DESIGN AND DEVELOPMENT OF FOOTWEAR WITH SPECIFIC EMPHASIS ON THERMAL COMFORT USING INTERCHANGEABLE UPPER COMPONENTS

A THESIS

Submitted by

SHIMELIS FELEKE

In partial fulfillment for the award of the degree of

MASTER OF TECHNOLOGY IN

FOOTWEAR SCIENCE AND ENGINEERING

A.C. COLLEGE OF TECHNOLOGY

DEPARTMENT OF LEATHER TECHNOLOGY

ANNA UNIVERSITY, CHENNAI

SEPTEMBER 2020

ANNA UNIVERSITY, CHENNAI

BONAFIDE CERTIFICATE

Certified this Thesis title "**DESIGN AND DEVELOPMENT OF SHOE WITH SPECIFIC EMPHASIS ON THERMAL COMFORT USING INTERCHANGEABLE UPPER COMPONENTS**" is the bonafide work of **SHIMELIS FELEK** (2018407007) who carried out the under my supervision. Certified further that to the best of my knowledge the work reported herein dose not form part of any other thesis or dissertation on the basis of which a degree award was conferred on an earlier occasion on this or any other candidate

Signature of the HOD
Dr. J. Raghava Rao
Head of the Department
Department of Leather Technology,
Anna University supervisor-honorary faculty
Chennai – 600 025

Signature of the Supervisor
Dr. Mohan
Honorary Faculty,
Department of Leather Technology
Anna University
Chennai – 600 025

ABSTRACT

Shoes with interchangeable upper, it is a new concept of shoes that are characterized by their upper are interchangeable which helps them to adapt for every occasion and that is transformed into light footwear and easy to save space during the trips. same size upper and soles are interchangeable. Design and development of interchangeable components of the shoe leather and leather lining combination is measured by using CAD is used to accomplish preliminary design and design details and calculations, creating 3-D models, creating and releasing drawings, as well as interfacing with analysis, manufacturing footwear. This manufacturing of changeable seasonal shoe upper is more comfortable on the human foot and intended to protect while the wearer is doing various activities. Also used as an item of decoration, fashion and footwear customization is simply unzip and re-zip the best style of the seasons easy to clean with good hygiene, separable upper and outsole, preventing smelly of shoes. lots of upper styles to be purchased separately. users purchase not only in pairs but also in 'parts' of the shoes, allowing users to reduce the cost of repurchase while extending the lifespan of the footwear by change only the part damaged. footwear customers are simply using unzip and re-zip their comfortable footwear style and users purchase not only in pairs but also in parts of the shoes, allowing users to reduce the cost of repurchase while extending the lifespan of the footwear by change only the part damaged.

Key word: interchangeable upper, thermal comfort

ACKNOWLEDGMENT

First and foremost, I express my heart felt and deep sense of gratitude to **DR. K.J SREERAM,** Director of CSIR-CLRI, Chennai, **Dr. J. RAGHAVA** RAO, Chief scientist, Head of the Department, Department of Leather Technology, Anna University-CLRI, Chennai, **Shri. MD. SADIQ**, Chief Scientist & Head SPDC-CLRI, Chennai for providing the necessary facilities for the proceeding of the project.

I am extremely grateful to my Supervisor **Dr. Mohan**, Senior Principal Scientist, **Shri. Akshaya Raman**, Scientist, SPDC-CLRI for her invaluable guidance, motivation, timely and

insightful technical discussions.

I am indebted to my project Coordinators **Shri. MATHIVANAN**, Senior principal scientist, SPDC-CLRI, **Dr. K. KRISHNARAJ**, Senior principal scientist, SPDC –CLRI, Chennai for their valuable suggestions and motivation.

I would be failing in my part if I don't acknowledge my family members

and my friends for their constant encouragement and support.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST ABBREVIATIONS

A.C. T	Alagappa College of Technology
3-D and 2-D	Three dimensional and two dimensional
CSIR-CLRI	The Council of Scientific & Industrial Research - Central leather research institute
LIDI	Leather industry development institute
°C	Degree centigrade
R/H	Relative humidity
Temp	Temperature
Rct	Thermal resistance
Ret	Water -vapor resistance
Kcm^2/W	Kilo centimeter square per watt
Mm	Millimeter
ISO	International organization for standardization
ASTM 1868	A Standard test method for thermal resistance and evaporative resistance
USB	Universal serial bus with a computer
CAM	Computer aided manufacturing
CAD	Computer aided design

CHAPTER 1

1.1 INTRODUCTION

Leather was the first footwear fabric over the past few decades. leather has developed an athletics name from bickers collars to underwear**.** leather is rising as a hip look on the streets and, in the workplace**,** covering men or girls, young or old from top to bottom. due to a mix of nature and fashionable technology, the style of leather is soft and supple

Leather has become a very specialized fashion material that requires talented specialists to show high-quality footwear. leather footwear is one in all the sophisticated products of finished leather. the leather shoe carries with its articles of leather apparel and completely different footwear style, accessories as per classification which might include a lot of specifically Gents leather boots shoes, oxford shoes, slip-on shoes, derby shoe, etc. leather footwear girls are knee boots, ankle boots, court shoes and children footwear. These are used only in cold places and usually, footwear made for autumn-winterer is made from somewhat serious leather from Hides with a thick lining of either wool or artificial fur. Demand for Goat suede and light-weight sheep Nappe is generally high for European markets in spring-summer whereas that for cowhides and somewhat heavy sheepskin is high for the time of year winter in Europe and also the USA.

Design and development of interchangeable upper components of the footwear leather shoes, leather shoes lining combination and fabrics is measured by using water vapors permeability test, Cold crack Resistance test, Flexing of vamp testing, water absorption test, and lining material, Resistance to Water Penetration of leather and leather lining

1.2 NEED FOR THE STUDY

Today we have advanced foams and gel inserts and a great understanding of human anatomy. However, human beings are need changing rapidly and multi-functional shoes are required near future and required to high comfort of shoe.

Footwear can directly lead to foot pain or other foot health issues with the cause of hot and cold temperature (corns and blisters, sunburned feet, sweaty feet, swollen feet, diabetes, nerve disorders, hypothyroidism)

A poor choice in footwear can directly lead to foot pain or other foot health issues people have more problems in the summer and winter because they tend to be less supportive shoes.

Leather shoes with the interchangeable component are not available on the market it is a new idea for leather shoes that are characterized by their upper and soles are interchangeable.

There is no standard generated used as a baseline for the thermal comfort of shoe leathers even though human feeling depends on thermal regulation properties of leather shoes.

1.3 OBJECTIVES

1.3.1 GENERAL OBJECTIVE

The aims of this study were to increasing shoe comfortable and therefore the increasing affordability of people easily assessing different seasonal shoes in one product to considering the temperature distribution through thermal comfort of shoes in four seasons.

1.3.2 SPECIFIC OBJECTIVES

This producing changeable comfortable footwear to protect whereas the user is doing numerous activities and footwear customization is simply unfastened and re-zip the most effective style of the seasons simple to clean with good hygiene, separable upper and preventing the odor of shoes.

upper shoe component is interchangeable which helps them to adapt for every occasion and that is transformed into light footwear and easy to save space during the trips. same size upper are interchangeable.

CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

Not research has been done on the thermal comfort of the interchangeable upper shoe (interchangeable thermal comfort of the upper shoe is a new idea of shoes). But a lot of research has been done on thermal comfort.

The widely accepted basic requirements of mankind are clothing, food and shelter. Food provides sustenance and shelter protects humans from the elements of nature. Clothing, in a broad sense, covers all items which serve to cover the human body. This broad class can be divided into garments, footwear, body decorations, etc. [1]

The ergonomics and also thermal comfort of footwear is presented work was an attempt to use selected modeling CAD software system and the finite volume technique for analysis of heat transfer through footwear between the shoes' user and his surroundings. Based on the actual two selected sports shoes, three-dimensional models have been designed, taking under consideration their completely different geometry and raw material composition. The models used simplifications associated with the internal construction (in microscale) of the specific parts of the footwear (sole, insole, shank, lining, and tongue). The main purpose of the work was to work out the influence of the simplifications used on the accuracy of simulation as a tool to predict thermal insulation of real shoes determined by suggests that of the thermal imaging camera. The simulations results were in correlation with the experiment

and showed that the applied software system may be a good tool in learning the chronophysiological properties of footwear (2)

Human thermal comfort depends on combinations of footwear structure and chemical nature of leather and other footwear materials, external conditions and factors related to wearer. Human micro climate is an important factor in maintaining of optimal capacity for work and feeling of comfort. High heat conditions may cause health problems, as well as psychiatric problems, which can lead not only to the reduction in quality of work, but also to the human vital organ dysfunction. The concept "human thermal comfort" is not unequivocal explainable. The human being has its own dynamics, thereby footwear comfort is a subjective feeling and it is quite difficult to define all factors which can affect this feeling. (3)

2.2 THERMAL COMFORT AND INSULATION STUDIES ON LEATHER FOOTWEAR

Leather was the first footwear fabric over the past few decades. Leather has developed a racing reputation from bickers collars to lingerie. Leather has become a very specialized high fashion fabric that requires talented specialists to turn into a quality shoe.

Leather footwear is widely used as protective shoes against a cold environment. The relationship between footwear comfort and footwear materials lies in the ability of a material to retain or conduct body or environmental heat, absorb or repel moisture and feel next to the skin. There are two main aspects of footwear comfort. These are the physiological and sensorial that combine to create a subjective perception of satisfactory performance (4). Thermal insulation main parameter to provide physiological comfort (5).

Optimal thermal comfort on wearing apparel is achieved by balancing the rate of heat transfer by the human body, insulation value of the apparel and environment temperature. Heat transfer is related to the determination of the rate when energy is transferred as heat under temperature difference between two bodies (6). The thermal situation of apparel as a protective layer between the human body and the environment is very complex and largely depends on human factors (activity, individual factors),footwear (material, fit) and environment factors (temperature, wind, radiation) (7).To remain comfortable, the human body must maintain a skin temperature of 34°C and in thermal equilibrium with the environment (8).

Cow full-grain leather: is the most common leather used in the making of high-quality footwear. It covers a wide spectrum of textures and quality. It is quite durable, easy to care for and resistant to water and dirt. It takes the shape of the wearer making it more comfortable with everyday use. (9)

The data shows the thermal resistance of goat suede is 69 Kcm2/W lower than sheep suede leathers. This indicates goat suede leather is better to utilize in a hot environment. While sheep suede is the material suggest for cold environment shoe making. Cow suede has thermal resistance value between sheep suede and goat suede which can make an alternative candidate for both hot and cold environments. The thermal resistance value can be affected by the quality of garment leathers used for testing and finishing operation during post tanning. Hence, we suggest running more tests in each with a different source to conclude the investigation. However, based on the current study the result is reliable since the sweat guarded hot plate machine generates reproducible data. (10)

Table 1

Table 2.1: thermal resistance of cow garment leathers

Sample	R/H	Temp Air	Air Speed	Rct(K cm^2/W)
Cow full grain	65	20.00	1.00	166
Sheep suede	65	20.00	1.00	205
Goat suede	65	20.00	1.00	136

The thermal resistance of leather footwear is clearly seen on the graph below

- Goat suede. – in a hot environment
- Sheep suede. -in a cold environment
- Cow full grain- between sheep and goat

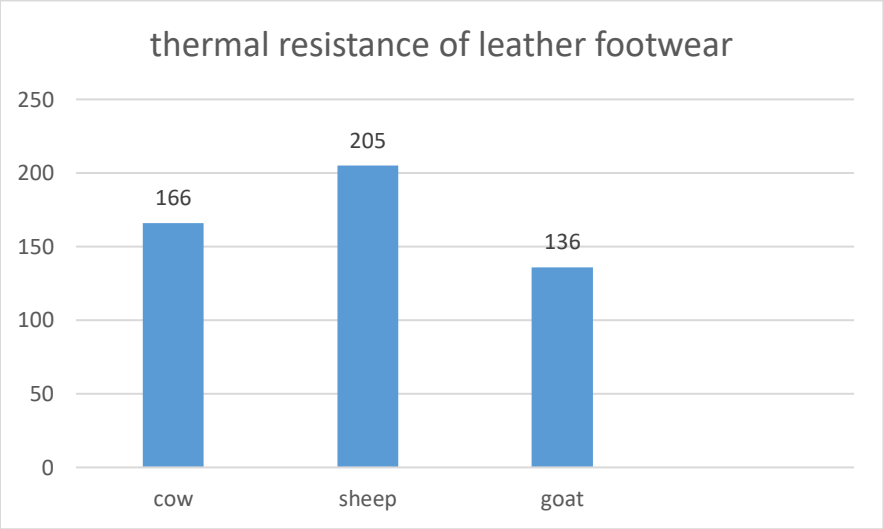

figure 2.1 thermal resistance of footwear leathers

Sheep full-grain leather: refers to the hide of a sheep used with the wool still attached. Usually, the wool side faces into the footwear or accessory but it can also be reversible. The wool can be ironed which means straightened to yield a smooth for like appearance or it can be left naturally curly. Whichever the way the wool is styled, this is the warmest leather available.

Goat sued leather: has characteristic pattern and short and compact fibrous structure, with a unique look to the skin. It is used for a variety of products ranging from footwear to garments.

2.3 **THE GENERAL PROPERTIES OF UPPER FOOTWEAR LEATHERS [9, 10, 11,].**

The properties of upper leathers used in top quality shoe producing area unit indicated as below;

1. Structural Strength: the most necessary factor on the leather quality is the strength of the leather to the external influences. Poor tensile, tear and sew tearing strength square measure the good indication of the poor structural strength of leather material. the upper leather product should demonstrate high tensile and tear strength values with extension in sure limits. Additionally, the structural properties might vary depending on the leather type and tanning method.

2. Flexibility: The bending and flexion properties of leather materials, which will be used in shoe producing, the square measure needed to be high and compatible. Therefore, the leathers with poor flexibility values show folding and braking components. inadequate fatliquoring, heterogeneous tanning might be the reason for this undesired flexibility further because of the inadequate removal of globular proteins between the albuminoid fibre bundles.

4. Resistance to Water: leather has a water absorption property because of its structural property. However, water absorption characteristic is accepted as a standard property up to some sure limits and extreme values will have an effect on the leather quality negatively. The wetting capability of leather grain is depended on the external physical phenomenon and also the grain characteristic of leather. during this respect, the present condition of the leather and also

the circumstances have played an important role. The high-water absorption property of leather may be a well-known undesired property and also the shoe upper leathers ought to be processed as a water repellent.

5. water vapor and Air Permeability: water vapor and air permeability have played an important role to see the hygienical property of shoe higher leathers. Leathers used each in garment and shoe production, ought to have the water vapor and air permeability characteristics to some extent. the human body has the flexibility of holding the body temperature stable and spreading it to the surroundings.

CHAPTER 4

MATERIAL AND METHODOLOGY

4.1 MATERIALS

Based on the environmental condition that shoe is used to supply optimum comfort with the use of high-quality leather footwear components. Leather as material is usually chosen once considering consumer goods properties and used as upper, lining and sole material in shoe producing. Particularly lining and sole material have quite important functions and might have an effect on the health of the food and comfort of the wearer working below significant condition and might even increase their work efficiency.

The choice of raw material should be considered according to the final function of the shoe and new special or technological strategies should be chosen rather than classic footwear product processes. The absence of the leather product standards supported the ultimate product usage functions, standard values got to be determined for the shoe higher quality leathers. As a result, the shoe higher leather utilized in completely different surroundings has to be investigated in any scientific researches.

The samples for the study were prepared using various types of leathers footwear and leather lining. The leathers used were sheep nubuck (1.2 mm thick), goat nubuck (1.2 mm thick), cow leather (1.6 mm thick), goat suede (1.4 mm thick), sheep suede (1.4 mm thick) and zipper, Velcro, foam. Commercially available top-grade leathers were procured from different sources with uniform

size and for lining garment we purchased form Chennai shop. The thickness of all leather was adjusted by buffing to 1.2mm-1.6mm.

4.2 METHODOLOGY

CAD is used to accomplish preliminary design and style details and calculations, creating 3D models, making and releasing drawings, also as interfacing with analysis, manufacturing footwear.

2D styles into the Shoe master system. Once digitized, you will be able to engineer the styles for production, or quickly produce new designs from one last to another.

4.3 DESIGN OF SHOE (CAD)

PREPARE A STANDARD FOR DIGITIZING

Before you begin digitizing any new shell it is wise to take a few minutes to consider the best methods of working e.g. the most effective way of digitizing. Consider any factors affected by grading restrictions or holding required for production. A few minutes of preparation at this early stage might save you time in unnecessary modification later. The shell lines that you digitize represent the “flattened” shoe last that your style is developed on. Although you will be able to make modifications to these lines once digitized, you should aim to be as accurate as possible with your digitizing. The center line is used to enter important reference points in the first stage of digitizing.

4.4 2D- DIGITIZING

Initializes a Digitizing Tablet: -ensures that the computer and the digitizing tablet are talking to each other, and also registers important reference points – the Net Toe point and one other point anywhere along the center line of the standard. These are important reference points, particularly the net toe point, enabling you to return to the style at a later date to make any necessary modifications and additions.

1. Position the supplied Simple shell standard on your digitizing tablet.
2. Use the Line drop down menu.
3. Select New.

4. Select Dignities.
5. Select Shell.
6. Now select initializes Tablet.

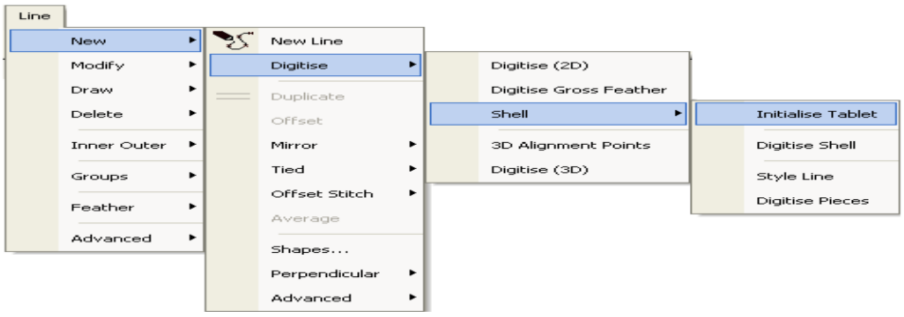

Figure 3.1 select initializes Tablet.

7. You are now prompted to "enter net toe point and one point along the center line". The points required are shown in below.

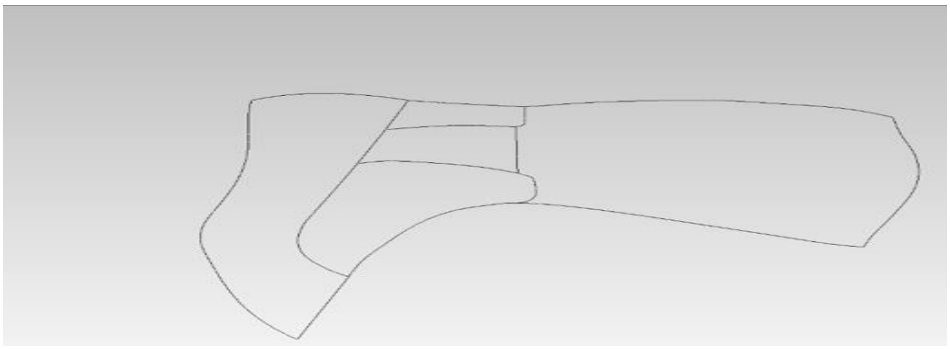

Figure 3.2 center line

8. Click the left mouse to enter the Net Toe Point.
9. Click the left mouse to enter the other required point along the Centre line.

This completes the Tablet Initialization and the tablet is now ready for digitizing

4.5 DIGITIZE A BASIC STANDARD

Digitizing is the first important step in implementing your work into the CAD CAM process. Once complete, you will be able to use many more Shoe master features to engineer your design to production standards. A 2D standard is created as a traditionally flattened 3D shoe last, therefore the lines you will digitize make reference to those of a shoe last.

1. Use the Line drop down menu.
2. Select New.
3. Select digitize.
4. Select Shell.
5. Now select digitize Shell

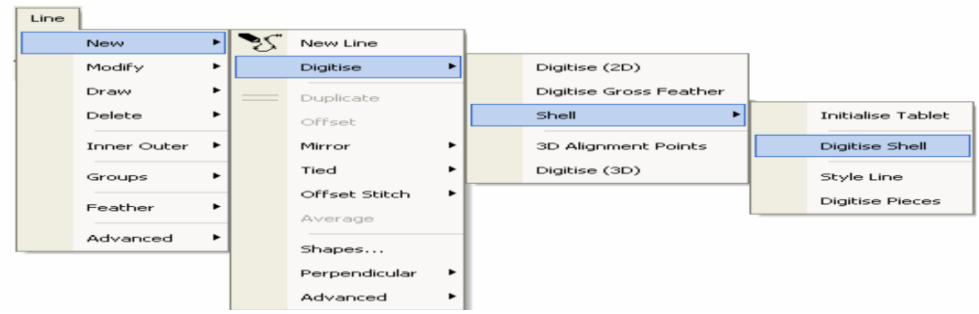

Figure 3.3 select digitize Shell

On selection of the command, the following dialog is produced.

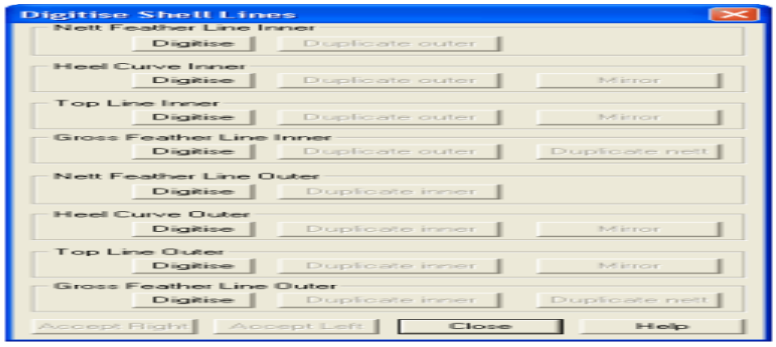

Figure 3.4 dialog is produced.

You will need to work through each section to digitize your shell lines.

6. Click on the button in the Net Feather Line Inner section of the dialog box

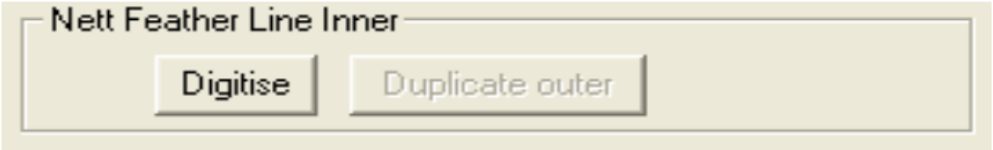

Figure 3.5 net feather line inner

7. Click the XY button on the digitizing
8. mouse at various intervals on the line to replicate the shape on screen. The clicks you make will produce “nodes” that build up the line. The first click you make should be about 1mm away from the center line, starting at the toe and working towards the heel using the reference points you made earlier as

a guide. This will prevent any potential problems later on when you "accept" the digitized standard.

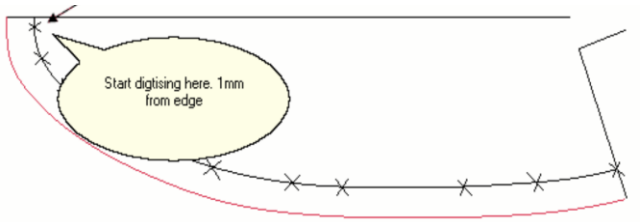

Figure 3.6 start digitizing

9. When you have completed the line use the Accept, Draw Line 2D, Disable Tablet on the digitizing mouse. This completes the line and draws it on the screen. The crosses you see on the line represent the nodes e.g. clicks you made with the mouse.
10. Select in the Net Feather Line Outer section of the dialog box.

Figure 3.7 duplicate inner

11. Now move onto the Heel Curve Outer section of the dialog box.
12. Now move onto the Top Line Outer section of the dialog box.
    Again, the Duplicate Inner option is available and since this part of the design is also symmetrical you can use this option.
13. *Now move onto the Gross Feather Line Outer section of the dialog box.*

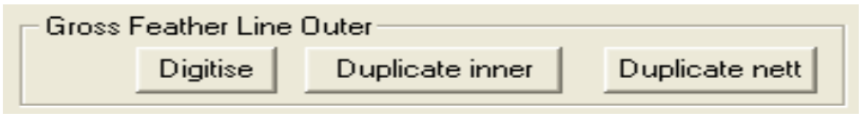

Figure 3.8 duplicate net

14. Select in the Gross Feather Line Outer section of the dialog box.

15. Select Accept Right or Left (as appropriate) to accept the lines you have digitized

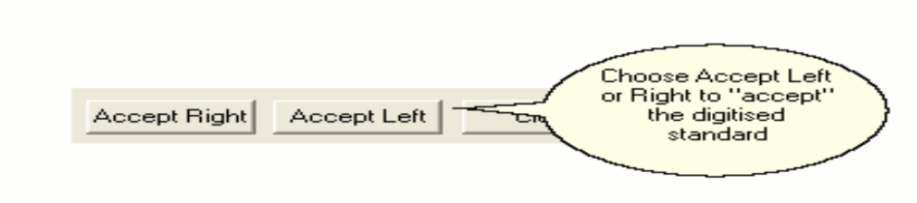

Figure 3.9 accepting left

This accepts the lines that you have digitized including the duplicates you have made, and draws them altogether on the screen as a right (or left) foot.

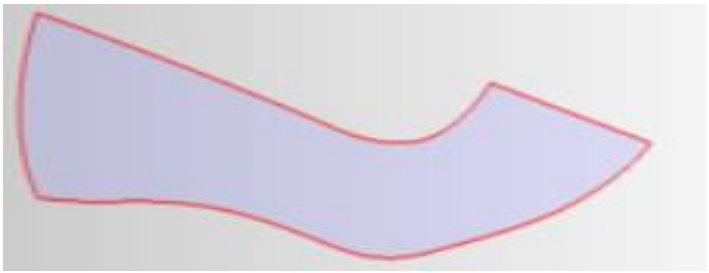

Figure 3.10 screen as a right (or left) foot

4.6 PATTERN CREATION

CREATE A NEW PRODUCT

A Packet is effectively an “envelope” that contains all the pattern pieces you are about to generate. You may create more than one packet per style so you can organize patterns into separate envelopes if you wish.

If you do not create and name a new packet prior to selecting the New Piece function, a new packet will be generated automatically with a default name. Therefore, if you want to control the name of the packet, or make more than one per style, you will need to use the New Packet function described here.

1. Use the Packet drop down menu.

2. Select New.

3. and New Packet.

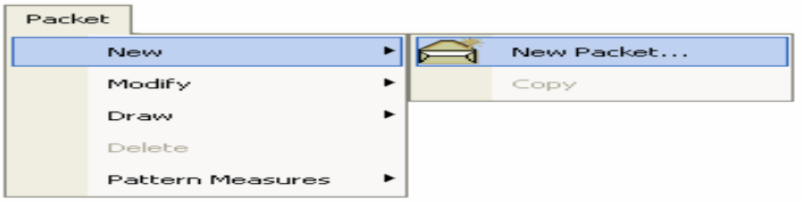

Figure 3.11 New Packet.

4. Enter a new name for the packet in the New Packet Name dialog.

5. A new packet is automatically generated with the name you entered.

CREATE A SET OF NET PATTERN PIECES

This Module is designed to introduce you to the basic functions required for generating a set of net pattern pieces. The pieces can later be used for design and/or engineering purposes.

1. Use the Piece drop down menu.
2. Select New.
3. Select Piece.

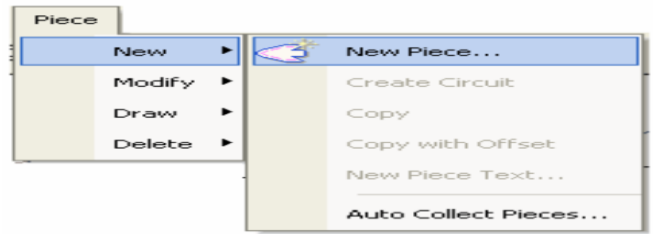

Figure 3.12 Select Piece.

4. *Enter a name for the piece in the Piece Name dialog.*

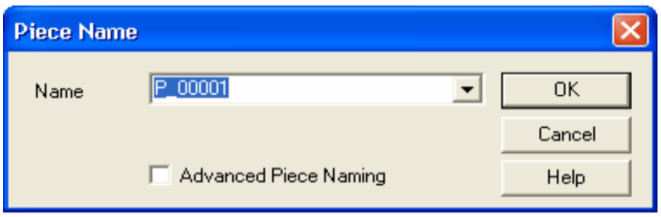

Figure 3.1piece name dialog

Here you can either use the default names P_00001 etc., you can type a name of your choice, or alternatively you can tick the Advanced Piece Naming dialog to produce a list of technical shoemaking terms.

5. Click Ok to accept the new name. You are now ready to collect the piece and will see an Arc dialog box. This box simply contains information on the piece that is about to be collected
6. Now click the lines that you want to make a piece in a CLOCKWISE direction, being sure to make the click at the very end of the line to ensure all nodes are included.
7. You must select consecutive lines when picking up a new piece. There must be no gaps between the lines that make up the shape. If you make a mistake during the process you must select “undo” until you are able to select the correct lines in the correct order, the program will not allow you to go back and select missed lines out of sequence.
8. When you have selected the final line of the piece, right click the mouse top produce a menu
9. Select Complete and Accept to finish the piece.

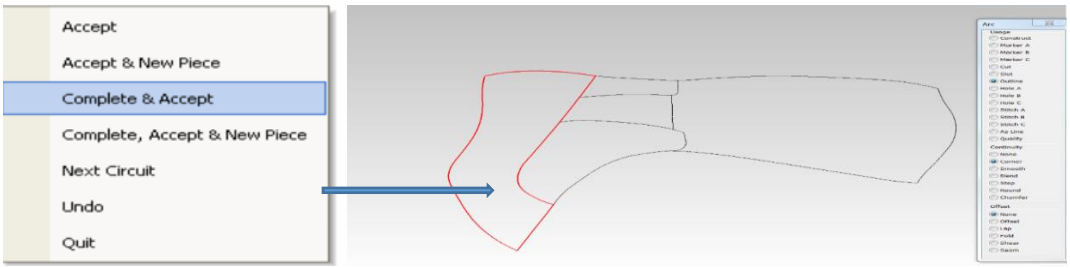

Figure 3.14 select complete and accept to finish the piece

4.7 Basic 2D grading

Work through the following modules to create a simple grade for a 2D Standard.

Set the Default Grade Type

This function allows you to set the type of grade of you want to apply, choosing from Metric, English or Continental.

1. Use the Grade drop down menu.
2. Select Settings.
3. Select Default Grade Type.
4. Now select the range you would like to work with.

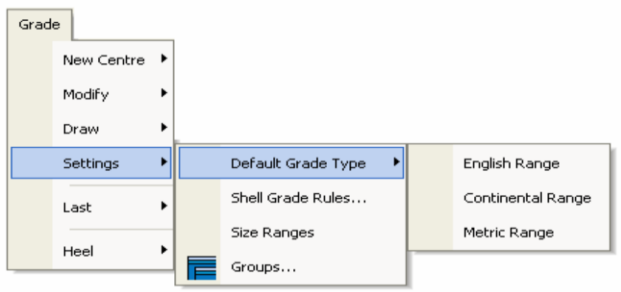

Figure 3.15 select the range

The range you would like to use is now automatically set.

Set the Shell Grade Rules

This function allows you to set up the rules you want to use for the grading. You

will learn how to set the width and length distances of the standard, and set up the increments for grading.

1. Use the Grade drop down menu.
2. Select Settings.
3. Now select Shell Grade Rules.

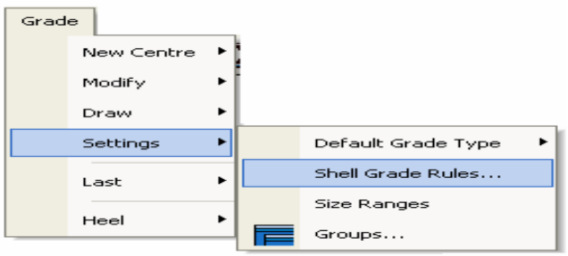

Figure 3.16 select shell grade rules

On selection of the function the following dialog is produced which will be used to set up the rules for grading.

The dialog is divided in four sections. The Grade Rule section is the first you will need to consider:

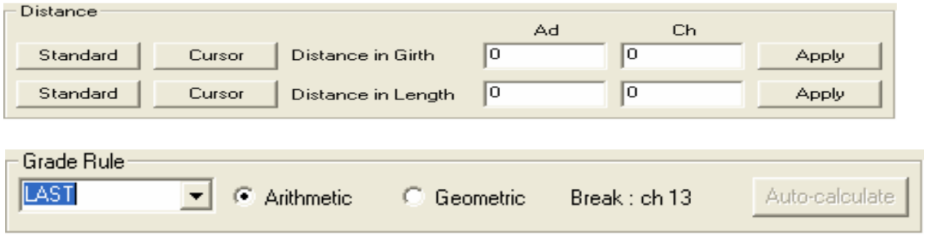

Figure 3.17 grade rule section

In this section you can set and apply the width and length distances of the standard.

1. Click on the Standard button.
2. You are prompted to "Enter the Girth Point" and will need to make one click in the center of the standard that represents the girth (or widest) point of the standard.

The Girth is calculated from net feather to net feather and you will now see a figure for the measurement has appeared in the Distance in Girth window.

3. Click the Apply button.
4. Now click the Standard button in the Length section

The Length is calculated from the net toe point to the intersection of the heel curves. This section is automatically updated and you will see a figure in the Distance in Length window.

5. Click the Apply button. The Size section is the next section to consider.

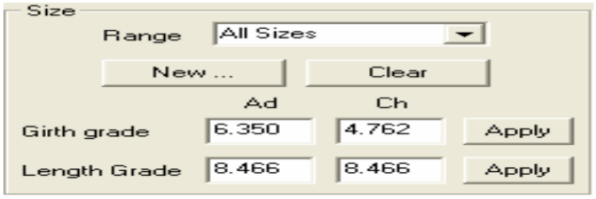

Figure 3.19 standard button in the length

5 In this section you need to specify the values you use for the grading increments.

SET THE SIZE RANGES

This function allows you to set up the size range you want to use for the grading.

1. Use the Grade drop down menu.
2. Select Settings.
3. Now select Size Range

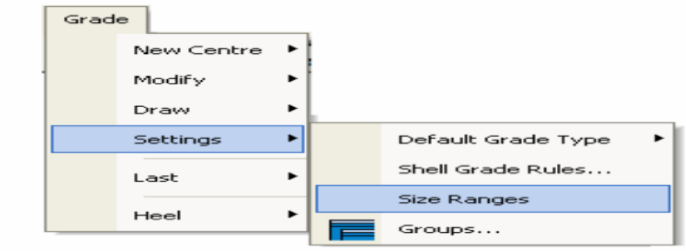

Figure 3.20 size range

On selection the Shell Grade dialog is produced. You will use this dialog to enter all size range information required for your grading.

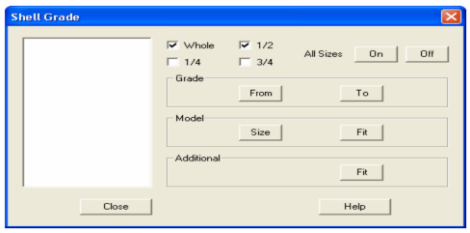

Figure 3.21 size range

4. Tick in the boxes to indicate if you want to use whole sizes, and/or half sizes
5. In the Grade section click the from button to produce a further dialog.

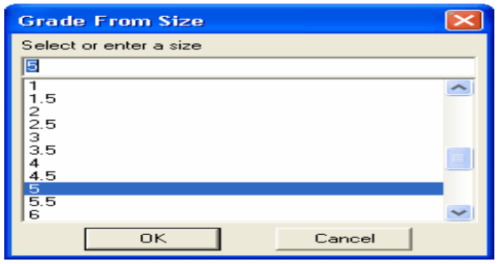

Figure 3.22 button to produce a further dialog

6. In this dialog you will need to select or enter the size that you want to start grading from.
7. Click ok to confirm.
8. Now select the to button in the Grade section, to produce a further dialog.

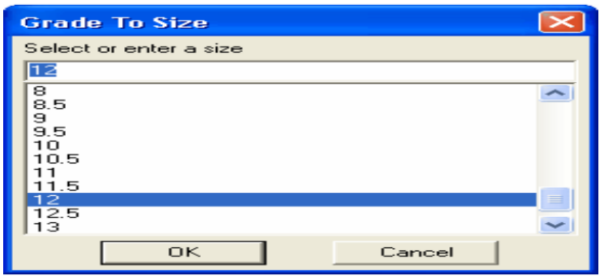

Figure 3.23 button to produce a further dialog

9. In this dialog you will need to select or enter the size that you want to start grading to.
10. Click ok to confirm.

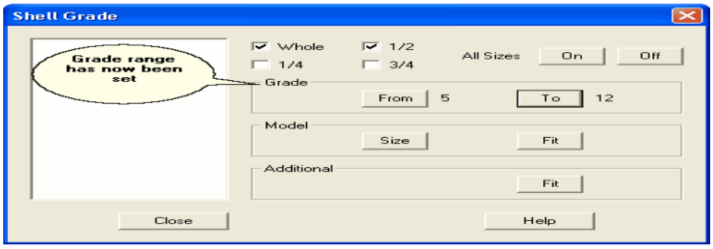

Figure 3.24 ok to confirm

11. Now refer to the Model section of the dialog. In this section you will enter a model size and fit.
12. Click on the Size button to produce a further dialog.

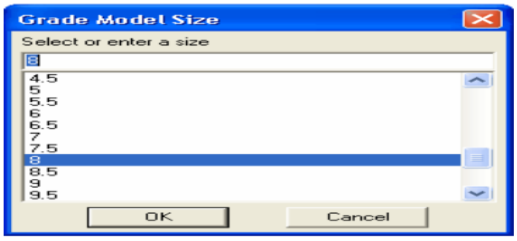

Figure 3.25 ok to confirm

13. Select or enter the model size you want to use
14. Click ok to confirm.
15. Click on the Fit button to produce a further dialog.
16. Select or enter the model fit you want to use.
17. Click ok to confirm.

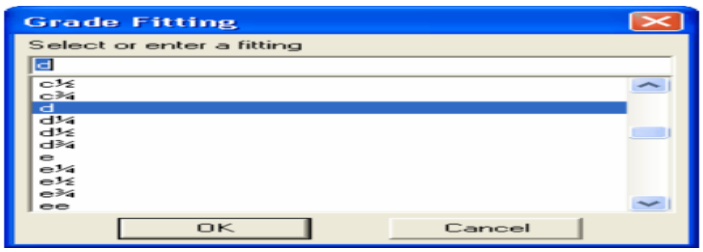

Figure 3.26 ok to confirm

18. This completes the process and you can Close the dialog. Knock the Graded Standard The knock function allows you to draw all sizes of the graded standard together, knocked from the same point on each style. Therefore, you are able to easily see the difference between sizes. In order to use this function, you should have previously created, at least, a basic grade. If you have not already done so, please refer to the following Modules.

- Set the Default Grade Type
- Set the Shell Grade Rules
- Set the Size Ranges

1 Ensure the style is drawn on screen. Please note that you can knock a style, a packet of pieces, or individual pieces

2. Now use the Knock Cursor icon found on the Toolbar

This will automatically put the program in the Knocking mode and will remain in this mode until you select the normal cursor with this icon on the toolbar. all the sizes of your style are now knocked together on the screen.

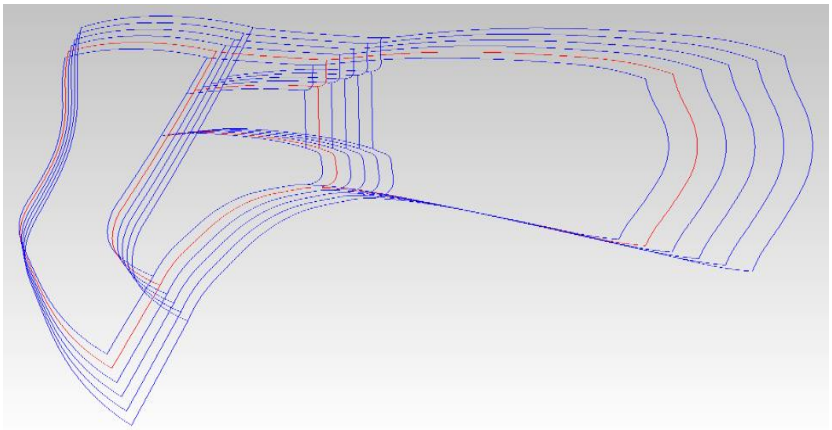

Figure 3.27 size ranges

If you want to change the place the style is knocked from, simply click the mouse to indicate where you want to knock from and it will automatically change

4.8 CUTTING SHOE COMPONENTS

1. Prepare material based on selection made in designing department
2. Cut the components using cutting pattern by considering defect area, line of tightness and stretchiness (leather and fabric), flexing direction for insole board, foam and synthetics by layer.

4.9 SHOE MATERIAL TEST

Design and development of interchangeable components of the footwear leather and fabric material combination is measured by using water vapors permeability test, Cold crack Resistance test, Flexing of vamp testing, water absorption test.

Specimen of leather for tensile strength and elongation at break dumbbell shaped test pieces of required shape and size are cut both at parallel and perpendicular directions to the back bone of leather depending upon the size of the sample available from proper location of hide or skin as given earlier Condition the test specimens and measure the width of each test piece to the nearest 0.1 mm at three places on grain side and three places on flesh side. Measure the thickness at three places. Calculate the area of cross-section on the test specimen by multiplying its width with thickness. Set the jaws of the tensile tester 100, 50- or 20-mm part for large, medium or small side sample respectively.

4.10 ASSEMBLY OF SHOE COMPONENTS

Closing is one of the departments in which to the preparation, fitting together and finishing off the cut components to produce an upper ready for lasting

4.11 LASTING AND FINISHING OF INTERCHANGEABLE SHOES

Lasting is that the term applied to the processes concerned in stretching the upper material over the last and securing it to the bottom of the insole either with tacks, adhesives or threads Providing that the operations square measure distributed within the correct method, the upper can ensure itself to the contours of the last and, once the last is removed, retain this shape and cleaning of the shoe.

CHAPTER 5

RESULT AND CONCLUSION

5.1 INTRODUCTION

Thermal resistance of footwear is one of determinant factors to evaluate comfort ability of footwear. The utilization of footwear in different atmospheric condition based on how footwear materials protect human body against wearer. In hot environments the footwear materials need to have low thermal resistance to allow heat movements between human body and environments. In contrast, in cold weather footwear must have high thermal resistance to prevent transfer of heat from human body to environment. Hence, shoe materials physical properties related to thermal resistance must measure to help selection of footwear materials for shoe in different atmospheric condition.

5.2 DESIGN OF INTERCHANGABLE UPPER SHOE

1. SKETCH (FREE HAND SKETCHING)

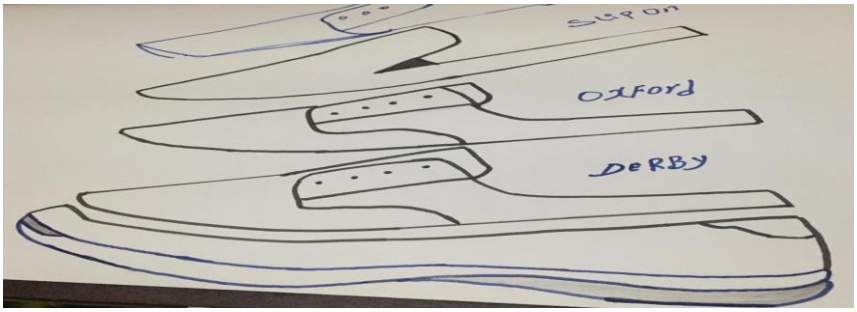

Figure 4. 1 sketched interchangeable shoe style

2. DESIGN A STANDARD FOR DIGITIZED

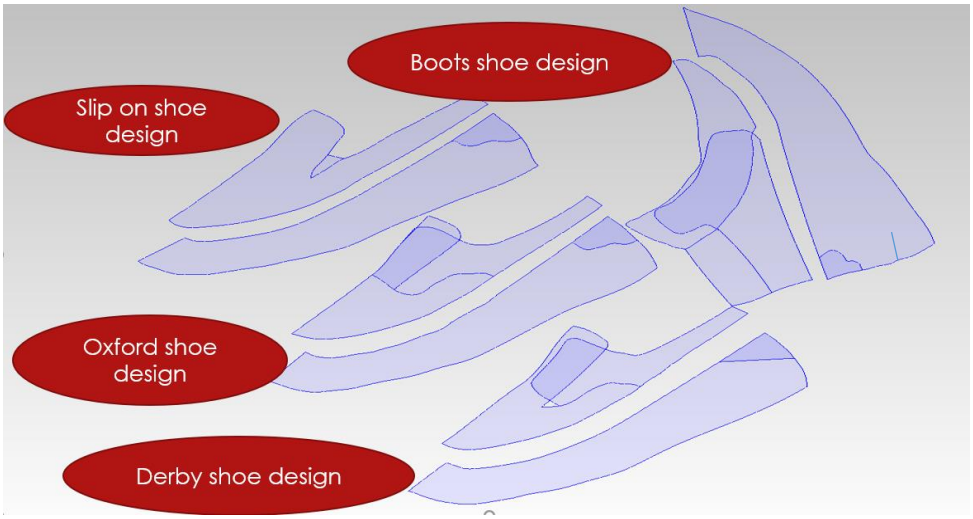

Figure 4. 2 sketched interchangeable shoe style

I. Most widely used as formal shoe.
II. Unisex.
III. Quarter is locked at the vamp point and hence opening quarter is limited.
IV. Has an independent tongue which is stitched at the stage of the upper.
V. In most of cases vamp will be on the quarter.
VI. Most widely used as formal shoe.

5.3 INTERCHANGEABLE UPPER SHOE MATERIAL SELECTION

COMFORT PROPERTIES

Footwear material thermal comfort properties for based on the lab test

Physical testing is a quantitative procedure that consists of determination of one or more characteristics of a given product, process according to a specified test method and procedure

COMFORT PROPERTIES: Permeability, water resistance, heat and cold insulation resistance etc.

BULK PROPERTIES: tensile strength, elongation at break, tear strength, lasting strength, substance etc.,

SURFACE PROPERTIES: – Flexing endurance, adhesion strength of finish, color fastness, gloss, smoothness etc.,

Most common types of leathers which are used for making leather shoe is given below:

COW LEATHER: is the most common leather used in the making of shoe. It covers a wide spectrum of textures and quality. It is quite durable, easy to care for and resistant to water and dirt. It takes the shape of the wearer making it more comfortable with every day use.

Figure 4. 3 cow leather

Physical properties of cow leather

i. High tensile strength
ii. Resistance to tear
iii. Good heat insulation
iv. Ease of working

SHEEP LEATHER: products sheepskin leather commonly used for Because sheepskin leather is lightweight, many people find sheepskin leather to be

significantly more comfortable for a shoe. Sheepskin's elasticity likewise makes it an excellent material for any season. It even makes a great lining for shoes.

Figure 4. 4 sheep leather

Physical properties of sheep leather

i. Enhanced water vapor permeability
ii. less tensile strength
iii. High elongation properties
iv. Less tear strength
v. Real feather-touch feel,

GOAT LEATHER: has characteristic pattern and short and compact fibrous structure, with a unique look to the skin. It is used for a variety of products ranging from making of shoe.

Figure 4. 5 goat suede leather

Physical properties of goat leather

- Extremely durable

- High flexible
- Moderate tear syrength
- Good insulating properties
- Resistance to wind and water

Figure 4. 6 Buffalo leather

BUFFALO LEATHER

- ❖ Quite durable
- ❖ Breathable and comfort
- ❖ High tensile strength
- ❖ High resistance to tear
- ❖ Good heat insulation

COW, SHEEP, GOAT AND BUFFALO PUNCHING LEATHERS

Thermal comfort is an important element for the human body and is increasingly becoming an important factor to be considered in footwear design. Development of thermal models that are capable of predicting in-shoe temperature distributions is an efficient thanks to assist in design optimization. These will make easier to approximate a heat transfer thermal-comfort relationship among the components.

Figure 4. 7 puncher leather

Physical properties of any punching leather

- Extremely breathable (easily air inlet and outlet)
- High durable
- High flexible
- Enhanced water vapor permeability
- Good insulating properties

5.4 WATER VAPOUR PERMEABILITY

water vapor permeability is a measure of the passage of water vapor through a material. It is also known as water vapor transmission rate or moisture vapor transmission rate.

It is the mass of water vapor that is transmitted through a measured area in a specific unit of time under specified conditions of temperature and humidity.

Package materials testing, as well as package evaluation and testing, are important parts of the research and development process. Testing helps ensure that new primary packaging materials and package designs are created specifically to handle real-world situations.

Table 4.1 Water vapour permeability

St no	Origin	Test result (Minimum standard) ($mg/cm^2/hr.$)	Result .			Test Method (SATRA TN 172:1993)
			Water Vapors Permeability $mg/cm^2/hr$	Water Vapors absorption $mg/cm^2/hr$	Environment (season)	
1	Cow leather	0.8	2.60	5.20	between hot and cold environment	(SATRA TN 172:1993)
2	Buffalo leather	0.8	6.44	5.067	cold environment	(SATRA TN 172:1993)
3	Goat leather	0.8	1.56	4.99	high hot environment	(SATRA TN 172:1993)
4	Sheep leather	2.0	6.46	4.93	cold environment	(SATRA TN 172:1993)
5	Oil pull up (Buffalo leather)	0.8	9.62	6.82	high cold environment	(SATRA TN 172:1993)

Calculation

Water vapour permeability = $\frac{n \times m}{d2xt}$

Weight, m = Gain in weight in mg

Weight, d = Mean internal diameter in mm of the neck of the bottle

Time, t= Time in minutes between the two weighing

Calculation for water absorption

1. Time for water penetration in minutes

2. Water absorption, percent for 60 minutes / customer's requested time

3. Water transmission in gram for 30 minutes

Water absorption, % = (W2 – W1) X 100

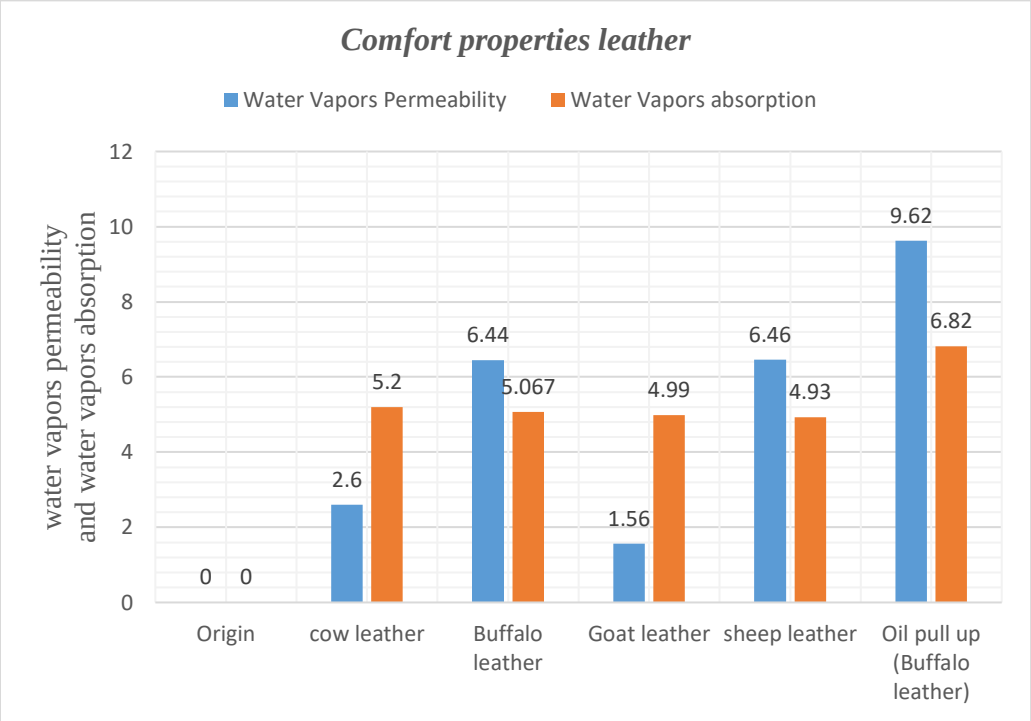

Figure 4. 8 Water vapour permeability

The thermal resistance of leather is clearly seen on the graph Figure 4.12

- ❖ Goat full grain): - in high hot environment
- ❖ Sheep full grain): -in hot environment
- ❖ Cow (full grain): - between Buffalo and Goat
- ❖ Oil pull up (Buffalo leather): - in high cold environment
- ❖ Buffalo leather: - in cold environment

5.5 THERMAL RESISTANCE OF LEATHER

The thermal resistance of footwear leather is one of the determinant factors to evaluate the comfortability of leather. The utilization of footwear leather in different atmospheric conditions based on how footwear leather materials protect the human body against the wearer. In hot environments, the leather materials need to have low thermal resistance to allow heat movements between the human body and the environment. In contrast, in cold weather footwear leather must have high thermal resistance to prevent the transfer of heat from the human body to the environment. Hence, leather materials' physical properties related to thermal resistance must measure to help the selection of leather materials for footwear leather in different atmospheric conditions.

Conditioning and testing in conditioned atmosphere are another important step in order to meet the accurate and inter laboratory confidence level in test results.

Therefore, leathers should be conditioned before testing for a period of 48 hours at any one of the three different climatic conditions

(1) At 20±2^{o}c & 65±2% rh

(2) At 23±2^{o}c & 50±5% rh

(3) At 27±2^{o}c & 65±5% rh

Laboratory climatic conditions according the customer's requirement as described in IS 2419 standard. Testing should also take directional effects.

Some of its physical properties vary with its moisture content, which in turn is related to the relative humidity of the atmosphere.

So, the testing should be conducted in the environment of any one of the above-mentioned conditions.

Table 4.2 Insulation against cold c⁰ and heat of leather

St no	Origin	Result			Test method
		Insulation against cold c⁰	Insulation against heat c⁰	Environment (season)	
1	Sheep full grain)	9.90	17	both hot and cold environment	Iso 20344:2011 Clause-5.12
2	Goat full grain):	10.3	19.6	high hot environment	Iso 20344:2011 Clause-5.12
3	Cow (full grain)	11.2	20.3	cold environment	Iso 20344:2011 Clause-5.12
4	Buffalo leather (full grain)	11.1	28.3	cold environment	Iso 20344:2011 Clause-5.12
5	Oil pull up (Buffalo leather):	11.9	33.7	high cold environment	Iso 20344:2011 Clause-5.12

The thermal resistance of leather is clearly seen on the graph Figure 4.1

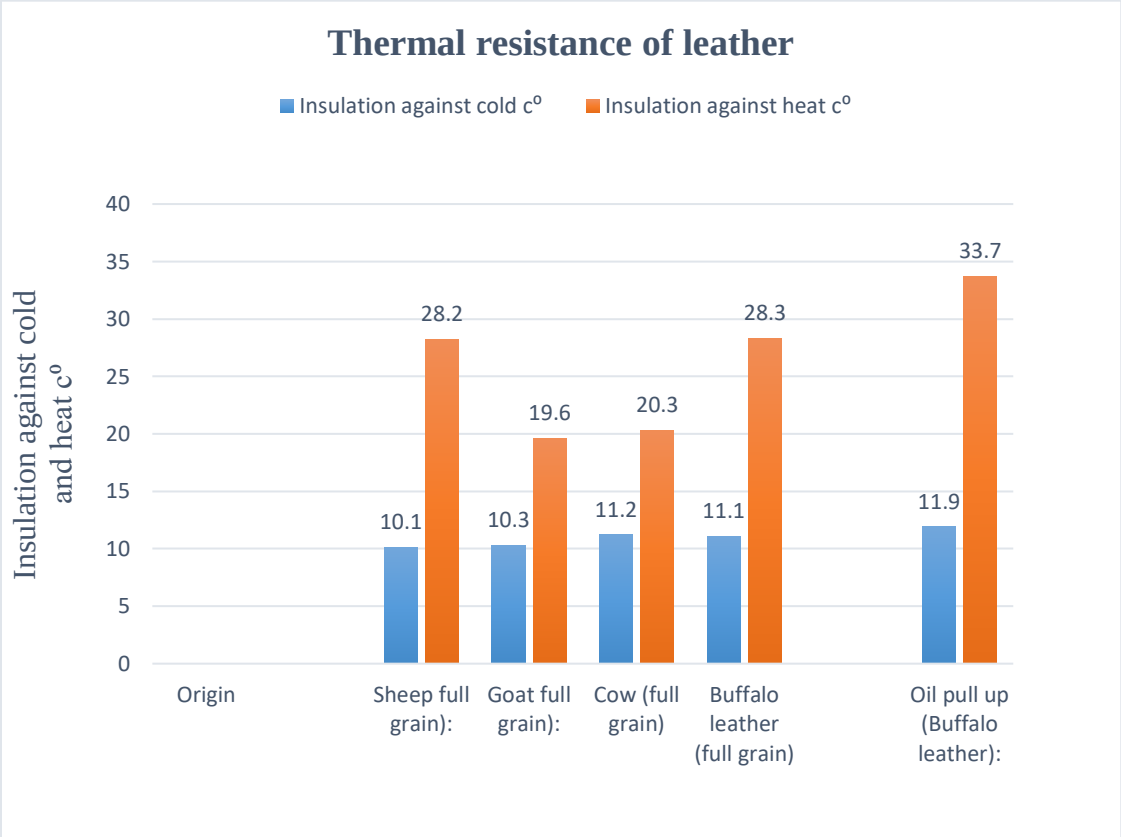

Figure 4. 9 Insulation against cold and heat leather

The thermal resistance of leather is clearly seen on the graph Figure 4.18

- Goat full grain): - in high hot environment
- Sheep full grain): -both hot and cold environment
- Cow (full grain): - in cold environment
- Oil pull up (Buffalo leather): - in high cold environment
- Buffalo leather: - in cold environment

LEATHER SOLES

Leather is nothing but an animal skin (generally a cow hide) that undergoes a particular tanning process to make it firm and resistant. It is therefore completely natural.

There is only one tanning method that allows the hides to acquire the characteristics necessary to become sole leathers: slow vegetable tanning in pits, using only tannins**.**

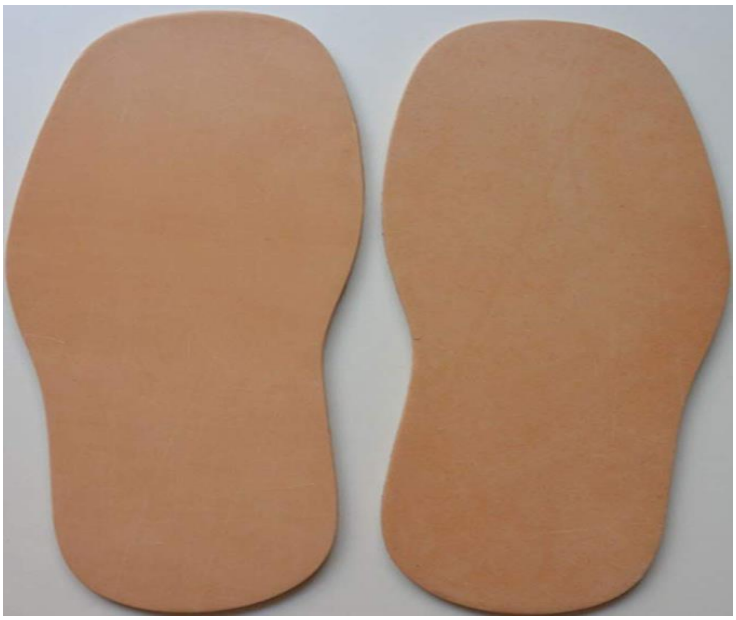

Figure 4. 10 sketched interchangeable shoe style

PHYSICAL PROPERTIES OF LEATHER SOLE

- **Breathability**: leather soles allow the foot to breathe, keeping the interior of the shoe cool and dry. They are therefore the ideal element to combine with a shoe upper and lining made of vegetable tanned leather with tanning.

- **Resistance**: the leather sole resists the roughness of the ground, avoiding perforation and acting as an effective barrier to protect the foot.

- **Thermal regulation**: the leather sole allows a good temperature regulation**.** A key ability, especially for summer shoes: let's think about the sidewalk pavement, which turns so hot under the sun.

- prevents the “shock”: shoes are often rubbed on fabrics and other surfaces, thus creating an electrostatic shock. While walking, you can accumulate the electrostatic charge and the shoes with the rubber sole act as insulation. To avoid getting shocked it is recommended to wear shoes with leather soles which greatly reduce the risk.

- **No allergies**: leather is a material with very limited risks of allergies or other contraindications for consumer health.

Maintenance**:** once worn, leather soles can be resolved**.** An important detail, because it extends the life of the product, making the shoe a long-lasting item. Shoes with “rubber” soles, on the other hand, are generally thrown away when the sole is worn out.

Qualities of good soling material

1. Durability
2. Flexibility
3. Water proof
4. Light weight
5. Non-Slip
6. Uniformity

Synthetic sole material

Figure 4. 11 sketched interchangeable shoe style

These boards mainly consist of fibers of polyester, poly propylene, acrylic and viscos impregnated with thermoplastic resins,

PHYSICAL PROPERTIES OF SYNTHETIC SOLE

i. Very high laminar strength
ii. High dimensional stability
iii. Capacity to bear high heat, moisture and pressure
iv. Good stitch holding capacity
v. Very high absorption resistance
vi. Clean, even, smooth surfaces character
vii. Flexibility

5.6 SHOE FLEXING

RESISTANCE OF FOOTWEAR TO FLEXING, (SATRA TM 92)

This method is intended to assess the resistance to repeated flexing. This method is applicable to of all types of completed footwear. The footwear specimen is repeatedly flexed through a specified angle about its natural flexing line in a test machine. After a predetermined time or number of flexes the footwear and its components are subjectively assessed for signs of damage. The number of flexes or the time between assessments and the angle through which the footwear is flexed are determined by the style of footwear being tested.

Table 4.3 Shoe flexing

Shoe components	Oxford shoe (leather sole)	Oxford shoe (TPR sole)	Oxford shoe (rubber sole)	boots (leather sole)	Boots (TPR sole)	Boots (rubber sole)
No, of flexes	400,000	500,000	2,00,000	500,000	400,000	2,00,000
Upper	No damage	No damage	No damage	No damage	No damage	No damage
Lining	No damage	No damage	No damage	No damage	No damage	No damage
Insole	No damage	No damage	No damage	No damage	No damage	No damage
In sock	No damage	No damage	No damage	No damage	No damage	No damage
Thread	No damage	No damage	No damage	No damage	No damage	No damage
Outsole	Crack	No damage	Crack	No damage	No damage	Crack
Sole bonding	No damage	No damage	No damage	No damage	Crack	No damage

A flexing machine has a number of clamps necessary to secure footwear at heel and toe. It flexes at the rate of 140 ± 10 flexes /minute through a range of flexing angles about a flexing line. A means of recording the number of flexes is provided. A pair of footwear can be tested at one time

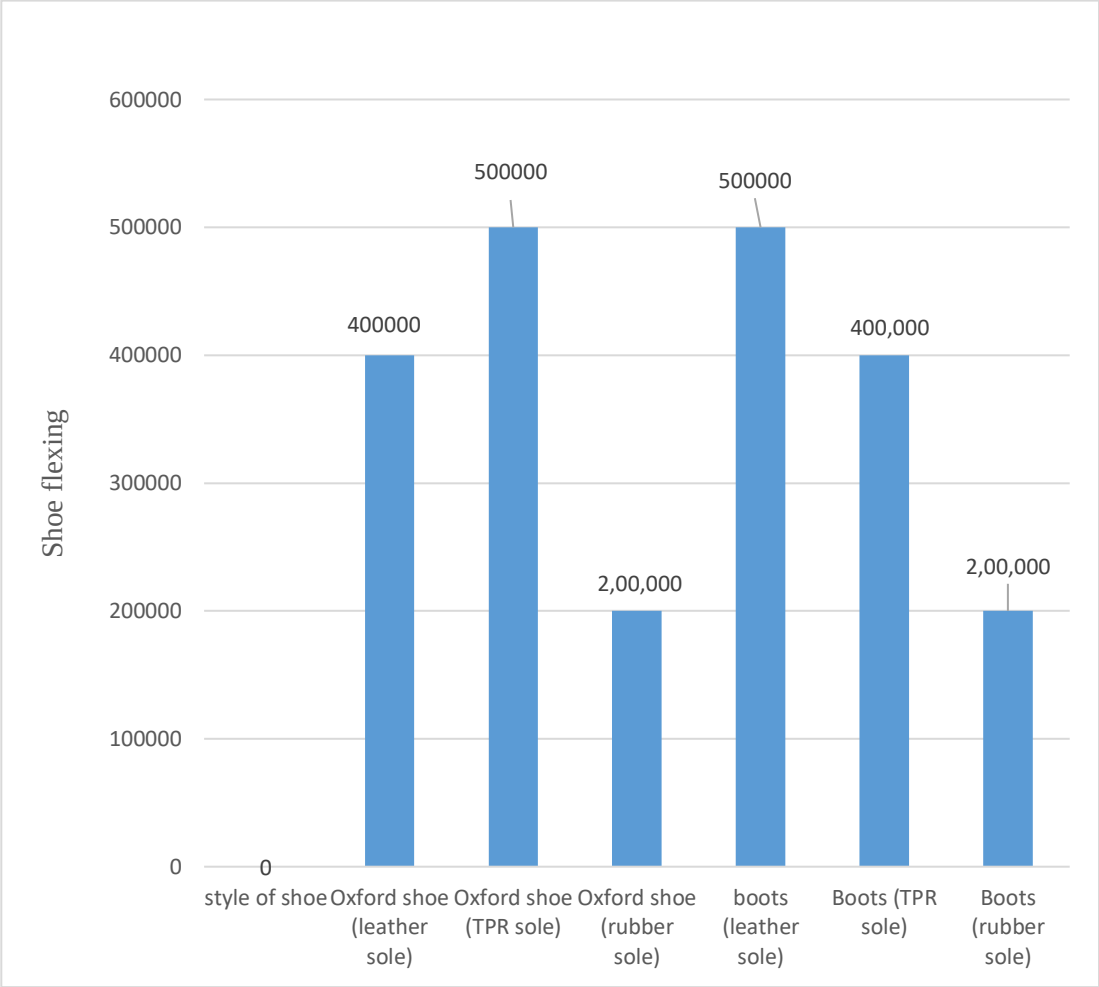

Figure 4. 12 shoe flexing test

The leather sole and TPR sole have good shoe flexing properties, so again, another shoe flexing test is needed to distinguish one from the cold season and the other on the hot season.so the table below will be able to identify

Sample name		leather sole		TPR sole	
Test temperature		At 23c^{o}		At 23c^{o}	
		Specimen 1		Specimen 2	
St no	flexes	center		center	
1	Cut length in mm	2.0	2.0	2.0	2.0
2	Initial observation	2.0	2.0	2.0	2.0
3	5,000	2.0	2.0	2.2	2.2
4	10,000	2.0	2.0	2.2	2.5
5	20,000	2.0	2.0	2.4	2.8
6	30,000	2.0	2.0	2.6	3.2
7	40,000	2.0	2.0	3.0	5.6
8	50,000	2.0	2.0	3.2	10.2
9	60,000	2.2	2.2	8.6	15.6
10	70,000	2.2	2.2	15.2	20.2
11	80,000	2.2	2.2	20.6	25.0
12	90,000	2.2	2.2	25.0	
13	100,000	2.4	2.2		

14	110,00	2.4	2.4		
15	120,000	2,5	2.4		
16	130,000	2.5	2.4		
17	140,000	2.6	2.5		
18	150,000	2.6	2.5		
19	Cut growth length, mm	0.6	0.5	23.0	23.0
20	Cut growth rate, mm/kc	0.004	0.003	0.25	0.28
21	Mean, mm/kc	0.0036		0.265	

Leather sole are comfortable in hot season because

- Thermal regulation: the leather sole allows a good temperature regulation. A key ability, especially for summer shoes: let's think about the sidewalk pavement, which turns so hot under the sun. TPR sole is less than the leather sole thermal regulation.
- Leather sole are high dimensional stability in hot season but TPR sole are melting in high temperature.

TPR sole are more comfortable in cold season and rain season because of

- TPR sole are high dimensional stability in cold and rainy season but leather sole is less absorption resistance.

5.7 THERMAL RESISTANCE OF INTERCHANGEABLE FOOTWEAR

The thermal resistance of footwear is one of the determinant factors to evaluate the comfortability of the shoe. The utilization of footwear in different atmospheric conditions based on how footwear materials protect the human body against the wearer.

In hot environments, the footwear materials need to have low thermal resistance to allow heat movements between the human body and the environment. In contrast, cold weather footwear must have high thermal resistance to prevent the transfer of heat from the human body to the environment. Hence, footwear material's physical properties related to thermal resistance must measure to help the selection of footwear materials for a shoe different atmospheric condition.

The thermal resistance of footwear is one of the determinant factors to evaluate the comfortability of the shoe. The utilization of footwear in different atmospheric conditions based on how footwear materials protect the human body against the wearer. In hot environments, the footwear materials need to have low thermal resistance to allow heat movements between the human body and the environment. In contrast, cold weather shoes must have high thermal resistance to prevent the transfer of heat from the human body to the environment. Hence, footwear materials' physical properties related to thermal resistance must measure to help the selection of footwear materials for a shoe different atmospheric condition.

Table 4.6 Insulation against cold and heat shoe

St no	Shoe style	Result		Environment (season)
		Insulation against heat c^{o}	Insulation against cold c^{o}	
1	Goat lather oxford shoe	20.10	10.9	high hot environment
2	Cow leather ankle boots	12.60	11.9	cold environment
3	Buffalo Oil pull up leather knee boots	13.10	20,12	high cold environment

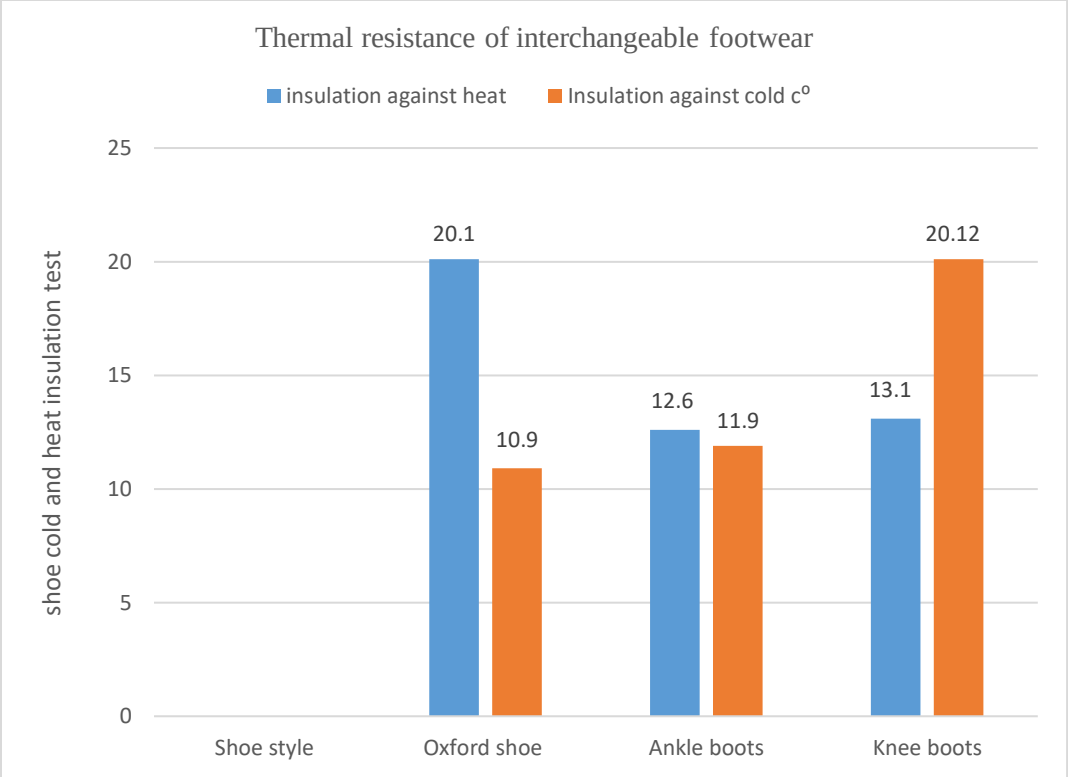

Figure 4. 12 shoe cold and heat insulation test

figure 4.13 Knee boots changeable shoe

The results have also shown on the figure 4.12 The results indicate thermal resistance of Buffalo leather oxford shoes; Buffalo Oil pull up leather knee boots

shoe with foam and with different lining combinations have higher thermal resistance when compared to Goat full-grain oxford shoe and cow full grain ankle boots shoe values. This makes the material suitable for cold environment

Goat full-grain leather oxford shoe and punching cow leather oxford shoe have low thermal resistance when compared with their relative. Therefore, those types of leather are suggested for utilization in a hot environment.

5.8 LEATHER SHOES WITH THE INTERCHANGEABLE SHOE COMPONENT

MEN'S SHOE

Oxford (Balmoral): The main feature of this shoe is V-shaped slit in vamp area with lace fastener. An oxford is a style of laced shoe wherein quarter are stitched underneath the vamp (middle component of the shoe upper), a construction method that is also sometimes referred to as "closed shoe.

Figure 4. 13 Oxford changeable shoe

A. Most widely used as formal shoe.
B. Unisex.
C. Quarter is locked at the vamp point and hence opening quarter is limited.
D. Has an independent tongue which is stitched at the stage of the upper.
E. In most of cases vamp will be on the quarter.
F. Most widely used as formal sho

Boots: Universal footwear for harsh environments, made from leather or rubber.

Figure 4.20 ladies' changeable boot shoe

6 CONCLUSION

Shoes with interchangeable upper is a new concept of shoes that are characterized by their upper and soles. The interchangeability concept helps the consumers by adapting every occasion, that is transformed into light footwear and easy to save space during the trips and more thermal comfort. The same-sized upper and soles are interchangeable. The results indicate thermal resistance of Buffalo full-grain leather (oxford shoes), Buffalo Oil pull up leather (knee boots) with foam, TPR sole and different lining combinations have higher thermal resistance when compared to Goat full-grain (oxford shoe) and cow punched (ankle boots) shoe values. These make the material suitable for a cold environment. Goat full-grain leather (oxford shoe) and punched cow leather (oxford shoe) with leather sole has low thermal resistance when compared with their relative. Therefore, this makes the material suitable for a hot environment.

7 RECOMMENDATION

Interchangeable footwears are manufactured from leather with a detachable or interchangeable upper which permit to create a better choice of style and perfect thermal comfort for various environmental condition. On the events of traveling, biking, running, working or simply going out, the customer can carry around the upper that has to be replaced in flat-packed skins. Simply select the styles of footwear and zip them together and get going. The footwear is designed to suit different geographical location.

REFERENCES

(1) D. Apurba. Science in clothing comfort. New Delhi: Wood head Publishing India 2010.

(2) The Study of Footwear Thermal Insulation Using
Thermography and the Finite Volume Method

(3) Fan. A study of heat transfer through clothing assemblies. [PhD Thesis]. Leeds: University of Leeds; 1989.

(4) Fu, G. 1995. A Transient, 3-D Mathematical Thermal Model for the Clothed Human, Doctoral Dissertation, Kansas State University, USA.

(6)Barker R L, from fabric hand to thermal comfort: the evolving role of objective measurements in explaining human comfort response to textiles, Int J Clothing Sci Tech, 14 (2002) 181-200.

(7) Diebschlag and Knocker, A comparative analysis of the comfort of leather and substitute materials especially for footwear, J Amer Leather Chem Ass, 73 (1978) 307-332.

(8) Nag P K, Engineering Thermodynamics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1989.

(9) Bitlisli B.O., Sari Ö. Problems Stemming from Upper Leathers in Military Shoes and Boots and Suggested Solutions. *Infantry 2000 Symposium CD, Tuzla Infantry Cadet School Command.* Istanbul, 2000.

(10) Bitlisli B.O., Karavana H.A., Başaran B., Aslan A. Importance of Using Genuine

(11) Leather in Shoe Production in Terms of Foot Comfort. *Journal of the Society of Leather Technologists and Chemists,* 2004, vol. 89, 107 p.

(12) Bitlisli B.O. *Technology of Shoe Upper Leathers.* Lecture Notes. Leather Engineering Department, Engineering Faculty, Ege University. Izmir, 2013.

(13)Howie I. Competing Materials in Shoemaking. *Leather Int'l.*, 1995, pp.41-43.

(14) M. Yaghoubi, Experimental study of turbulent separated and reattached flow over a finite blunt plate, Exp. Therm. Fluid Sci. 29 (1) (2004) 105.

(15)Gytis Balilionis 2011 clothing fabric effects on physiological and comfort responses

(16) Scanlan, Dascombe, Reaburn, and Osborne M (2008). The effects of wearing lower body compression garments during endurance cycling.