# OPTIMISATION OF PROCESS PARAMETERS FOR FUSING OF SEAMS IN APPARELS

A PROJECT REPORT

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## BONAFIDE CERTIFICATE

Certified that this project report "**OPTIMISATION OF PROCESS PARAMETERS FOR FUSING OF SEAMS IN APPARELS"** is the bonafide work of **S.KIRUTHIKA, P.VIJAYALAKSHMI,** who carried out the project work under my supervision.

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## ABSTRACT

The dominant process in garment assembly is sewing. The objective of sewing is concerned with the achievement of satisfactorily constructed seams. The construction of seams combines the required standards of appearance and performance with an appropriate level of economy in production.

The appearance in a seam normally means smooth fabric joined with no missed stitches and no damage to the material. The appearance and performance of sewing seams are as the results of combination of Seam types, stitch types. sewing machine feed mechanism, needle, sewing thread. Required quality can be achieved if all these factors are considered carefully while assembling.

In this project an attempt has been made to investigate the use of fusing technology instead of sewing in garment manufacturing and also to optimize the fusing process parameters to achieve good seam performance in fusing. The polypropylene resin is used to join the seams under different temperatures. The strength. elongation. stiffness and thickness of fused seams at different temperatures and different seam types are compared with that of sewn samples.

The results show that fused seams gives more seam strength than sewn seams.

# திட்டப்பணிச் சுருக்கம்

ஆடைத் தயாரிப்புத் தொழிலில் முக்கியமான பணி தையல் பணி, தையல் பணியின் முக்கிய நோக்கம் தையல் அமைக்கும் முறை, ஆடையின் தோற்றம், அதன் பயன்பாடு மற்றும் ஆடைத் தயாரிப்பின் செலவீனம் ஆகியவை தையல் அமைக்கும் முறையைப் பொருத்தே அமைகிறது.

ஆடைத் தயாரிப்பின் தொழில் நுட்பம் சரியான தையல் முறையை அமைப்பது பொருத்தே அமைகிறது. மேலும் தையல் இயந்திரத்தை தையல் முறை தேர்ந்தெடுக்கப்படுகிறது.

இந்த திட்டப்பணியில் தையல் பணி இல்லாமல், குங்கிலியங்கள் பயன்படுத்தி ஆடை தயாரிக்க முயற்சி மேற்கொள்ளப்பட்டுள்ளது. பாலிபிரொப்பிலின் குங்கிலியங்களைப் பயன்படுத்தி, வெவ்வெறு வெப்ப நிலையில் செய்முறை விதிகளில் முயற்சிகள் செய்யப்பட்டுள்ளன.

குங்கிலியங்கள் மூலம் இணைக்கப்பட்ட துணிகளின் உறுதித் தன்மையும், நீலும் தன்மையும், தையல் மூலம் இணைக்கப்பட்ட துணிகளின் உறுதித் தன்மையும் மற்றும் நீலும் தன்மையோடு ஒப்பிடப்பட்டது. மேலும் குங்கிலியங்கள் மூலம் இணைக்கப்பட்ட துணிகளின் விறைப்புத் தன்மையும், தடிமனும், தையல் மூலம் இணைக்கப்பட்ட துணிகளின் விறைப்புத் தன்மையும், தடிமனும் ஒப்பிடப்பட்டுள்ளது.

இந்த ஒப்பீடு பலவகை துணிகளுக்கு மேற்கொள்ளப்பட்டது. தையல் மூலம் இணைக்கப்பட்ட துணிகளின் உறுதித்தன்மையை விட குங்கிலியங்கள் மூலம் இணைக்கப்பட்ட துணிகளின் உறுதித் தன்மை அதிகமாக காணப்படுகிறது.

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# 1. INTRODUCTION

## 1.1 Apparel production

Apparel production deals with the conversion of two dimensional fabrics into three dimensional garments. This combines a series of sequential processes which is as given below.

DESINGING → PATTERN MAKING

FABRIC SELECTION → GARMENT ACCESSORIES PURCHASING

↓

FABRIC INSPECTION & TESTING

↓

SPREADING

↓

CUTTING

↓

LABELLING

↓

SEWING & FUSING

↓

FINISING

↓

FINAL INSPECTION

↓

PRESSING & PACKING

The production of apparels starts from Designing. Patterns are made according to the design for particular size. The patterns are graded for other sizes and then the marker is prepared. The marker is placed on the fabric lay and cut accordingly. Cut fabrics are assembled to form the garment and required trims and accessories are attached to the garment. Then finished product is checked for the quality aspects, then pressed and packed. In this garment production sequence, cutting and assembling are the most important aspects which convert the two dimensional fabric into three dimensional apparel.

## 1.2 Assembling:

Assembling is a critical process in apparel production. Assembling process is done by splitting it into a number of sequential operations, which involves a lot of technical expertise, labour, various machines, etc., The process of assembling is mostly done by sewing. Latest research activities have resulted in alternative assembling techniques. Some of those have turned out successful, though not economic, which are listed below.

- Welding
- Ultrasonic Bonding
- Moulding
- Adhesives Bonding

## 1.3 Problems in Sewing:

The dominant process in garment assembly is sewing. A good quality garment can be produced with good sewing method, which involves stitches and seams of adequate quality standards. The factors affecting the quality of sewing are:

- Men
- Machine
- Material

### 1.3.1 Men:

Sewing is a labour intensive process. For each and every operation, an operator has to be engaged. For some of the processes, a helper is also required to assist that operation and for other allied works. As so much of labour is engaged, the quality of the garment is affected by the handling process. Also due to some inexperienced operators, the fabric also gets damaged which ultimately increases the production cost and time.

### 1.3.2 Machinery:

As the number of operations is more in sewing, the number of machines employed is also more. This involves a high investment for machinery, land and building. To ensure good production and quality, all the machines have to be maintained in a good condition, which requires more killed and technical people. When mass production is done, all the machines work continuously at high speeds that result in high wear and tear of the machine. Hence frequent replacement of machine parts and or change in settings between the machine parts has to be done. Setting of timing of needle and shuttle is a tedious job. These settings if not rectified immediately results in damage of machine parts or damage of garment parts or even lead to accidents of operators which again results in the higher production cost.

### 1.3.3 Material:

The quality of the fabrics and other accessories like needles, thread, trims, fabrics, etc., should have very good quality. Poor quality fabrics and accessories deliver poor production rate and low quality apparel. The needle used in the sewing machines gets damaged due to various reasons. Replacing of the broken needle with a new one consumes a considerable time. The running off of sewing thread package and thread breakage involves a rework in the stitching process which increases the production time to a great extent. Because of these constraints, alternative methods of joining gain popularity. One among them is fusing.

To overcome the problems, the new method of joining the fabrics parts is needed. One among them is fusing. The project deals with the fusing of seams in apparels.

## 1.4 Fusing:

### 1.4.1 Current Status:

Now-a-days the fusing process is widely used for fusing the interlinings with the main fabric, used in apparels to provide stiffness and shape to the garment parts. These interlinings help in the reinforcement of seams and to avoid seam puckering. In case of fusing, the interlining is bonded to the fabric by means of a thermoplastic resin. The resin is coated on the interlining by various methods, which on application of heat and pressure melts and bonds to the fabric.

This process provides several advantages such as

- Improvement in seam properties like seam strength and seam slippage.
- Reduction in seam defects to a great extent.
- Improvement in production rate to a considerable extent.
- Provides an enhanced aesthetic appeal.

- Reduced production cost.
- The number of machines and the skill level required are less.
- Achievement of consistent quality.

## 1.5 Scope of the Project:

As stated above the fusing process makes the joining process very easy and at the same time improves the quality. This process in future is expected to replace the sewing operation completely. If the process of fusing replaces the sewing process, it will be a great boon to the apparel manufacturers.

Fusing technique is expected to reduce or eliminate the problems arising during sewing such as

- Machine downtime for changing the damaged needle and fixing a new needle.
- Mending the damaged garment part due to the needle breakage or needle heat.
- Sewing thread run off or breakage, and hence unraveling and re- stitching the particular garment part from the start.
- Rework in stitching involved due to defective seams and stitches because of inefficiency or carelessness of the operator.
- Accidents due to tension or lethargic attitude of the operator.

The above said factors result in high production, good quality, less inventory, economic maintenance, easy labour management etc., which altogether results in the reduction of production cost.

## 2. LITERATURE SURVEY

Assembling is the process in which two dimensional form of fabric is converted into three dimensional form of garment. This assembling or joining of fabrics is widely carried out by sewing operation. Stitching is carried out commercially and extensively throughout the garment manufacturing process. Stitched seams dominate others because the resulting seam is flexible, extensible, reformed and stitching can be carried out on a variety of substrates.

Now many processes have been developed as alternatives for sewing. But at present these are not widely practiced. Some of them are:

- Fusing
- Moulding
- Welding
- Adhesive bonding

The construction of garments by forming the seam should satisfy certain requirements so that the garments should have good durability and aesthetic appeal. These properties are affected by certain parameters. Performance of seams comprises of high strength, elasticity, durability, security, and comfort and maintenance of any specialized fabric properties. Early industrialized countries are now focusing on more sophisticated, automated processes designed to meet demands of all consumers. Concepts such as 'just in time' and 'quality response' have been introduced by many countries. Fusing is one such concept which can be achieved 'just in time'.

Study of structural properties and behavior of seams results from the investigations of fibers, yarns and fabrics. Literature on some technical aspects of stitches and seams is extensive (Crum, 1983; Worthing, 1975, 1980). But those literature deals with complex investigations. Literatures show that considerable efforts have been taken in developing a new technology for processing fabrics into garment (Berkstresser and Buchanan, 1986; Byrne 1995).

## 2.1 Seams:

Seams has been defined as joint consisting of a sequence of stitches uniting two or more pieces of material.

## 2.2. Performance of seams: [4, 6, 8, 9]

The basic performance properties of seams includes

- Strength
- Elasticity
- Durability
- Security

### 2.2.1 Seam strength:

Seam strength is the maximum resistance to rupture at the juncture formed by stitching together two or more planar materials. The greater the force needed to rupture the seam the greater is the strength.

When seam is loaded parallel to the direction of sewing, it may fail due to sewing thread breakage. But in case of fusing seam strength is high compared to sewing. Seams joined by fusing can withstand the stress applied in both parallel and perpendicular directions to the seams or in number of directions simultaneously.

### 2.2.2 Seam Elasticity:

Seams may be stretched up to the point at which they break. More often they are stretched a few percent of their original length and allowed to relax. This is termed as seam elasticity. External factors which had to be taken into account in measurement of elasticity include whether deformations are small or large and how long the seam is held in the deformed state by the external forces. The internal forces caused by the deformation diminish with time i.e. they are visco elastic in nature.

### 2.2.3 Seam Durability:

Durability of seam depends on the factors such as strength relationship between the elasticity of the seams and elasticity of the material and also the abrasion, acids, alkalis and sunlight.

### 2.2.4 Security:

The Security of seam appears to depend on the nature of stitches. The stitches that have quite complex interlacing/interloping structures present in the underside of the cloth are exposed to possible snagging and reduced security. So sewing creates problems in seam security. This problem of snagging or abrasion is reduced in fusing.

## 2.3 Factors influencing seam properties: [1, 3, 6]

Seams can be joined either by sewing or fusing. So the parameters involved in fusing or sewing influences the seam properties. Some investigators consider the seam as a composite. So seams have more complex structures than fibers, yarns or fabrics. Variables which may affect the seam properties in case of sewing are:

- Seam type
- Stitch type
- Angle of seam in relation to the yarns in fabric
- Thread tension
- Linear stitch density

- Type and finish of sewing thread and its resistance to abrasion, mould/mildew and attack by acids and alkalis, etc.,

### 2.3.1 Seam type:

The British standard classifies seams into eight classes. The eight classes of seams are as follows.

**Class I: SUPER IMPOSED SEAM**

- Super imposed seam
- French seam
- Piped seam

**Class II: LAPPED SEAM**

- Lapped seam
- Lap felled seam
- Wetted seam

**Class III: BOUND SEAM**

- Bound seam
- Common bound seam

**Class IV: FLAT SEAM**

**Class V: DECORATIVE STITCHING**

- Pin tucks
- Channel seams

**Class VI: EDGE NEATENING**

- Hemmed edges.

**Class VII: ADDTION OF SEPARATE ITEMS**

- Lace

**Class VIII: BELT LOOP AND BELTS**

### 2.3.2 Stitch Types:

The term "stitch" is defined as one unit of conformation resulting from one or more strands or loops of thread intra looping, inter looping, or passing into or through material or on material. This is the definition given by international organization of standards.

Types of stitches also have influence on seam strength and elongation. Because of the different number of threads on upper and lower surfaces and also their load-bearing capacities, the thread selected often has different tensile properties. So different classes of stitches provide different strength to the seam.

Stitches are classified into six classes. Each class is differed by geometrical arrangement of thread in the stitch. As per the British standards stitches are classified into six classes.

**Class 100:** Chain stitches

**Class 200:** Stitches originating as hand stitches

**Class 300:** Lock stitches

**Class 400:** Multi-thread chain stitches

**Class 500:** Over edge chain stitches

**Class 600:** Covering chain stitches

### 2.3.3 Stitch density:

Stitch density has great influence on seam strength and seam elasticity. Increase in linear stitch density results in increase in seam strength. Increase in stitch density does not necessarily increase breaking elongation.

### 2.3.4 Needle size:

The way in which the fabrics are penetrated by the needle during sewing takes place in of the two ways:

1. By needle directly striking the yarn and damaging it

2. Needle penetrates through the inter yarn spaces available in the fabrics.

Selection of needles and thread sizes for a particular type of seam is necessary for achieving a balance between minimum damage and pucker, which is usually a matter of small needle size and fine thread, and seam strength needle and thread.

The perfect needle assures perfect stitching. But damage in the needle parts causes damage to seams. This problem is completely eliminated in fusing.

### 2.3.5 Thread type:

If seams are to have satisfactory appearance and performance, a prime contributory factor is the sewing thread used. Correct selection of sewing thread requires consideration of its performance during sewing as well as its performance in the completed garment under conditions of wearing and cleaning. It also requires consideration of its appearance in the sewn seam, both with respect to its appearance as sewing thread and the effect it has on the appearance of the materials being sewn. Some of the factors like fibre type thread construction thread finishes and thread count also affect seam performance.

### 2.3.6 Thread count and Diameter:

Yarn count is the measure of relation between the length and the mass of the yarn. It is expressed/denoted by two systems

**Direct system (Tex system):**

It is the number of mass units per unit length. Tex system is the most universal.

**Indirect system (Ticket number):**

It is the number of length units per unit mass. This widely used system is based on the cotton and metric count systems where the ticket number is approximately equal to three times the original count.

The sewing thread diameter is the important physical property, not only it provides a guide line for seam strength and appearance, but because of its effect in creating undulations in dense fabric.

### 2.3.7 Sewing machine feeding mechanism:

In the construction of seams and the formation of stitches that holds them together, the seam properties are influenced by the sewing machine feed system. The simplest and commonest feed system is the drop feed system. The three important parts of the feed mechanism are the presser foot, the throat plate or needle plate, and the feed dog.

Though it is simple and common, it suffers from a serious limitation in its ability to produce a seam of perfect appearance on all types of material. Most common defect is the seam puckering.

## 2.4 Sewing problems: [1, 3, 6]

The problem which arises when the materials are sewn are

- Problems of stitch formation which leads to poor seam appearance like Slipped stitches, Staggered stitches, Unbalanced stitches, Non uniform stitch density, Needle, bobbin or looper threads breakage
- Problems of fabric distortion known as pucker
- Problems to damage to fabrics along with stitch line

### 2.4.1 Seam slippage:

Slippage of yarns is broadly defined as 'the sliding of one of the set of threads over the other, resulting in some sort of opening in the fabric, under the influence of a load or tension lower than that is normally required to rupture the fabric itself'. Seam slippage is slippage at the stitching line. This gives an unacceptable appearance long before the seam actually breaks down.

#### 2.4.1.1 Factors Influencing Seam Slippage:

- A low number of interlacing of warp and weft threads allowing the threads to slide easily over each other when the seam is subjected to a load.
- An open fabric constructions, which allows yarns to move freely.
- Smooth yarns, again allowing yarns to move easily over each other.
- Finishes with lubricant or softener, which lower friction and facilitate movement of yarn.

Effects of stitch density, thread tension, size of seam allowance and seam type has an effect on seam slippage. Increasing the seam allowance was effective only in the extreme case of seams slipping completely out of the fabric. Increasing sewing tension generally had no effect on minimizing seam slippage. Changing the stitch length may have an effect, but determining the optimum stitch length can be done only by experiment.

### 2.4.2 Seam pucker:

The unwanted waviness on the surface of material along the seam line is called puckering of seam.

Pucker may show itself when the garment is sewn or it may not appear until later when the garment is pressed, wetted or washed. It may show itself in all the plies of material which have been sewn together or only in some.

#### 2.4.2.1 Factors contributing seam puckering:

- Effect of material feed on differential fabric feed
- Fabric dimensional instability in use
- Sewing thread extension and recovery
- Fabric structure, bending and compression.
- Structural jamming in woven plain fabric

## 2.5 Fusing: [1, 4]

Fusing is the process by which interlining is bonded to the outer fabric. The thermoplastic resin coated on the interlining is melted by the application of suitable temperature and pressure. This process can be done in various types of fusing machines, according to our requirement.

The fusible interlining consist of

1. Base cloth
2. Thermoplastic resin

The base cloth is of different types like woven and non-woven. The base cloth is important factor which determines the stiffness of fused material. The thermoplastic resin is the one which contributes to bonding stability of the interlining. The selection of interlining depends upon the outer fabric, end use of the material, the behavior of the resin.

### 2.5.1 Assembly of interlining and fabrics for fusing:

The fusible interlining is placed between two fabrics and then the composite is placed in the fusing machine for fusing.

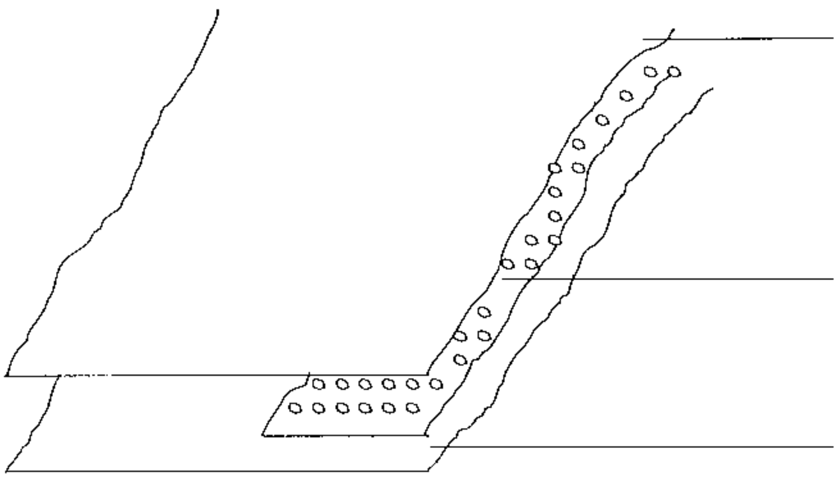



**Fig 2.1 Assembly of interlining and fabrics for fusing**

## 2.6 Factors influencing the fusing process: [1, 2, 5, 7]

The quality of fusing is influenced by the following factors

- Type & amount of resin,
- Its suitability with the fabric,
- Method of applying resin to the base cloth.
- Process parameters like temperature, pressure and time.
- Fabric type
- Fusing equipment

### 2.6.1 Type of resin:

The choice of resin is restricted by certain factors like end use of the finished material, behavior of the resins to heat, etc..

The requirements of resins are

- Resins must provide the bond which is suitable to with stand washing and dry cleaning.
- Resins must have the ability to with stand the temperature so as to give a good bonding strength.
- The nature of thermoplastic resins should avoid strike through or strike back effects
- Resins must have low dye retention property.

The most commonly used resins are

- Poly amide
- Polyester
- Polypropylene
- Polyethylene
- Polyvinyl chloride

**Commonly used resins and their characteristics:**

**TABLE 2.1 Resin Characteristics**

| TYPE | TEMPERATURE | DRY-CREANABLE | WASHABLE | NOTE |
|---|---|---|---|---|
| **POLY-AMIDE** | 120° C to 160°C | Especially adopted to dry cleaning | Not suitable for high temp. | Low temp fusing (100-130° C) |
| **POLY-VINYL CHLORIDE** | 130° C to 160° C | Withstands dry cleaning | Good Results | Needs high temp. and pressure |
| **HIGH DENSITY POLYETHYLENE** | 150° C to 180° C | Withstands dry cleaning | Very Good Results | Needs high temp. and pressure |
| **LOW DENSITY POLYETHYLENE** | 130° C to 160 ° C | Adhesive Remelts | Poor Results | Stitching is necessary. |
| **ETHYLENE VINYL ACID COPLYMER (EVA)** | 120° C to 150° C | Adhesive Remelts | Poor Results | Stitching is necessary. |
| **POLYESTER** | 130° C to 160° C | Very good only when used with polyester. | Good Results | Needs high temp and pressure |

The amount of resin is controlled by the method of coating resins to the base cloth. The amount of resin coated to the base cloth is quite enough to avoid the "strike back" or "strike through" through the outer fabric.

### 2.6.2 Method of applying resins to outer fabric:

The choice of the resin and method of coating relates to the cost, suitability for use with particular fusing equipment, durability for washing and dry cleaning and particular garment end use. There are different methods of coating resins to the base cloth. Some of them are:

- Scatter coating
- Dry powder dot coating
- Paste coating

#### 2.6.2.1 Scatter coating:

The scatter coating is the oldest and easiest method to apply the dry and freely flowing powder, in an undefined pattern to the web. Scatter coating uses the particles of the size from 150 to 600 microns. It is the crude method and uneven add-on weights resulted. The scatter coating machines are capable of scattering per 1000 mm needled roller width between about 10 g/min to 2000 g/min. If the resin coating is less then the bonding strength is also less. It also affects the bending modulus of the fused material.

#### 2.6.2.2 Dry powder dot coating:

For the powder dot coating the powders in the range of 0 to 200 microns can be used. The powders are applied with the help of engraved rollers. The resin density is varied according to the depth, diameter, and distance of each engraving. Patterns of dots can vary from 3 to 12 dots per cm and they are uniformly placed. For satisfactory bond lighter fabrics need smaller dots with higher concentration, while heavier fabrics need large dots with lower concentration. The number of dots per unit area affects the strength of the bond. The materials with powder dot coating are less stiff than scatter coating.

#### 2.6.2.3 Paste coating:

Fine powders in the range of 0 to 60 microns are dispersed in a watery medium to form the smooth paste and are printed to the base cloth, usually non-woven. When the heat is applied over the interlining it removes the water and the dots coalesce into solid resin. This type of coating gives shaped and finer dots used in shirt collars.

### 2.6.3 Fusing parameters:

The parameters which governs the quality of fused products is

- Temperature
- Pressure
- Process time

#### 2.6.3.1 Temperature:

The temperature should be sufficient to change the dry thermoplastic resin into a partially or fully molten state so that it will flow and make bond with the outer fabric. In the fusing process it is essential that the heated resin reaches a pliable paste state. This exact consistency of flow ensures a high level of penetration into the outer fabric to produce acceptable bond strengths. Too little heat restricts the flow, limits penetration and produces weak bond, whereas too much heat over activates the flow and causes "strike through" or "strike back". The semi liquid either pressed through the interlining or the outer fabric at the point of pressure and causes serious problems. This adhesive sticks to conveyor belts and makes removal of the fused parts difficult and also degrades the belts. This can be prevented by using paddle wheel flapping system to prise-off the fused parts adhering to conveyor belts.

### 2.6.3.2 Pressure:

The important parameter to be considered is pressure. The pressure rollers are made to a very high degree of precision and must operate 100% parallel to each other. The pressure applied in the fusing process is as sensitive and precise as the care taken to heat the resin to reach the glue line temperatures. Too much of pressure leads to strike back or strike through and too little pressure will limit the penetration for the resins into the outer fabric. For this reason the fusing machines are provided with the pressure setting device.

### 2.6.3.3 Process time:

The process time is the least temperamental of the controls needed to produce the fusing conditions but it is important to graduate the speed at which the belt moves through the conveyor press. The process time should also be quite enough otherwise it leads to unsatisfactory bond or "strike through" or "strike back".

These three factors are inter related; a change in one may necessitate the change in other.

### 2.6.4 Fabric type:

The fabric used for fusing also influences the strength of the bond. According to the fabric to be fused the fusing parameters and the interlining should be selected.

### 2.6.5 Fusing equipment:

Fusing machine are divided into

1) Flat bed fusing machine.
2) Continuous fusing machine.

### 2.6.5.1 Flat bed fusing machine:

Flat bed fusing machine consist of two horizontal metal platens between which the fabric and interlining laminate are sandwiched. The top placed resilient cover typically made of silicon rubber. Both the platens have outer cover of poly tetra fluro ethylene (PTFE) which can be easily cleaned. Heat is provided by electric elements usually in top platen only but some times in the bottom also. The elements are designed so that it provides the uniform heating over the whole assembly. Pressure is applied by closing the platens together mechanically, hydraulically or pneumatically. The process time is controlled by automatic timer. In the simplest mode of operation, the operator places the garment part face down on the bottom platen, places the interlining resin side down on the top in the correct position and closes the platens. One advantage in the simplest version, their small size and relative low cost allow their use by the smaller clothing manufacture.

### 2.6.5.2 Continuous fusing machine:

These systems operate by passing the garment part with its interlining placed on it, through a heat source and either simultaneously or subsequently applying pressure. Heat is provided in one of the three phases.

1) With direct heating- the conveyor belt carries the components to be fused into direct contact with heated surface.
2) With indirect heating- the components to be fused are carried through a heater chamber.
3) With no temperature, gradient heating-the components are carried through the preheating zone. Heating is either direct or indirect.

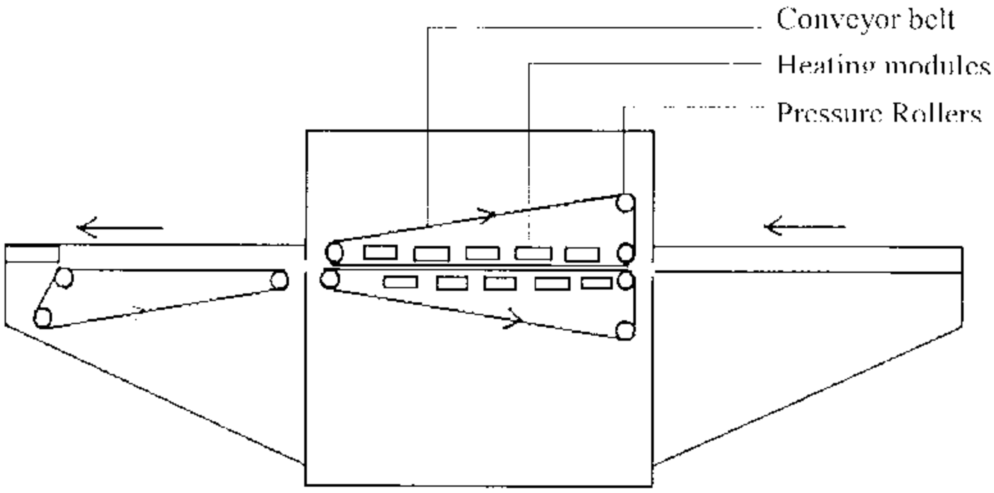



**Fig 2.2 Line diagram of continuous fusing machine**

This is the line diagram of the continuous fusing machine. The laminate is made to pass between the heating modules in the conveyor belt; the nip rollers apply the pressure to the assembly after heating. The maintenance at the required temperature is simple compared with the flat bed fusing machine. On drum presses the tension of the conveyor belt press the components continuously against the heated drum during the complete fusing process. Process time is very small when compared to the flat bed machine, has to be precisely controlled. Preventing the conveyor belt from "tracking" and fabric shrinkage are major problem. This can be controlled by selecting the process parameters and the resin type according to the fabric type. The interlining requires glue line temperature of about 120 -140 C, since the water boils at 100 C steam is instantly generated as the work enters the press creating the thermal shock, causes the shrinkage.

## 2.7 Methods of fusing: [1, 3]

Some of the methods of garment construction that involve fusible interlinings are described below.

- Reverse fusing
- Sandwich fusing
- Double fusing

### 2.7.1 Reverse Fusing:

In this method the outer fabric lies on top of the fusible material. It is sometimes used in fusing shirt and blouse collars. On flat bed presses with elements only in the top platen, it is necessary to adjust temperature settings. Since the interlining part is normally slightly smaller than the garment part, accurate positioning may be difficult.

### 2.7.2 Sandwich Fusing:

This is effectively carried out on a horizontal continuous press where heat is applied both from top and bottom sides. Two pairs of components forming two laminates are fused together, with the two outer fabrics on the outside of the sandwich and the two interlinings on the inside. With correct temperature settings, the glue line temperature may be achieved in both laminates but the potential for strike-back occurring and causing all the layers adhere together is considerable. A small amount of fusing time will be saved but preparation will take longer and the quality of the results may be satisfactory.

### 2.7.3 Double Fusing

This is fusing of two sorts of interlining to the outer fabric in one operation. It is most commonly used in shirt collars and men's jacket fronts.

# 3. MATERIALS AND METHODS

In this study, fabrics knitted with different fibers and various structures are fused using polypropylene resin (film type) at different fusing temperatures. The fused seams and sewn seams are compared for various seam properties like seam strength, elongation at break, stiffness and thickness.

The following tables give the specifications of the fabrics and other parameters used for producing fused and sewn seams.

**Table 3.1 Fabric specification:**

| Fabrics Used | Count/ Denier | WPI | CPI | GSM | Thickness (mm) |
|---|---|---|---|---|---|
| Cotton single jersey | 25 | 40 | 52 | 190 | 0.51 |
| Polyester single jersey | 25 | 42 | 47 | 185 | 0.53 |
| Viscose single jersey | 25 | 35 | 46 | 190 | 0.49 |
| Polyester/cotton single jersey | 25 | 36 | 50 | 205 | 0.55 |
| Cotton Rib | 32 | 30 | 43 | 230 | 0.81 |
| Cotton Interlock | 32 | 40 | 45 | 240 | 0.77 |

**Table 3.2 Fabric Strength (kgs) and Elongation (%) at break for the fabrics used:**

| S. No. | Fabric type | Load (kgs) | Elongation (%) at break |
|---|---|---|---|
| 1 | Cotton single jersey | 26.928 | 63.5475 |
| 2 | Polyester | 23.817 | 60.4225 |
| 3 | Polyester/cotton | 37.128 | 85.975 |
| 4 | Viscose | 22.44 | 56.545 |
| 5 | Cotton rib | 43.044 | 66.925 |
| 6 | Cotton inter lock | 38.148 | 75.905 |

## 3.1 Seam type used:

These fabrics were joined by sewing and fusing operations using the following seam types.

- Lapped seam
- Lap felled seam

The various process parameters used for sewing and fusing are given in Table 3.3 & 3.4 respectively

### 3.2 Fusing:

The fusing was first carried out with different non woven interlinings coated with polyester resins. Seam strength obtained by fusing the samples with this resin was very low about 2 kgs. Due to poor seam strength, fusing was carried out with more suitable interlining that provides good seam strength.

The fusing process is done with the poly propylene interlining (film) and with different fusing temperature is given in Table 3.1.4.the pressure and time is maintained as constants. The fusing process was carried out in a continuous fusing machine.

**Table 3.3 FUSING PARAMETERS**

| Particulars | Description |
|---|---|
| Resin used | Poly propylene (film type) |
| Film strength | 8.61 kgs |
| Film GSM | 49.3 |
| Temperature ( C) | 125, 150, 175. |
| Time (seconds) | 30 |
| Pressure (psi) | 2 |
| Number of lining | 1 |
| Number of presses | 2 |

**Table 3.4 SEWING PARAMETERS**

| Particulars | Description |
|---|---|
| Thread type | 100% Polyester |
| Ticket number | 120 |
| Stitches per inch | 12 |
| Needle size | 11(singer system) |

## 3.3 Testing of Seam Strength and Elongation

The samples produced were tested for seam strength and elongation at break (%) using STARIMAT-M TENSILE STRENGTH TESTER under standard conditions. The effect of seam type and joining method on seam strength and elongation is assessed with the results of the tests given in 4.1 and 4.2.

**Instrument** : Starimat-M Tensile tester.

**Sample preparation :** 2 Inch cut strip method

**Standard** : ASTM D5035: 1995

## 3.4 Seam stiffness test

The samples produced are tested for seam stiffness using SHIRLEY STIFFNESS TESTER under standard conditions. Stiffness is calculated from bending length and weight per square yard of the fabric. Thickness has also a considerable effect on fabric stiffness.

**Instrument** : SHIRLEY STIFFNESS TESTER

**Sample preparation** : 6" x 1" strip

**Standard** : ASTM D1388

## 4 RESULTS AND DISCUSSIONS

### 4.1 Effect of Seam Type and Joining Method on Seam Strength for Different Types of Fabrics.

The samples were tested for the effect of seam type and joining method for different types of fabrics. The resultant seam strength for various fabrics fused using (polypropylene film as interlining) and sewn are discussed below with relevant tables and graphs. In the graphs LS represents lapped seam and LFS represents lap felled seam.

#### 4.1.1 Polyester Fabrics

Table 4.1 & Figure 4.1.1 shows that lap felled seam gives more seam strength than lapped seam for both fused and sewn samples. Increase in temperature reduces the bonding strength of polyester fabric due to its synthetic nature. So, at higher temperature the strength is considerably lower than sewing strength. In polyester fabrics, with resin, polyester filament also melts, so that it gives good seam strength to the lap felled seam.

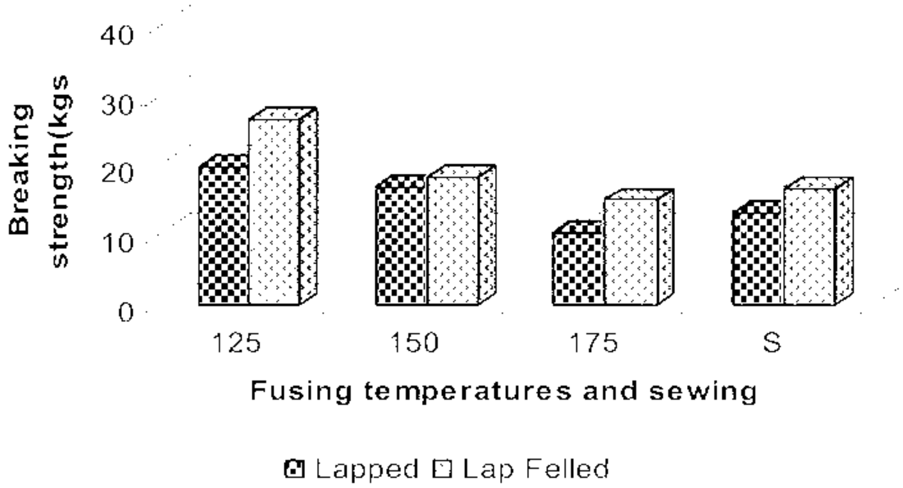
#### 4.1.2 Viscose Fabrics

From the Table 4.1 & Figure 4.1.2, It can be viewed that viscose fabric gives better seam strength for fusing than sewing. Compared to lapped seam lap felled seam gives good seam strength. Due to its complicated structure lap felled seam provides good seam strength. Since viscose fibre is the regenerated fibre rise in temperature reduces the fibre strength. So, at lower temperature seam strength is good. Both polyester and viscose fabrics results in decreasing of seam strength as temperature increases.

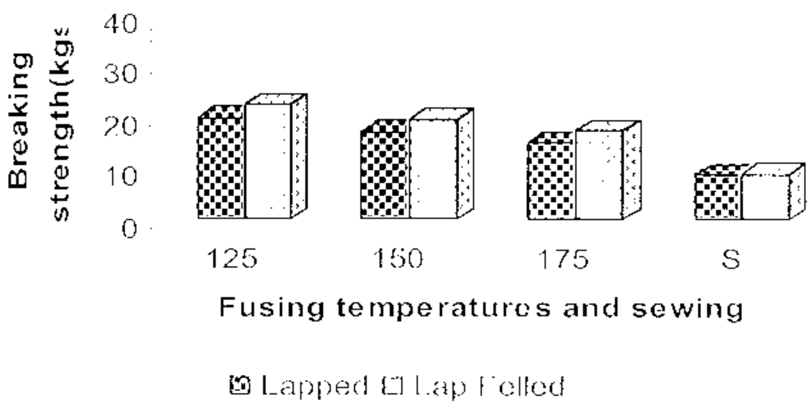
## Table 4.1 Seam Strength (kgs) for Fused and Sewn samples

| S.No | Fabric type | Seam types | Fused Samples | | | Sewn samples |
|---|---|---|---|---|---|---|
| | | | 125 | 150 | 200 | |
| 1 | Polyester single jersey | Lapped | 19.8135 | 16.8045 | 10.149 | 13.1325 |
| | | Lap Felled | 26.5455 | 18.36 | 14.9685 | 16.575 |
| 2 | Viscose single jersey | Lapped | 19.992 | 17.238 | 15.147 | 8.874 |
| | | Lap Felled | 22.6695 | 19.635 | 17.544 | 9.027 |
| 3 | Polyester/Cotton single jersey | Lapped | 30.214 | 31.707 | 32.5675 | 16.4985 |
| | | Lap Felled | 28.794 | 29.377 | 29.8095 | 12.852 |
| 4 | Cotton single jersey | Lapped | 23.256 | 22.8445 | 21.981 | 14.382 |
| | | Lap Felled | 25.194 | 23.409 | 21.981 | 13.056 |
| 5 | Cotton rib fabric | Lapped | 38.9895 | 40.667 | 42.5705 | 12.189 |
| | | Lap Felled | 32.232 | 30.7785 | 27.693 | 10.7865 |
| 6 | Cotton interlock fabric | Lapped | 34.374 | 35.1245 | 36.261 | 14.025 |
| | | Lap Felled | 29.835 | 29.0445 | 31.0335 | 18.5385 |

## Fig 4.1.1 Seam Strength (kgs) of fused and sewn samples for polyester single jersey fabric




## Fig 4.1.2 Seam Strength (kgs) of fused and sewn samples for viscose single jersey fabrics



### 4.1.3 Polyester / Cotton Fabrics

It can be viewed from table 4.1 & figure 4.1.3 that Polyester cotton fabric provides good seam strength for fusing than sewing. The lapped seam gives better strength than lap felled seam. Increase in temperature increases the bonding strength. Since polyester / cotton blend has more cotton fibre, rise in temperature doesn't affect seam structure.

### 4.1.4 Cotton Fabrics

In case of cotton single jersey fabrics, Table 4.1 & Figure 4.1.4 shows that fusing gives good seam strength than sewing. Fusing lapped seam shows better strength than lap felled seams. Temperature has only less influence on seam strength. Lapped and lap felled seam shows only slight variation on seam strength. Comparing with the polyester/cotton fabrics. cotton single jersey seems to give lower seam strength.

**Fig 4.1.3 Seam Strength (kgs) of fused and sewn samples for P/C single jersey fabrics**

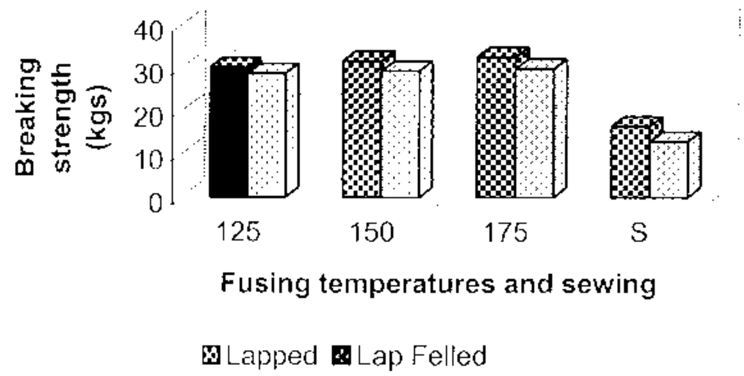
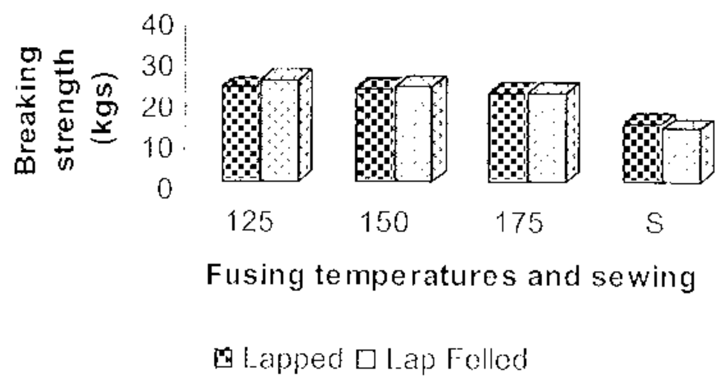



**Fig 4.1.4 Seam Strength (kgs) of fused and sewn samples for Cotton single jersey fabrics**



### 4.1.5 Cotton Rib Fabric

For cotton rib fabrics fused seams gives very good seam strength than sewing compared to single jersey fabrics. Lapped seams show good strength than the lap felled seam. As the temperature increases the bond ability of fabrics also increases. Since rib fabrics has complicated structure than single jersey fabrics the resin enters into these structures and gives good bonding strength than cotton single jersey. These effects can be viewed from Table 4.1 &Figure 4.1.5

### 4.1.6 Cotton Interlock Fabric

Table 4.1 & Figure 4.1.6 shows that lapped seam gives better seam strength than lap felled seam for cotton interlock structure. Increase in temperature considerably increases the bonding strength of the fused samples. Since interlock has similar structure as rib fabric the resins provide good bonding strength to seams. In case of cotton fabrics, the fibre doesn't melt with the resin so in lap felled seam the amount of resin adsorbed by the fabric is less so this causes reduction in strength of the seam.

Fig 4.1.5 Seam Strength (kgs) of fused and sewn samples for cotton rib fabric

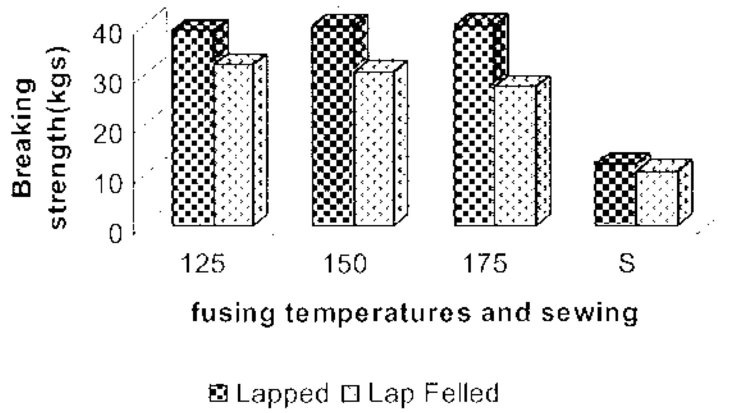
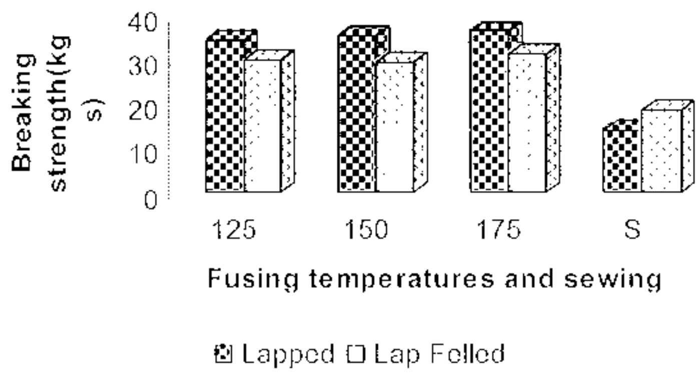



Fig 4.1.6 Seam strength(kgs) of fused and sewn samples for cotton interlock fabric



## 4.2 Effect of Seam Type and Joining Method on Seam Elongation For Different Types Of Fabrics.

The samples were tested for the effect of seam type and joining method on seam elongation for different types of fabrics.

### 4.2.1 POLYESTER FABRICS

Table 4.2& figure 4.2.1 shows that elongation in polyester fabrics is improved when the seams are fused as lapped felled seam than lapped seam. As it is a synthetic fibre lower temperature gives high seam elongation. Lap felled seam has good seam elongation than lapped seams.

### 4.2.2 VISCOSE FABRICS

In case of viscose fabrics Table 4.2 & Figure 4.2.2 shows that elongation of fused samples gives better seam elongation than the sewn samples. The elongation result shows that there is no much difference between both the lapped and lap felled seams at all temperatures. Temperature has no much effect on seam elongation. When viscose fabrics are compared with polyester, seam elongation is less in viscose fabrics.

## 4.2 SEAM ELONGATION (%) OF FUSED AND SEWN SAMPLES

| S.No | Fabric type | Seam types | Fused Samples | | | Sewn samples |
|---|---|---|---|---|---|---|
| | | | 125 | 150 | 175 | |
| 1 | Polyester Single Jersey | Lapped | 89.84 | 77.8 | 74.265 | 99.32 |
| | | Lap Felled | 112.4 | 110.78 | 92.133 | 106.195 |
| 2 | Viscose Single Jersey | Lapped | 55.05 | 49.765 | 45.43 | 39.02 |
| | | Lap Felled | 51.50 | 47.09 | 49.55 | 38.025 |
| 3 | Polyester/Cotton Single Jersey | Lapped | 75.1 | 72.425 | 58.3 | 69.9425 |
| | | Lap Felled | 83.24 | 71.692 | 75.345 | 62.36 |
| 4 | Cotton Single Jersey | Lapped | 59.19 | 53.085 | 58.36 | 56.69 |
| | | Lap Felled | 55.85 | 56.07 | 53.925 | 51.11 |
| 5 | Cotton Rib Fabric | Lapped | 59.55 | 60.485 | 61.61 | 47.98 |
| | | Lap Felled | 55.10 | 55.465 | 51.702 | 47.3675 |
| 6 | Cotton Inter Lock Fabric | Lapped | 63.35 | 62 | 68.975 | 55.935 |
| | | Lap Felled | 57.90 | 65.595 | 59.815 | 59.7 |

**Fig 4.2.1 Seam elongation (%) of fused and sewn samples for polyester single jersey fabric**

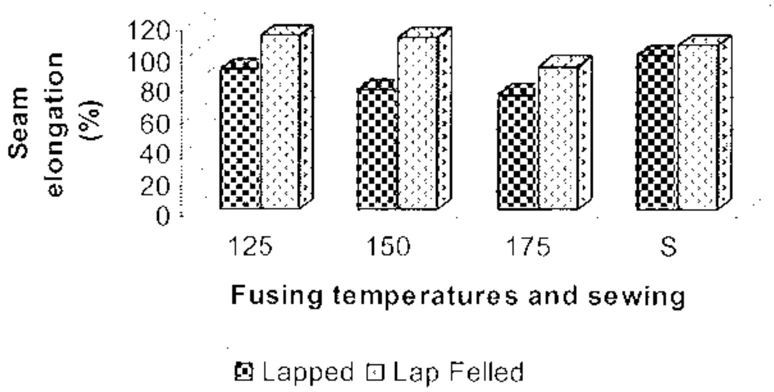
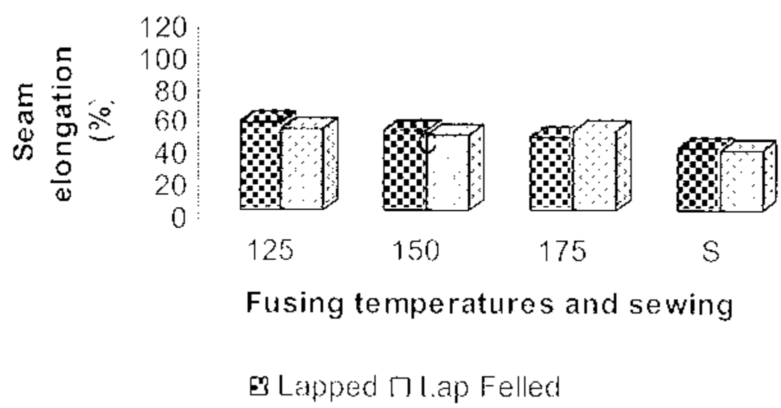



**Fig 4.2.2 Seam elongation (%) of fused and sewn samples for viscose single jersey fabrics**



## 4.2.3 POLYESTER / COTTON FABRICS

The elongation results showed in Table 4.2.1 &Figure 4.2.3 gives a clear view that sewn seams provide only a little variation than fused seams in seam elongation results. At lower temperatures lapped seams shows good elongation than lap felled ones. Temperature affects the structure and this has direct effect on elongation properties. In higher temperature seam elongation is considerably less than sewn seams.

## 4.2.3 COTTON SINGLE JERSEY FABRICS

For cotton fabrics seam elongation in fused samples does not greatly vary from that of sewn samples. The elongation is slightly less in case of sewn samples which can be observed from Table 4.2.1& Figure 4.2.4.Both the seams types has only a little variation in elongation. Rise in temperature doesn't make more difference in seam elongation values.

**Fig 4.2.3 Seam elongation (%) of fused and sewn samples for p/c single jersey fabrics**

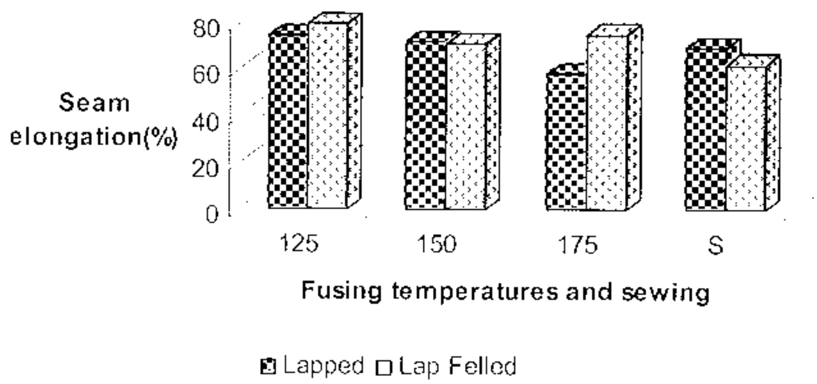
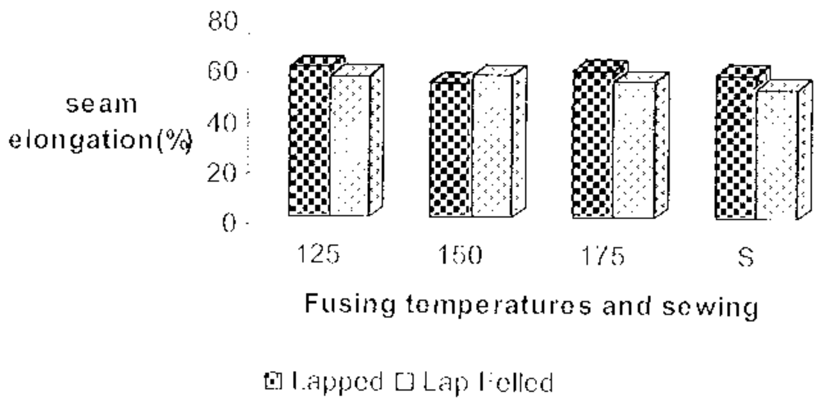



**Fig 4.2.4 Seam elongation (%) of fused and sewn samples for cotton single jersey fabrics**



### 4.2.5 COTTON RIB FABRICS

For cotton rib fabric elongation in fused samples is slightly increased than sewn samples. Lap felled seams gives good results than the lapped seam. At high temperature has no much effect on seam elongation. These results are shown in Table 4.2 & Figure 4.2.5

### 4.2.6 COTTON INTERLOCK FABRICS

Table 4.2& Figure 4.2.6 shows that in case of cotton interlock fabrics there is no much difference in seam elongation compared to fusing and sewing. Temperature has no much influence on seam elongation. Lapped seams give a better result.

According to seam elongation, viscose single jersey fabric has less seam elongation than other fabrics

**Fig 4.2.5 Seam elongation (%) of fused and sewn samples for cotton rib fabrics**

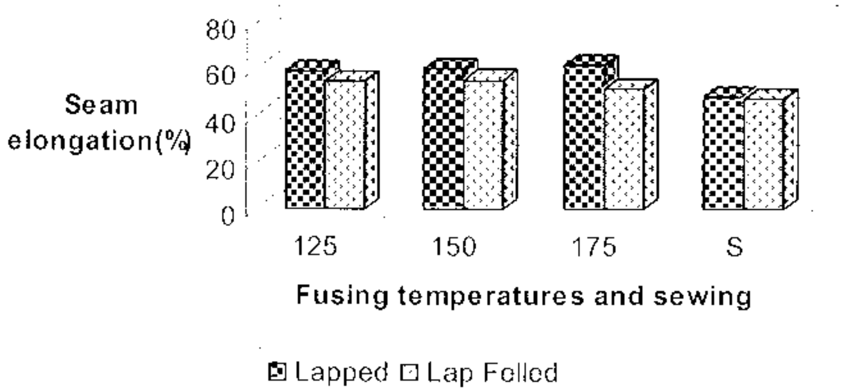
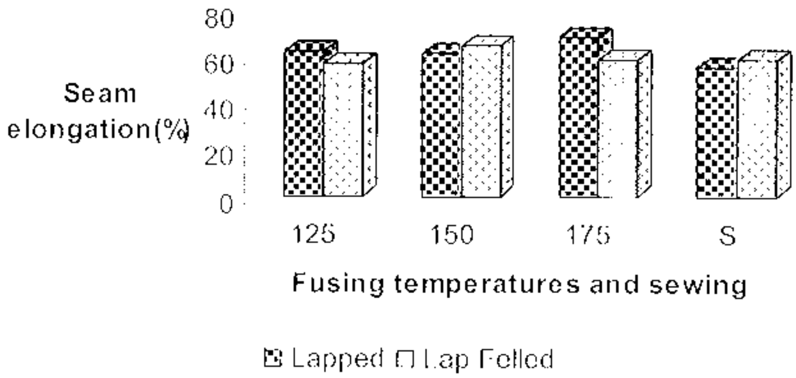



**Fig 4.2.6 Seam elongation (%) of fused and sewn samples for cotton interlock fabrics**



### 4.3 Effect of Seam type and joining method on stiffness and seam thickness for different samples

The samples were tested for the effect of seam type and joining method on seam stiffness and seam thickness for different types of fabrics.

The seam stiffness is increased in case of fused samples than the sewn samples.

4.3.1 Seam Stiffness

Table 4.3.1 shows the seam stiffness value for different fabrics fused and sewn with lapped and lap felled seams. On comparing with sewing,fusing gives more stiffness.

**Table 4.3.1 Seam Stiffness (kg/sq.cm)**

| S.no | Fabric types | Fused seams | | Stitched seams | |
|---|---|---|---|---|---|
| | | Lapped | Lap felled | Lapped | Lap felled |
| 1 | Cotton single jersey | 100.38 | 444.8 | 2.284 | 5.138 |
| 2 | Polyester single jersey | 95.84 | 311.14 | 4.517 | 1.863 |
| 3 | Viscose single jersey | 192.4 | 219.76 | 18.7 | 7.137 |
| 4 | Polyester/Cotton (blend) single jersey | 129.4 | 278.8 | 22.92 | 8.73 |
| 5 | Cotton rib fabric | 33.63 | 50.12 | 3.343 | 5.60 |
| 6 | Cotton interlock fabric | 32.84 | 108.82 | 3.352 | 5.487 |

### 4.3.2 Seam thickness

Seam thickness values for both fused and sewn samples are given in the table 4.3.2. Fusing gives less seam thickness than sewing for all types of fabrics in both seam types.

**4.3.2 Seam thickness** (mm)

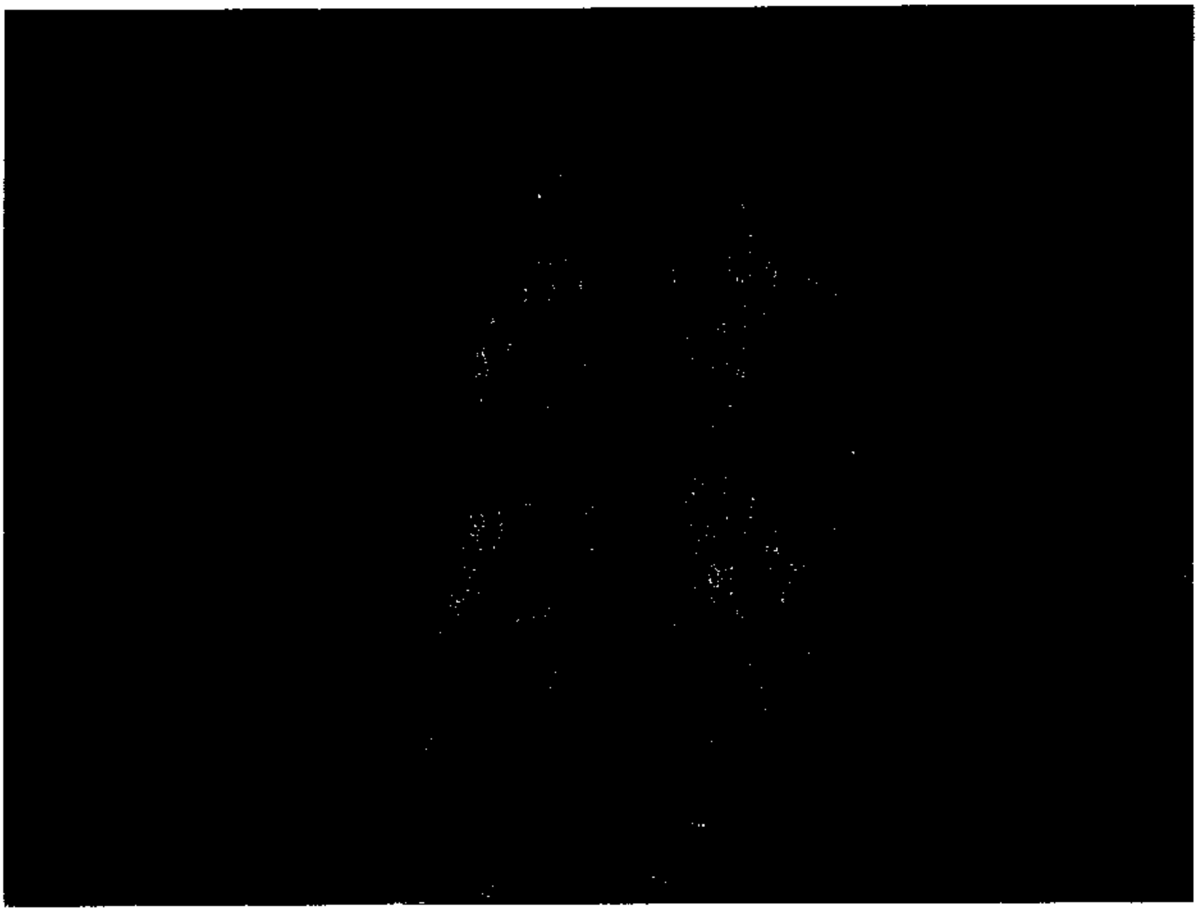
| S.no | Fabric types | Fused seams | | Stitched seams | |
|---|---|---|---|---|---|
| | | Lapped | Lap felled | Lapped | Lap felled |
| 1 | Cotton single jersey | 0.84 | 1.5 | 0.96 | 1.85 |
| 2 | Polyester single jersey | 0.58 | 0.98 | 1.05 | 1.85 |
| 3 | Viscose single jersey | 0.76 | 1.3 | 0.92 | 1.65 |
| 4 | Polyester/Cotton (blend) single jersey | 0.92 | 1.53 | 1.05 | 1.82 |
| 5 | Cotton Rib fabric | 1.30 | 2.45 | 1.43 | 2.78 |
| 6 | Cotton Interlock fabric | 1.22 | 1.91 | 1.44 | 2.55 |

# 5. CONCLUSION

From the results and discussions done for the comparison of the effect of seam type and joining method on seam strength and seam elongation following conclusions are arrived.

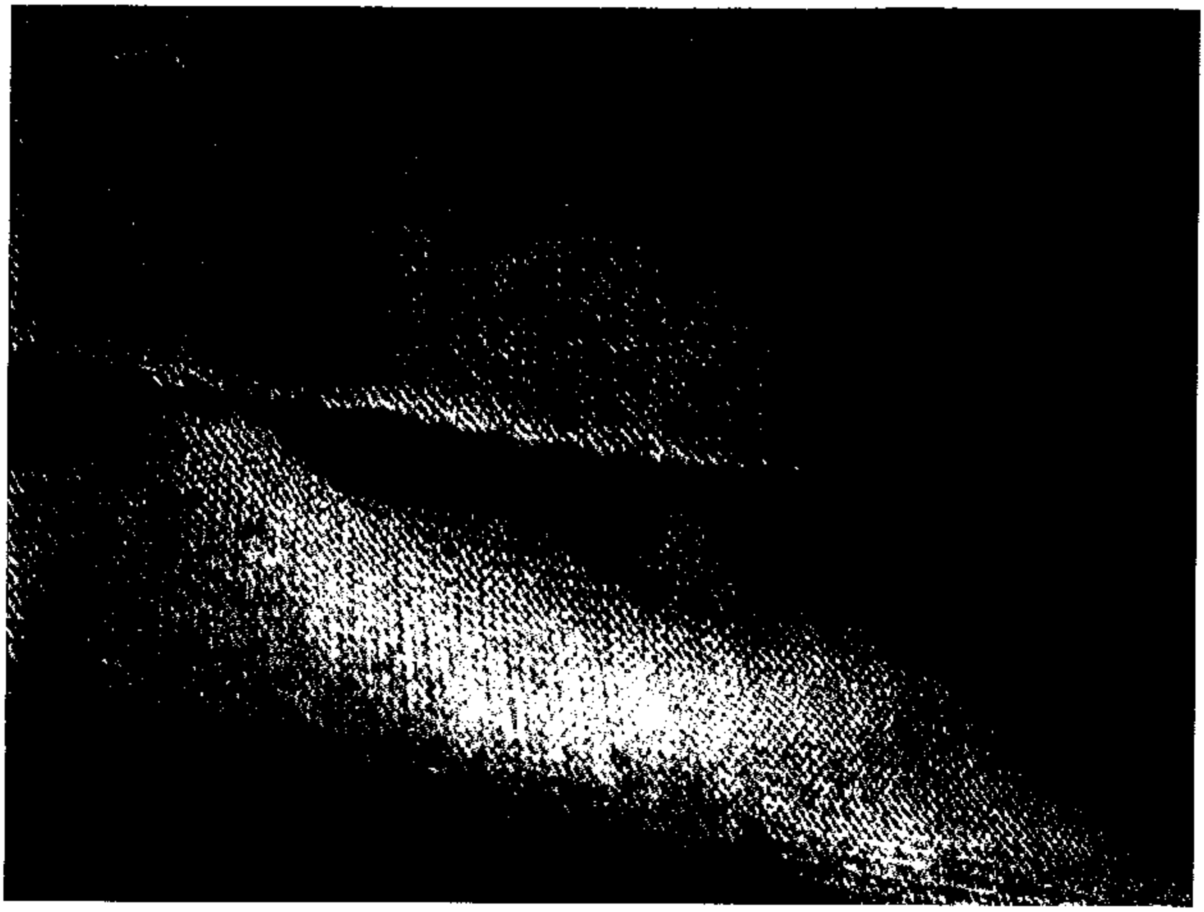
- In polyester fabrics, fused samples have good strength and good elongation than sewn samples at lower temperatures.
- In case of polyester /cotton blend higher temperature reduces the strength and seam elongation. Seam strength is good at lower temperatures.
- Cotton single jersey fabric doesn't show much difference in seam strength by rise in temperature.
- Cotton rib structure gives very good seam strength for fusing at higher temperature than the sewing. There is only slight increase in seam elongation of fused seams compared to sewn seams.
- Cotton interlock structure gives very good seam strength compared to sewing. Fusing has no considerable effect on seam elongation.
- Results from seam stiffness tests shows that sewn samples have less seam stiffness than fused samples.
- In case of fused samples, seam thickness is lower than the sewn samples.
- On comparing all types of fabric, Cotton rib structure seems to give high strength regardless of temperature rise. Polyester single jersey fabrics show less seam strength than others.

ANNEXURE.



FUSED GARMENT

SEAM FRONT



SEAM BACK.

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