 * 0.0254}{12} + 2 * 0.2\right)} = 51\ times$$

For back side:

$$n_2 = \frac{60 * \vartheta * \eta}{2 * \left(\frac{И_2 * 0.0254}{K} + 2C\right)} = \frac{60 * 1.2 * 0.85}{2 * \left(\frac{164 * 0.0254}{12} + 2 * 0.2\right)} = 41\ times$$

For sleeve:

$$n_3 = \frac{60 * \vartheta * \eta}{2 * \left(\frac{И_3 * 0.0254}{K} + 2C\right)} = \frac{60 * 1.2 * 0.85}{2 * \left(\frac{152 * 0.0254}{12} + 2 * 0.2\right)} = 44\ times$$

For collar:

$$n_4 = \frac{60 * \vartheta * \eta}{2 * \left(\frac{И_4 * 0.0254}{K} + 2C\right)} = \frac{60 * 1.2 * 0.85}{2 * \left(\frac{476 * 0.0254}{12} + 2 * 0.2\right)} = 22\ times$$

There in:

ϑ- linear speed of carriage – 1.2 m/c

η- coefficient of carriage slippage- 0.85

И - number of needles in each details

K-gauge of knitting machine

C-carriage run out, 0.15-0.22 m

1. Machine time is calculated:

For front side:

$$t_{m1} = \frac{R_1 * z_1}{n_1} * \frac{60}{m} = \frac{177 * 2}{51} * \frac{60}{2} = 208\ second$$

For back side:

$$t_{m2} = \frac{R_2 * z_2}{n_2} * \frac{60}{m} = \frac{231 * 1}{41} * \frac{60}{2} = 169\ second$$

For sleeve:

$$t_{m3} = \frac{R_3 * z_3}{n_3} * \frac{60}{m} = \frac{219 * 1}{44} * \frac{60}{2} = 149\ second$$

For collar:

$$t_{m4} = \frac{R_4 * z_4}{n_4} * \frac{60}{m} = \frac{25 * 2}{22} * \frac{60}{2} = 68\ second$$

There in:

R- number of knitting course

n- number of double carriage movement per minute

z- number of knitting system, participating in the interloping of one course

m- number of knitting system on the machine

$$\sum t_m = t_{m1} * 2 + t_{m2} + t_{m3} * 2 + t_{m4} = 208 * 2 + 169 + 149 * 2 + 68 = 951\ second$$

2. Theoretical productive capacity of machine is calculated:

$$A_t = \frac{T_{sm}}{t_m} = \frac{3600}{951} = 4\ pcs.$$

3. Servicing norm of machine is calculated:

$$H_o = \frac{t_m + t_{bn}}{t_n + t_{bn}} * K_z = \frac{951 + 238}{60 + 238} * 0.85 = 3.4$$

$$K_z = 0.85$$

$$t_{bn} = t_m * 25\% = 951 * 25\% = 238\ second$$

$$t_n = t_{bn} * 25\% = 238 * 25\% = 60\ second$$

Accepted 3 pcs.

4. Knitter's workload on one machine is calculated:

$$K_z' = \frac{t_n + t_{bn}}{(t_m + t_{bn}) * K_z} = \frac{60 + 238}{(951 + 238) * 0.85} = 0.3$$

5. From interpolation, we get coefficient $K_c = 1.1$

6. K_a - The coefficient, expressing portion of machine time in operational time is calculated:

$$K_a = \frac{t_m}{(t_m + t_{bn}) * K_c} = \frac{951}{(951 + 238) * 1.1} = 0.73$$

7. K_b – The coefficient, expressing portion of operational time in working shift duration is calculated:

$$K_b = \frac{T_{sm} - T_b}{T_{sm}} = \frac{28800 - 900}{28800} = 0.96$$

8. Coefficient, expressing time usage is calculated:

$$КПВ\ (CTU) = K_a * K_b = 0.73 * 0.96 = 0.7$$

9. Practical productive capacity of machine is calculated:

$$H_m = A_t * КПВ = 4 * 0{,}7 = 2.8$$

Accepted 3 pcs.

10. Knitter norm for production children's waistcoat:

$$H_b = H_m * H_o = 3 * 3 = 9\ pcs.$$

CALCULATION OF ANNUAL PRODUCTION VOLUME

$$B_{pcs}^{year} = M_z * (H_{m1} + H_{m2}) * KPO(COE) * T_{year}$$

There in:

B_{pcs}^{year}- The volume of production per year

M_z- number of installed machines

H_m- Practical productive capacity of machine

$KPO(COE)$- Coefficient of operating equipment

T_{year}- working hours in a year

Based on the theme of diploma project, projecting knitting company specialized on producing 1,5 million outerwears for children. Considering the practical productive capacity of machine, the number of machines M_z for each assortment is found by the following formula:

$B_{pcs.}^{year} = 1\,500\,000$ pcs.

$$M_z = \frac{B_{pcs}^{year}}{(H_{m1} + H_{m2}) * KPO(COE) * T_{year}} = \frac{1\,500\,000}{(5+3) * 0.97 * 4055} = 48\ machines$$

For the first assortment- children's waistcoat:

1. The volume of production per year, in pcs.:

$$B_{pcs}^{year} = M_z * H_{m1} * KPO(COE) * T_{year} = 48 * 5 * 0.97 * 4055 = 944\,004\ pcs./year$$

2. The volume of production per day, in pcs.:

$$B_{pcs.}^{day} = \frac{B_{pcs.}^{year}}{274} = \frac{944\,004}{274} = 3445\ pcs./day$$

3. The volume of production per shift, in pcs.

$$B_{pcs.}^{shift} = \frac{B_{pcs.}^{day}}{2} = \frac{3445}{2} = 1722\ pcs./shift$$

4. The volume of production per year, by weight:

$$B_{kg}^{year} = B_{pcs}^{year} * Q_{max\,1ass.} = 944\,004 * 0.071 = 67\,024\ kg/year$$

5. The volume of production per day, by weight:

$$B_{kg}^{day} = \frac{B_{kg}^{year}}{274} = \frac{67\,024}{274} = 245\ kg/day$$

6. The volume of production per shift, by weight:

$$B_{kg}^{shift} = \frac{B_{kg}^{day}}{2} = \frac{245}{2} = 123\ kg/shift$$

For the second assortment- children's cardigan:

1. The volume of production per year, in pcs.:

$$B_{pcs}^{year} = M_z * H_{m2} * KPO(COE) * T_{year} = 48 * 3 * 0.97 * 4055 = 566\,402\ pcs./year$$

2. The volume of production per day, in pcs.:

$$B_{pcs.}^{day} = \frac{B_{pcs.}^{year}}{274} = \frac{566\,402}{274} = 2067\ pcs./day$$

3. The volume of production per shift, in pcs.

$$B_{pcs.}^{shift} = \frac{B_{pcs.}^{day}}{2} = \frac{2067}{2} = 1033\ pcs./shift$$

4. The volume of production per year, by weight:

$$B_{kg}^{year} = B_{pcs}^{year} * Q_{max\ 2\ ass.} = 566\,402 * 0.112 = 63\,437\ kg/year$$

5. The volume of production per day, by weight:

$$B_{kg}^{day} = \frac{B_{kg}^{year}}{274} = \frac{63\,437}{274} = 232\ kg/day$$

6. The volume of production per shift, by weight:

$$B_{kg}^{shift} = \frac{B_{kg}^{day}}{2} = \frac{232}{2} = 116\ kg/shift$$

I.9 CALCULATION OF THE AREA OF MAIN AND AUXILIARY PERMISES

1. Calculation of raw materials warehouse area:

Calculation of consumption of raw materials per day:

$$B_{ton}^{day} = \frac{B_{kg\ 1\ ass.}^{day} + B_{kg\ 2\ ass.}^{day}}{1000} = \frac{232 + 245}{1000} = 0.477\ ton/day$$

$$\sum S = \frac{B_{ton}^{day} * K_z}{KIP\ (CUS) * H} = \frac{0.477 * 10}{0.6 * 0.315} = 25\ m^2$$

There in:

K_z- coefficient of reserve 7-10 K_z- =10 days

H- weight per square meter H=0.315

KIP (CUS)- coefficient of utilization area-0.4-0.7 KIP (CUS) =0.6

2. Calculation of product relaxing area

20 pcs. garments in pack

$B_{kg\ 1\ ass.}^{day} = 245\ kg$ $B_{kg\ 2\ ass.}^{day} = 232\ kg$

$Q_{max\ 1ass.} = 0{,}071\ kg$ $Q_{max\ 2\ ass.} = 0.112\ kg$

$Q_{package\ 1} = 20 * 0.071 = 1.4\ kg$ $Q_{package\ 2} = 20 * 0.112 = 2.24\ kg$

Calculation number of packs:

$$K_P = \frac{\sum B_{kg}^{day}}{\sum Q_{package}} = \frac{245 + 232}{1.4 + 2.24} = 131\ pcs.$$

Size cell:

Width of details SH=700 mm Length of details D= 600 mm

Depth of cell: G_{ya}=SH+200=700+200=900 mm

Width of cell: SH_{ya}=4D=4*600=2400 mm

Height of cell: H_{ya}=1300-1500 mm $H_{ya} = 1400\ mm$

$S_{ya} = 1 - 1.6$ S_{ya}=1.6

Coefficient of reserve: $K_z = 1 - 3$ K_z =2

Coefficient of layering: $K_{ya} = 1 - 3$ $K_{ya} = 3$

Practical number of cells:

$$P_P = \frac{H_{ya}}{D} + \frac{SH_{ya}}{D} = \frac{1400}{600} + \frac{2400}{600} = 6.3\ pcs.$$

Number of needed cells:

$$P_{ya} = \frac{K_p}{P_P} = \frac{131}{6} = 22\ pcs.$$

Surface of relaxing area:

$$S = \frac{P_{ya} * S_{ya} * K_z}{KIP\ (CUS) * K_{ya}} = \frac{22 * 1.6 * 2}{0.6 * 3} = 39\ m^2$$

Accepted 40 m^2

3. Calculation of ready garment's warehouse area:

Coefficient of reserve: $K_z = 7 - 10\ days$ $K_z = 10$

Coefficient of using each area surface: K=1.9

$N_m = 800 - 2200$ $N_m = 1100$

$$S_{a.r.g} = \frac{\sum B_{pcs.}^{day} * K_z * K}{N_m * KIP(CUS)} = \frac{5512 * 10 * 1.9}{1100 * 0.6} = 158\,m^2$$

Accepted 160 m^2

I.10 CALCULATION OF SEWING UNIT

Calculation of sewing unit for children's waistcoat

For first assortment

The volume of production per shift, in pcs. is calculated:

$$B_{pcs.}^{shift} = \frac{B_{pcs.}^{year}}{2 * 274} = \frac{944\,004}{548} = 1722\ pcs./shift$$

Number of sewing fluxes is calculated:

$$N_n = \frac{B_{pcs.}^{shift}}{M_n} = \frac{1722}{700} = 2\ fluxes$$

There in: M_n- Sewing unit capacity: $400-800 \qquad M_n = 700$

Time of sewing flux is calculated:

$$\tau = \frac{T_{sm}}{M_n} = \frac{28\,800}{700} = 41\ second$$

Number of workplaces in sewing unit is calculated:

$$n_k = \frac{t_k}{\tau}$$

1. Sewing the shoulders stitch on the drum type sewing machine:

$$n_1 = \frac{t_1}{\tau} = \frac{50}{41} \approx 1\ person$$

2. Sewing buttons in the buttons sewing machine:

$$n_2 = \frac{t_2}{\tau} = \frac{50}{41} \approx 1\ person$$

3. Waste cleaning:

$$n_4 = \frac{t_4}{\tau} = \frac{40}{41} \approx 1\ person$$

4. Formation on the mannequin on the air-steam mannequin for outerwear:

$$n_3 = \frac{t_3}{\tau} = \frac{40}{41} \approx 1\ person$$

5. Packaging:

$$n_5 = \frac{t_5}{\tau} = \frac{40}{41} \approx 1\ person$$

Number of workplaces for two sewing fluxes:

$$\Sigma n = 2 * (n_1 + n_2 + n_3 + n_4 + n_5) = 2 * (1 + 1 + 1 + 1 + 1) = 10\, person$$

Calculation of sewing unit for children's cardigan

For second assortment

The volume of production per shift, in pcs. is calculated:

$$B_{pcs.}^{shift} = \frac{B_{pcs.}^{year}}{2 * 274} = \frac{566\,402}{548} = 1033\ pcs./shift$$

Number of sewing fluxes is calculated:

$$N_n = \frac{B_{pcs.}^{shift}}{M_n} = \frac{1033}{500} = 2\ fluxes$$

There in: M_n- Sewing unit capacity: $400 - 800 \qquad M_n = 500$

Time of sewing flux is calculated:

$$\tau = \frac{T_{sm}}{M_n} = \frac{28\,800}{500} = 58\ second$$

Number of workplaces in sewing unit is calculated:

$$n_k = \frac{t_k}{\tau}$$

1. Sewing the shoulders stitch on the drum type sewing machine:

$$n_1 = \frac{t_1}{\tau} = \frac{50}{58} \approx 1\ person$$

2. Sewing profiles stitch on the drum type sewing machine:

$$n_2 = \frac{t_2}{\tau} = \frac{80}{58} \approx 1\ person$$

3. Sewing sleeves stitch on the drum type sewing machine:

$$n_3 = \frac{t_3}{\tau} = \frac{80}{58} \approx 1\ person$$

4. Linking sleeves on the drum type sewing machine:

$$n_4 = \frac{t_4}{\tau} = \frac{100}{58} \approx 2\ person$$

5. Linking collar on the linking machine:

$$n_5 = \frac{t_5}{\tau} = \frac{140}{58} \approx 2\ person$$

6. Sewing buttons in the **buttons sewing machine:**

$$n_6 = \frac{t_6}{\tau} = \frac{50}{58} \approx 1\ person$$

7. Waste cleaning:

$$n_7 = \frac{t_7}{\tau} = \frac{40}{58} \approx 1\ person$$

8. Formation on the mannequin on the air-steam mannequin for outerwear:

$$n_8 = \frac{t_8}{\tau} = \frac{60}{58} \approx 1\ person$$

9. Packaging:

$$n_9 = \frac{t_9}{\tau} = \frac{50}{58} \approx 1\ person$$

Number of workplaces for two sewing fluxes:

$$\Sigma n = 2 * (n_1 + n_2 + \ldots + n_9) = 2 * (1 + 1 + 1 + 2 + 2 + 1 + 1 + 1 + 1) = 22\ person$$

II. SPECIAL PART

II.1 CARDIGAN PATTERN EFFECT ON V-BED KNITTING MACHINE

Cardigan stitches are two-course repeat tuck rib knitwear structures, widely used in the body sections of heavy-weight stitch-shaped sweaters. The tuck stitches cause the rib wales to gape apart so that the body width spreads outwards to a greater extent than the rib border. The tuck loops increase the fabric thickness and make it heavier in weight and bulkier in handle, although the rate of production in rows of loops will be less than for normal 1x1 or 2x2 rib. The greater the proportion of tuck to cleared loops, the heavier and wider the finished relaxed structure [1].

Full-cardigan or polka rib (Fig. 13) consists of one course of loops knitted on the front bed and tucks on the back, and the second course with the sequence reversed, thus producing a balanced 1x1 tuck rib structure with the same appearance on both sides. If different coloured yarns are knitted at alternate courses, a **'shot rib'** will be produced which in the relaxed state will show one colour on one side and the second colour on the opposite side.

In open width, a 1x1 rib fabric will relax by about 30 per cent, half-cardigan by only 5 per cent, and full-cardigan will show no width shrinkage compared with its original knitting width.

To knit half-cardigan on a single-system hand-flat, one of the four cardigan cams is taken out of action so that in one direction of traverse a tuck stitch will be knitted on one needle bed only. To knit full-cardigan, diagonally opposite pairs of cardigan cams are taken out of action so that in one direction of traverse the front needle bed will tuck and in the return traverse the back needle bed will tuck.

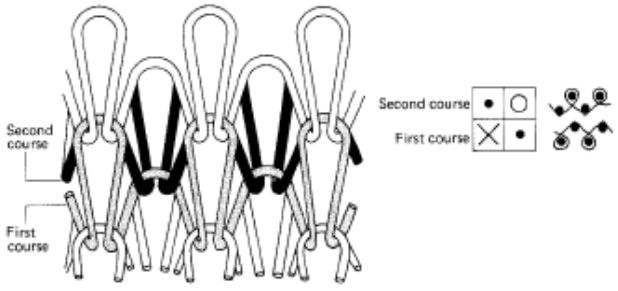

Fig. 13 Full cardigan loop structure.

For the purpose of definition of technological parameters and physic-mechanical properties in cardigan structure four samples have been developed. Technological parameters cardigan structures are defined; the received results are resulted in table 9.

The analysis of results of the researches spent by many science officers have shown, that decrease in surface density of knitting in certain limits leads to reduction of the expense of raw materials and are not less dangerous to it strength properties as the absolute size of durability of knitted fabrics is high, and while in service products are exposed to the loadings which are not exceeding 10 % from the explosive.

As the knitting is three-dimensional structure in the characterized length, width and thickness and lightness of this structure is necessary to define not two-dimensional criterion (surface density), and three-dimensional (volume density). The volume density of knitting shows the maintenance of textile threads in volume unit.

At use of volume density as criterion of structures lightness the concept “lightness” extends. Thus the category of fabrics with lowered raw material expenditure joins fabrics with the friable structure, having a considerable thickness in comparison with the base. As fabrics lowered raw material expenditure is called the fabrics, which volume density more low, than at base, developed with the optimum module of a loop from an identical yarn.

As criterion of raw material expenditure traditionally consider surface density of a fabric. As is known, decrease in surface density of knitting involves change of operational and hygienic characteristics. Therefore, the indicator which simultaneously characterizes and raw material expenditure of fabrics, and a quality indicator is entered. Such indicator is the indicator of lightness knitting structures in which along with surface density its thickness is considered also.

Indicator of lightness knitting structures it is possible to use volume density:

$$\delta = m_{тр} / M,$$

There in: δ - volume density of knitting, mg/sm^3

$m_{тр}$ - surface density of knitting, g/m^2

M - thickness of knitting, mm.

Table 9

Technological parameters of knitting

	Linear density of yarn, tex	Width of loop A, (мм)	Height of loop B, (мм)	Density of loops on horizontal, Pg	Density of loops on vertical Pv	Length of loop, l (mm)	Surface density, g/m^2	Thickness, mm	Volume density, mg/sm^3
0	PA 32/2	1	0,8	50	40	5	360,6	1,35	267
1		0,9/1	0,8	54/52	45	5,2/5	351,5	1,4	251
2		0,9/1	0,8	54/52	45	5,2/5	357,2	1,4	255
3		1/1	0,9	52/52	40	5,3/5	364,3	1,42	256,5
4		1/1	0,9	52/52	40	5,3/5	371	1,44	257

The surface density developed base cardigan makes interloping 360,6 g/m^2, the first variant makes - 351,5 g/m^2, the second variant makes - 357,2 g/m^2, the third variant - 364,3 g/m^2, the fourth variant - 371 g/m^2 (fig. 2.). If not to consider a base variant, among the developed new variants the highest indicator of surface density has the fourth variant - 371 g/m^2, the least indicator of surface density has the first variant - 351,5/m^2 surface density by variants vary on certain law, i.e. on increase within 5,3 %. The histogram of change of surface density is presented on fig. 14.

If to compare in a percentage parity the surface density of the fourth variant in comparison with the first increases by 5,3 %, on comparison with the second increases by 3,8 %, in comparison with the first increases by 1,9 %.

Proceeding from it is necessary to draw a conclusion, that all above-stated changes are influenced by knitting structure. As rib structures are entered into structure elements of pattern knitting, in this case cardigan sketches which quantity varies in variants, in the developed samples change of surface density is observed.

The volume density developed cardigan makes interloping of a base variant - 267 mg/sm^3, the first variant makes - 251 mg/sm^3, the second variant - 255

mg/sm^3, the third variant - 256,5 mg/sm^3, the fourth variant - 257 mg/sm^3 (fig.3). The histogram of change of volume density of knitting is presented on fig.15.

The volume density by variants varies on certain law, i.e. on increase within 2,4 %. If to compare in a percentage parity the volume density of the fourth variant in comparison with the first increases by 2,4 %, on comparison with the second increases by 0,8 %, in comparison with the third increases by 0,2 %.

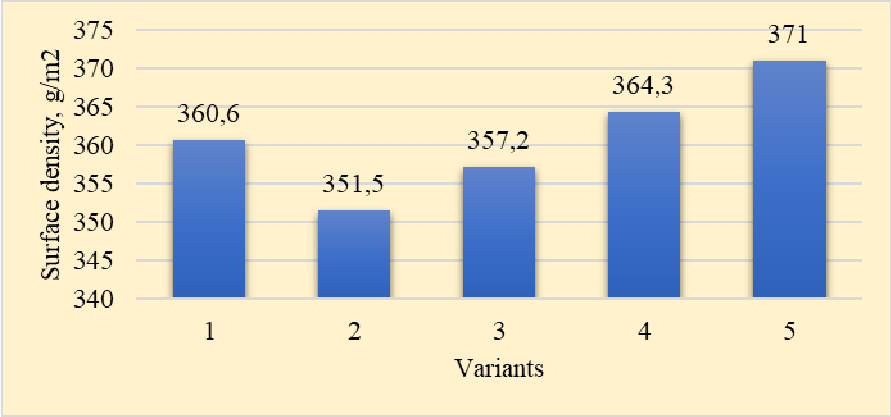

Fig.14 Histogram of surface density changing.

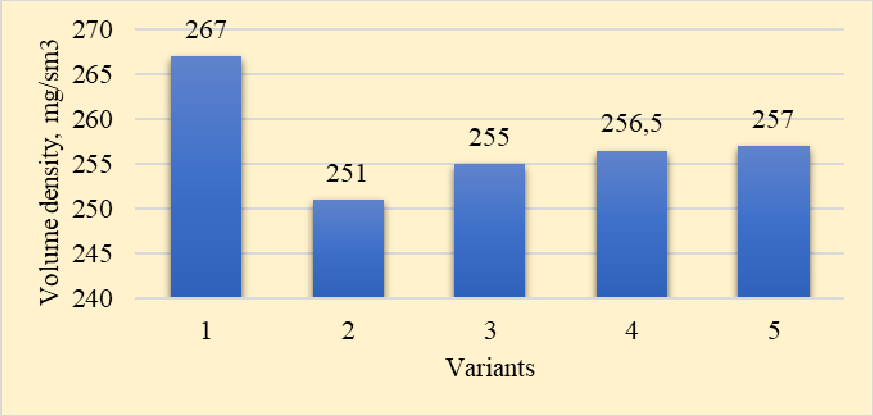

Fig. 15 Histogram of volume density changing.

From this it is visible, that the volume density of the developed samples also varies on law of increase, but in all new variants the volume density is less, than at a base structure. It means that the less volume density, the raw materials expense is less. Introduction in pattern knitting structure an element means - cardigan sketch reduces the raw materials expense, at the same time improves appearance of knitting.

Conclusion

Results of analyses show that offered structures have some advantages to compare to basic structure. On the aim of resource economy technology, they give a possibility of raw material expenditure decreasing 2,4%. There is not lost strength parameters. Structures consist of normal rib loops, plain structure loops, cardigan stitches and elongated loops. Meanwhile they are offered to produce both at simple and modern computerized flat knitting machines like SHIMA-SEIKI, PROTTI, STOLL, UNIVERSAL that have necessary technological possibilities.

III. LABOUR PROTECTION AND ECOLOGY PART

III.1 Sanitary and hygienic requirement for children's knitted garments

Designing of children's clothes in the conditions of industrial production assumes the account of the following requirements, shown to children's clothes, the main of which are: Beauty, Convenience, Hygienic, Security, Taking into account the physiological and psychological development of the child at every age.

All these requirements are reduced to a set of modern requirements of utilitarian, practical, hygienic and artistic order.

Hygienic requirements for children's clothing determine the choice of materials depending on the specific purpose of the product and climatic conditions, as well as optimization of the package of materials and product design.

Sanitary and hygienic requirement for children's knitted garments is established in “GENERAL TECHNICAL REGULATION on the safety of light industry products” approved on 11 May 2016 by the Cabinet of Ministers Reinstatement № 148 of the Republic of Uzbekistan.

According to Technical Regulation safety of light industry products is assessed by the following components of biological and chemical safety:

- biological properties (hygroscopicity, air permeability, water resistance, specific surface electrical resistance, electrostatic field strength, toxicity index);
- chemical composition (the maximum permissible release of harmful chemicals into the air and / or aquatic environment).
- clothing and products of the first and second layers in contact with the human skin should not have a local skin irritant effect or the toxicity index value determined in the aquatic environment should be in the range of 70 to 120%; in the air - from 80 to 120% inclusive.
- chemical fibers and threads, as well as auxiliary substances and materials used in the light industry, must have a safety data sheet.

Indicators of product safety for children and teenagers are regulated according to the age, functional purpose, the area of contact with the skin, the composition of the materials used.

In accordance with the function of clothing and products are divided into clothes and products of the 1st, 2nd and 3rd layers.

- For clothes of 1st layer comprises products in direct contact with the wearer's skin: underwear and bed linen, corsetry and swimwear products, hats (summer), hosiery, handkerchiefs and headaches and other similar products.
- For clothes of the 2nd layer are products that have limited contact with the wearer's skin: dresses, blouses, shirts, tops, pants, skirts, dresses, suits, sweaters, jumpers and other similar products.
- For clothes the 3rd layer includes coats, jackets, coats, suits (lined) and other similar products.

From the products must not emit chemicals first class of danger.

Products for newborns and linen products for children under the age of 1 year should be made of natural materials; connecting joints with buttonhole slices in Linen for babies to be performed on the front side; exterior and decorative elements (lace, sewing, and other applications) are made of synthetic materials not be in direct contact with the baby's skin.

In products for newborns (envelopes, blankets, pillows and the like) as fillers can be used artificial and synthetic materials.

Product safety evaluated by organoleptic (smell), sanitary and chemical (list of controlled chemicals is determined by the chemical composition of the material), physical hygiene (hygroscopic, air permeability, electrostatic field), toxicological and hygiene (index of toxicity or local irritant effect) safety parameters.

Requirements for the organoleptic characteristics

The intensity of the smell products of the 1st layer should not exceed 1 point; 2nd and 3rd layers - 2 points. The intensity of smell the water extract from products of the 1st layer should not exceed 1 point; 2nd layer - 2 points.

Requirements of sanitary and chemical, and physical and hygienic safety

A list of chemical substances controlled is determined depending on the chemical composition of the material and appearance of the product.

Harmful chemicals in the clothes of the 1st and 2nd layers are determined in an aqueous medium in the products of the 3rd layer (except products for newborns) - in the air. In products third layer neonatal determined harmful chemicals in an aqueous medium.

1) For children under 1 year from clothing textiles, knitwear and ready-made textile products must meet the requirements of the chemical, physical and hygienic safety:

- Clothes of the 1st layer (bed linen, knitwear and garments of textile materials) must comply with the following standards: hygroscopicity - not less than 14%; breathability - at least 150 dm3/m2s for products made of flannel and fustian allowed at least 70 dm3/m2s; free formaldehyde - less than 20 μg/g.

- Clothes of the 2nd layer (knitted garments and textile materials) must comply with the following standards: hygroscopicity - at least 10%; breathability - at least 150 dm3/m2s for products made of flannel, fustian allowed at least 70 dm3/m2s; free formaldehyde - less than 20 μg/g.

- Clothes of the 3rd layer (knitted garments and textile materials) must comply with the following standards: hygroscopicity (for lining) - not less than 10%; air permeability (for lining) - at least 100 dm3/m2s; for the lining of flannel, fustian lined (vorsovannyh) fabrics, denim and corduroy fabrics - not less than 70 dm3/m2s. free formaldehyde - less than 20 μg/g.

2) For children over 1 year and teenager's clothes and garments from textile materials shall meet the requirements of physical and chemical, and hygienic safety according to the requirements of Table

3) Textile materials shall meet the requirements of chemical safety.

4) Release of volatile chemicals contained in textiles caused by the use of coupling agents, shall not exceed the standards.

5) Leather for clothing, headgear must meet the following requirements:

Mass fraction of free formaldehyde - not more than 20 μg/g;

Mass fraction of water leachable chromium (VI) in the skin is not allowed.

6) Clothing and fur products for children under 1 year must meet the following requirements:

Mass fraction of free formaldehyde in the leather and hair - no more than 20 μg/g;

Mass fraction of water leachable chromium (VI) in the leather and hair - not allowed.

7) Clothing and fur products for children older than 1 year must meet the following requirements:

Mass fraction of free formaldehyde in the leather and hair - no more than 75 μg/g;

Mass fraction of water leachable chromium (VI) in the leather and hair - no more than 3.0 μg/g. Textiles clothing and fur products shall meet the requirements of biological and chemical safety requirements for textiles.

8) Electrostatic field on surface of the articles should not exceed 15.0 kV/m.

Requirements for toxicological and hygienic parameters

1. Clothing of the 1st and 2nd layers should not have the local skin-irritating.

2. Textile materials used for making clothes for infants should not have irritative action.

3. Toxicity index products in the aqueous medium (distilled water) should be from 70 to 120%, inclusive, in the air - from 80 to 120% inclusive. The toxicity index value determined using luminescent bacteria test, should be less than 20%.

The State Agency for Standardization, Metrology and Certification, the Ministry of Health of the Republic of Uzbekistan and their territorial bodies, as well as other specially authorized state bodies within their competence carry out the state control over compliance with the requirements of the Technical Regulations.

IV. ECONOMIC PART

IV.1 Calculation of business plan sections

A Business Plan is a document that outlines all major aspects of the projected business and includes the following sections:

- Executive summary - resume;
- Business model- general description of business;
- Marketing model- products and services;
- Production plan;
- Management and organization;
- Organizational and legal form of the enterprise;
- Financial plan.

Executive summary is written last, after calculating all sections of business plan completely. Executive summary includes information about main features of projecting company, volume of production, the number of required employments, payroll fond, sales volume and profit indicators, break-even volume of production and profitability, period of capital repayments. The general description of business, the product and service section is provided in the technological part of diploma project.

The production of knitted goods is planned on the basis of the main assortment in natural unit. The production capacity of the enterprise is also planned in value units, which include commodity, net products and sales.

In natural units we plan to produce how many kilograms of knitted fabric, in a set size, is needed for production of each product range that is planned to manufacture and how many units of knitted goods can be produced taking into account the raw material consumption per unit of production, we can plan the level of manufactured goods, real goods and sold products. The cost of product is calculated as follows: $P= AP*Wp*c$

There in: AP- production capacity of annual production;

WP- set wholesale price of a product;

C – sort coefficient, c=0,95

Machine hours ready to use and operating machine hours is calculated as follow:

Machine hours ready to use = $M_z * T_{year} = 96 * 4055 = 389\ 280$ hours

There in:

M_z – number of machines ready to use = 96

T_{year} – duration of the year (in hours) = 4055

Operating machine hours = Machine hours ready to use * KPO (COE) =

389 280*0.97 = 377 602 hours

There in:

KPO (COE) - operating efficiency of the machines = 0.97

Annual production volume of the natural units is determined as follows:

First assortment:

$$B_{pcs}^{year} = M_z * H_{m1} * KPO(COE) * T_{year} = 48 * 5 * 0.97 * 4055 = 944\ 004\ pcs./year$$

Second assortment:

$$B_{pcs}^{year} = M_z * H_{m2} * KPO(COE) * T_{year} = 48 * 3 * 0.97 * 4055 = 566\ 402\ pcs./year$$

There in:

H_m – Practical productive capacity of machine

First assortment:

$$B_{kg}^{year} = B_{pcs}^{year} * Q_{max\ 1ass.} = 944\ 004 * 0.071 = 67\ 024\ kg/year$$

Second assortment:

$$B_{kg}^{year} = B_{pcs}^{year} * Q_{max\ 2\ ass.} = 566\ 402 * 0.112 = 63\ 437\ kg/year$$

There in:

Q_{max} – Weight of product unit

Identified indicators by planning production of products is expressed in the form of production program.

Calculation of production program

Table 10

№	Type of product	Type of equipment	Number of equipment	Machine hours ready to use	a_1	a_2	a_3	a_4	KPO (COE)	Operating machine hours	B_{kg}^{year}	B_{pcs}^{year}	Practical productive capacity of machine	Price of products, thousand UZS	Sold product, thousand UZS
1	Children's waistcoat	STOLL CMS 502 HP	48	194 640	0.37	0.67	2	0.197	0.97	188 801	67 024	944 004	5	6 516 964	8 211 375
2	Children's cardigan	STOLL CMS 502 HP	48	194 640	0.37	0.67	2	0.197	0.97	188 801	63 437	566 402	3	10 280 283	12 953 197

Planning of raw materials

Planning efficient use of material resources is the ability to identify the amount of raw materials that should be spent on the production of the product unit at the enterprise, identify the measures to reduce the raw material consumption and, as a result, increase the production volumes.

In the production of knitwear, planning of raw materials is described in the form of a raw material balance sheet.

Quantity and value of raw materials required for the knitting fabric production and quantity and value of raw materials embodied in ready-made knitwear products are express as the raw material balance sheet.

Calculation of raw material balance sheet

Table 11

Entered to production					Received from production				
Type of raw material	Composition, %	Quantity, kg	1 kg of raw material price, UZS	Raw material value, thousand UZS	Type of product	Composition, %	Quantity, kg	Price, UZS	Value, thousand UZS
1	2	3	4	5	6	7	8	9	10
	100	67024	47500	3183640	Children's Waistcoat Waste: Main Additional	97.9 0.4 1.7	65616.5 268.1 1139.4	48509.5 475 427.5	3183025.6 127.3 487.1
Total	100			3183640	total	100			3183640
Acrylic yarn	100	63437	47500	3013258	Children's Cardigan Waste: Main Additional	94.5 3.8 1.7	59948 2411 1078	50237.7 475 427.5	3011652 1145.2 460.8
Total	100			3013258	total	100			3013258

Calculation of staff table

When planning labor resources at knitting company, they are divided into main, assistive and related team workers.

Employees of the main group are workers who are directly involved in the production of goods. These include group of workers, such as knitters, cutters, sewers, ironers, masters and business executives.

Employees of the assistive group are workers who are ensure the continuity of the main group worker's performance. These include group of workers, such as, master assistants, lubricant cleaning workers, carriers, an electrician, locksmith.

Employees of related team include workers such as cleaners, laboratory technicians and warehouse staff.

The number of main group workers is planned at the enterprise, depending on the planned production volume, the productivity of the machine and the machine operator's service norm.

The number of assistive and related team workers is planned at the enterprise, depending on their servicing norm.

In textile enterprises, salaries are planned in accomplished work basis or on a timely basis. Salaries that are paid in the proportion to the amount of work accomplished are calculated as follows:

$$AWS = UP*V$$

Where, AWS – Accomplished work basis salary;

UP - unit price for each produced good;

V – volume of produced goods.

Salaries that are paid on a timely basis are paid for working hours taking into account the tariff rates of each employee and calculated as follows:

$$WHS = TR*WH$$

Where, WHS – working hour salary;

TR- tariff rates, the fee for the time unit, taking into account the rates of employees; WH- working hours

Calculation of staff table

Table 12

Grouping of Workers by Occupation	Number of equipment	Ho	Number of workers	Number of workers	Total	Worked hours	Rates of employees	Tariff rates, UZS	Valuation, UZS	Fee system	Percentage of premium	Accomplished work basis salary, thousand UZS	Accomplished work basis premium, thousand UZS	Working hour salary, thousand UZS	Working hour premium, thousand UZS	Hourly salary fund thousand UZS	Average hourly salary, USZ
			1sh	2sh													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1-gr.Employees of the main gr.																	
Knitters	96	3	32	32	64	129760	4	4952		в/м	40	-	-	642571	257028	899599	6933
Defect testers			4	4	8	16220	4	4952		в/м	40	-	-	80321	32128	112449	6933
Sewers	20		20	20	40	81100	4	4952		в/м	40			401607	160643	562250	6933
Ironers (moulder)	4		4	4	8	16220	3	4506		в/м	40			73087	29235	102322	6308
Packer			4	4	8	16220	2	4024		в/м	40			65269	26108	91377	5634
Master			2	2	4	8110	6	6010		в/м	40	-	-	48741	19496	68237	8414
Total 1 gr.			**66**	**66**	**132**											**1836234**	
2-gr. Employees of assist. gr.																	
Team leaders			2	2	4	8110	6	5766		в/м	30	-	-	46762	14029	60791	7496
Master assistants			1	1	2	4055	6	5766		в/м	30	-	-	23381	7014	30395	7496
Lubricant cleaning workers			1	1	2	4055	2	3485		в/м	30	-	-	14132	4240	18372	4531
Carriers			2	2	4	8110	2	3485		в/м	30	-	-	28263	8479	36742	4530
Electricians			1	1	2	4055	5	5240		в/м	30	-	-	21248	6374	27622	6812
Locksmith			1	1	2	4055	5	5240		в/м	30	-	-	21248	6374	27622	6812
Total 2 gr.			**8**	**8**	**16**											**201544**	
3-gr. Related team workers																	
Laboratory technicians			1	1	2	4055	salary	600 th. UZS		в/м	25	-	-	14400	3600	18000	4440
Cleaners			2	2	4	8110	salary	500 th. UZS		в/м	25	-	-	24000	6000	30000	3699
Warehouse staff			1	1	2	4055	salary	550 th. UZS		в/м	25	-	-	13200	3300	16500	4069
Total 3 gr.			**4**	**4**	**8**											**64500**	
Totally on the enterprise			**78**	**78**	**156**											**2102278**	

Calculation of annual salary fund

Table 13

Salary funds	Amount, thousand UZS
1. Accomplished work basis salary	-
2. Working hour salary	2 102 278
3. Hourly salary fund	2 102 278
4. For preferential hour of teenagers	21 023
5. For the night shift work	31 534
6. Daily salary fund	2 154 835
7. For holiday	107 742
8. Annual salary fund	2 262 577
9. Unified social payment	565 644

$$Average\ monthly\ salary\ of\ a\ worker = \frac{Annual\ salary\ fund}{12 * number\ of\ workers}$$

$$= \frac{2\ 262\ 577\ thousand\ UZS}{12 * 156} = 1\ 208\ 642\ UZS$$

Planning production cost

All operating costs of the enterprise are divided into the following groups:

1. Costs incurred in production

2. The cost does not fall within production costs, but is related to the main business activities of the enterprise expense incurred by the time period. Production costs include labor inputs and other costs related to raw materials, materials, fuel, energy and basic production funds, which are subdivided into the following categories:

1. Material expenditure on production.

2. Labor costs for production.

3. Unified social payment.

4. Amortization of fixed assets.

5. Other expenses

1. Calculation of material costs in production character

Raw materials and basic materials. These costs are determined on the basis of the raw material balance sheet: 6 196 898 thousand UZS

a) Supplemental materials. These expenditures are planned based on the auxiliary materials used for the product unit, including all the auxiliary materials used for the selected assortments, such as yarn, button, trowel, paint, glue and various packaging materials. 8-10% 495 752 thousand UZS

b) Steam and water costs used for technological purposes. Consumption costs are planned based on the value of the steam and water price and the unit price.

1044 thousand UZS

d) Inventory costs. In order to identify these costs, the number of machines and equipment set at the enterprise can be estimated as a full value and can be planned at a rate of 1-3%.

215 035 thousand UZS

Value of the equipment can be determined as the following table

Table 14

№	Name of equipment	Number of equipment	Cost of one equipment, thousand UZS	Installation costs, thousand UZS	Total equipment cost, thousand UZS	Power consumption of one equipment KW	Total power consumption KW
1.	Stoll CMS 502 HP knitting machine	96	100 000	10 000	10 560 000	1.7	163.2
2.	Drum type sewing machine JUKI	12	4 200	420	55 440	0.4	4.8
3.	Linking machine Complett	4	5 200	520	22 880	0.25	1
4.	Buttons sewing machine Jack	4	4 800	480	21 120	0.4	1.6
5.	Yarn winding machine FSM-04-2	1	3 500	350	3 850	0.08	0.08
6.	Air steam ironman CO-1	4	20 000	2 000	88 000	2.2	8.8
7.	Table	2	200	20	440	-	-
	Total	123			10 751 730		179.5

e) The cost of storing and heating buildings for production purposes is planned for every 1 m^2 production area. $S_p = 1440\ m^2$

21 831 thousand UZS

f) Expenditures on current repair of buildings, which are planned for each 1 m^2 production area. $S_p = 1440\ m^2$

31 974 thousand UZS

g) Electricity costs are planned for each kW per hour and for each "kilowatt-hour" power.

Σg = 115 859 + 24 164 + 2 416 + 23 172 = 165 611 thousand UZS

All types of power costs are as follows: - for engines, lighting, auxiliary illumination, heating, moisture and air circulation.

g.a) The required electricity costs for engines are as follows:

$$X_{dv} = E_m * H_{en} = 115\,859\ thousand\ UZS$$

Where:

E_m - Annual demand for engine power, in kW / hour.

H_{en} - Cost of one kilowatt-hour of motor power, UZS.

$$E_m = \frac{\Sigma EDK_{dv} * D_{ik} * T_{sm} * n_{sm}}{K_e} = \frac{179.5 * 274 * 7.4 * 2}{1.2} = 606\,590\ kW/hour$$

Where:

ΣEDK_{dv} - The power of the installed equipment.

D_{ik} - The number of working days during the year.

K_e - energy utilization ratio for equipment (1,1-1,3).

g.b) calculation of electricity required for lighting:

Calculation of electricity required for lighting production.

$$X_{el.en.p} = \left(S_p * N_n * T_{year} * H_{\frac{1kw}{hour}}\right) : K_e = (1440 * 0.023 * 4055 * 0.191) : 1.2$$
$$= 21\,376\ thousand\ UZS$$

$N_n - 0.023\ kW/hour$

Calculation of electricity required for lighting of administrative building.

$$X_{el.en.ad} = \left(S_{ad} * N_n * T_{year} * H_{\frac{1kw}{hour}}\right) : K_e = (288 * 0.015 * 4055 * 0.191) : 1.2$$
$$= 2\,788\ thousand\ UZS$$

$$N_n - 0.015\ kW/hour$$

$$X_l = X_{el.en.p} + X_{el.en.ad} = 21\,376 + 2\,788 = 24\,164\ thousand\ UZS$$

g.c) duty lighting is 10% of the cost of electricity required for lighting:

$$24\,164\ thousand\ UZS * 10\% = 2\,416\ thousand\ UZS$$

g.d) The amount of electricity required for heating, moisture and air circulation will be 20% of engine power.

$$115\,859\ thousand\ UZS * 20\% = 23\,172\ thousand\ UZS$$

The sum of the above costs is equal to the cost of production:

a + b + c + d + e + f + g = 6 196 898 +495 752 +1044 + 215 035 + 21 831 + 31 974 + 165 611 = 7 128 145 thousand UZS

2. Calculation of labor cost in production character

(defined on the basis of staff table)

Table 15

Structure of the salary fund (IXF)	Basic salary, thousand UZS	Extra salary, thousand UZS	Total salary thousand UZS
1 group. Salary of workers involved in production	1 836 234	137 717	1 973 951
2 group. Salary of assistive workers	201 544	15 116	216 660
3 group. Salary of repair workers of industrial buildings	64 500	4 837	69 337
4 group Salary of executives, specialists and employees	82 630	6 197	88 827
Total:	2 184 908	163 867	2 348 775

3. Calculation of "Unified social payment"

$$X_{usp} = \frac{\Sigma IXF_{tot.} * X\%}{100} = \frac{2\,348\,775 * 25}{100} = 587\,194\ thousand\ UZS$$

4. Calculation of fixed assets amortization cost

This section includes:

1. Amortization of technological equipment.

$$A_{tech} = KM_{tech} * 20\% = 10\,751\,730 * 20\% = 2\,150\,346\ thousand\ UZS$$

2. Amortization of buildings.

$$A_b = KM_b * 5\% = (504\,000 + 80\,640) * 5\% = 29\,232\ thousand\ UZS$$

$$KM_b = S_p * H_{m.p} + S_p * H_{m.ad}$$

3. Amortization of vehicles related with production.

$$A_v = A_{tech} * 3\% = 2\,150\,346 * 3\% = 64\,510\ thousand\ UZS$$

Total amortization:

$$A_{tot.} = A_{tech} + A_b + A_v = 2\,150\,346 + 29\,232 + 64\,510 =$$

$$= 2\,244\,088\ thousand\ UZS$$

5. Other production costs

These expenditures include:

a) Maintenance costs of main production funds, maintenance costs, overhaul, medium and corrective maintenance.

$$X_{maint} = \frac{IXF_{ass.} * 100}{60} = \frac{216\,660 * 100}{60} = 361\,100\ thousand\ UZS$$

b) Environmental costs will be charged at a rate of 10% from the "Incurred period expense". $35\,531\ thousand\ UZS$

c) Costs of technical safety and protection of labor shall be determined on the basis of the established normative basis for each worker account.

$1\,092\ thousand\ UZS$

d) Scientific research, design, production at the workshops and the cost of rationalization will be charged at a rate of 10% of the cost of technological equipment. $215\ 035\ thousand\ UZS$

The sum of "Other production costs" is as follows:

$$X_{oth.} = X_{maint} + X_{envir.} + X_{tech\,saf.} + X_{ras.} = 361\ 100 + 35\ 531 + 1\ 092 + 215\ 035 = 612\ 758\ thousand\ UZS$$

The cost of annual production volumes

Table 16

№	Expenditures:	Total prime cost, thousand UZS	Prime cost of one product, UZS	In percentage to the total %
1.	Material costs in production character	7 128 145	4 719	55.2
2.	Labor cost in production character	2 348 775	1 555	18.2
3.	Unified social payment	587 194	389	4.5
4.	Fixed assets amortization cost	2 244 088	1 486	17.4
5.	Other production costs	612 758	406	4.7
	Total product prime cost	12 920 960	8 555	100

6. Operating or incurred period expenses

"Incurred period expense" is calculated using the follow formula:

$$Incurred\ period\ expense = \frac{Salary\ of\ the\ general\ factory\ staff}{25} * 100 = \frac{88\ 827 * 100}{25} = 355\ 308\ thousand\ UZS$$

Other expenses in "Incurred period expense" is distributed as follow:

Table 17

№	Expenses:	Percentage, %	Value, thousand UZS
1.	Expense for salary of the general factory staff	25	88 827
2.	Office and administration expenses	6	21 318
3.	Business trip expenses	7	24 871
4.	Maintenance cost of general factory administration	15	53 296
5.	Maintenance cost of general factory laboratory	12	42 637
6.	Scientific research and experimental-design costs associated with the development and management of the enterprise	8	28 425
7.	Preparation and development of new products and new technologies	9	31 978
8.	Costs related with marketing research and sales	8	28 425
9.	Other business expenses	10	35 531
	Total:	100	355 308
10.	Property tax	5%*MPF	566 818
11	Land tax	$(S_p + S_{ad.}) * 1m^2$	133 920
12	Payment for water	$B_{year} * H_{pcs}$	1044
13	Road fund payments	$(TM_{w.con} - VAT) * 1.5\%$	251 959
	Total:		1 309 049

Calculation account cost plan of projected products

(1-assortment) Table 18

Expenditures:	For annual volume of production, thousand UZS	For one product, UZS
1. Material expenditure	2 765 564	2 930
2. Labor costs.	911 273	965
3. Unified social payment	227 818	241
4. Fixed assets amortization cost	870 657	922
5. Other production costs.	237 737	252
Total product prime cost	5 013 049	5 310
Profitability of the product	30%	30%
Profit	1 503 915	1 593
Wholesale price of the product	6 516 964	6 903
Value added tax (VAT)	1 303 393	1 381
Wholesale price based on contract	7 820 357	8 284
Sale Discount	391 018	414
Retail price based on contract	8 211 375	8 698

Calculation account cost plan of projected products

(2-assortment) Table 19

Expenditures:	For annual volume of production, thousand UZS	For one product, UZS
1. Material expenditure	4 362 580	7 702
2. Labor costs.	1 437 502	2 538
3. Unified social payment	359 376	634
4. Fixed assets amortization cost	1 373 431	2 425
5. Other production costs.	375 021	662
Total product prime cost	7 907 910	13 961
Profitability of the product	30 %	30 %
Profit	2 372 373	4 188
Wholesale price of the product	10 280 283	18 149
Value added tax (VAT)	2 056 057	3 630
Wholesale price based on contract	12 336 340	21 779
Sale Discount	616 817	1 089
Retail price based on contract	12 953 157	22 868

Company financial indicators

Table 20

№	Indicators	Measurement unit	Amount
1.	Company gross profit	thousand UZS	3 876 288
2.	Incurred period expense	thousand UZS	355 308
3.	Profit of main production activity	thousand UZS	3 520 980
4.	Taxes paid out of profits:		
4.1	Income tax	thousand UZS	492 937
5.	Net profit	thousand UZS	3 028 043

Technical and economic indicators

Table 21

№	Indicators	Measurement unit	Amount
1.	Number of installed knitting machine	pcs.	96
2.	Practical productive capacity of machine	pcs/hour	3 5
3.	Number of staff	person	156
4.	Annual production volume	kg pcs.	130 461 1 510 406
5.	Production prime cost	thousand UZS	12 920 959
6.	Price of product	thousand UZS	16 797 247
7.	Sold product	thousand UZS	21 164 532
8.	Capital expenditure	thousand UZS	11 336 370
9.	Fund efficiency	UZS	1 482
10.	Average annual productivity of workers	thousand UZS	107 675
11.	Average monthly salary of workers	UZS	1 208 642
12.	Expenditures on production of goods worth 1 UZS	UZS	0.77
13.	Company profitability	%	22
14.	Profitability of the product	%	30
15.	Payback period	year	3.7

Conclusion

All in all, in this diploma project projected Knitting Company specialized on producing 1.5 million outer wear for children. It is not secret that nowadays, knitting garments are more demanded and widely used than other types of textile product. Because of its elasticity and air permeability and other properties, it is comfortable for children and adults. That's why as assortment for diploma project were chosen children's waistcoat and cardigan.

All tasks given for projecting were executed completely.

In Technology part of diploma project were completed following tasks: chosen assortments for producing and substantiated, selected appropriated knitting machine, chosen proper knit structure and raw material, calculated technological parameters of structures, raw material consumption and annual volume of produced knitting garment. Designed knitting section, sewing unit and other sections of main and auxiliary premises.

In Special part of diploma project researched Cardigan pattern effect on V-Bed knitting machine. Results of analyses show that offered structures have some advantages to compare to basic structure. On the aim of resource economy technology, they give a possibility of raw material expenditure decreasing 2,4%.

In part Labor protection and Ecology substantiated Sanitary and hygienic requirement for children's knitted garments.

In Economic part of diploma project calculated all business plan sections: planned raw material consumption cost and calculated labor cost in production character, material costs in production character, "Unified social payment", fixed asset amortization cost and other type of expenses. At the end analyzed financial, technical-economic indicators of projected Knitting Company. The results show that company net profit consists about 3 milliard UZS and subsequently planned to reach 22% of company profitability.

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