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Determination of Various Parameters on Leather using Different Testing Methods

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Abstract

This research explores the impact of multiple parameters on Cow Softy Leather, employing a range of testing methods. The study assesses factors like material composition, thickness, flexibility, and moisture resistance to enhance understanding of how these aspects influence the performance and durability of footwear materials. Through different testing conducted, this investigation aims to provide valuable insights for improving footwear design and material selection, ultimately leading to more comfortable, long-lasting and sustainable shoe products. Throughout the investigation, a variety of footwear upper materials are analyzed, including leather, synthetic textiles, and innovative composite materials. The findings from these tests offer valuable data for designers, manufacturers, and consumers to make informed decisions regarding material selection and footwear performance expectations. The outcomes of this study contribute to the continuous improvement of footwear design and production processes, resulting in more comfortable, durable, and functional footwear products. Moreover, it aids in the development of sustainable materials by evaluating their performance in comparison to traditional options.

Key words- Leather, Hide, Portions, Testing, Physical, Chemical, Tensile, Elongation

1. Introduction

In this paper, different factors affecting tensile strength, including leather type and source, tanning process, fiber alignment and structure, processing and treatment, thickness, moisture content, grain structure, temperature, and environmental conditions, quality of hide, finishing, and coating were examined. Subsequently, high-voltage testing of various types of leather will be conducted to assess insulation quality and dielectric strength [1]. The dielectric strength of an insulating material refers to its ability to withstand high voltage without breaking down. High-voltage current testing will help determine the dielectric strength of leather, ensuring its capability to safely insulate against high voltages without electrical breakdown. Following this, safety assurance, compliance with standards, and quality control measures will be examined. The process involves preparing a sample, testing it with equipment, configuring electrodes, applying voltage, and recording observations [2].

1.1 Motivation

The quality and performance of footwear largely depend on the properties of upper materials, which directly affect comfort, durability, and aesthetics. Cow softy leather, known for its softness and flexibility, is widely used in footwear uppers but exhibits variable characteristics depending on processing and treatment methods. Determining its key physical and mechanical parameters through various testing methods is essential to ensure optimal material selection and enhance footwear design [3]. This study aims to systematically evaluate the properties of cow softy leather using standardized tests to provide reliable data that can guide manufacturers in improving product quality, performance, and consumer satisfaction.

1.2 Problem Statement

To investigate various parameters on cow softy leather on different portions using different testing methods.

1.3 About the Cow Softy Leather

The process of manufacturing cow softy leather begins with the hide of an adult cow. The hide or side (basically a by-product of meat industry) is first preserved through a chemical treatment known as tanning. This process converts the otherwise perishable skin into a non-decaying material called leather. The hide is first tanned with bag tanning and then re-tanned with vegetable tanning. After wetting back, the leather butts are cut and shaved to the required thickness. They are then semi chrome tanned and finished in desired colors. To make the leather stronger and softer, special fats are added in a process known as liquoring [4]. The result is fuller-bodied leather that is soft, supple, and durable. Cow softy leather is known for its softness, thickness, and abrasion resistance. It is incredibly robust and unlikely to split apart, although this can make it slightly stiff when used to manufacture garments. It is used to produce a large variety of leather products [5].

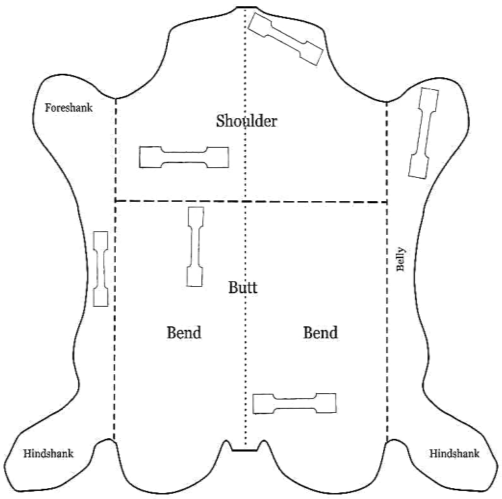

Figure 1.1 various components of hide [13]

1.4 Various types of upper material

Natural materials:

- **Leather:** A classic and durable material that is naturally water-resistant and breathable. Leather can be full-grain, top-grain, or split-grain, with each grade offering different levels of quality and durability.
- **Suede:** A soft and luxurious type of leather with a napped finish. Suede is not as water-resistant as full-grain leather, but it can be treated with protectants.
- **Nubuck:** Similar to suede, but with a slightly smoother finish. Nubuck is also water-resistant and can be treated with protectants.
- **Canvas:** A strong and breathable fabric that is often used for casual shoes. Canvas is not as water-resistant as leather or suede, but it is generally more affordable.
- **Wool:** A warm and comfortable material that is often used for winter boots. Wool is naturally water-resistant and can be treated with protectants for even better performance [6-9].

Synthetic materials:

- **Mesh:** A lightweight and breathable fabric that is often used for running shoes and other athletic footwear. Mesh is highly breathable and allows for good air circulation, making it ideal for warm weather activities.

- **Nylon:** A strong and durable synthetic fabric that is often used for hiking boots and other outdoor footwear. Nylon is water-resistant and can be treated with protectants for even better performance.
- **Polyester:** A versatile synthetic fabric that can be used for a variety of footwear applications. Polyester is generally less expensive than nylon, but it is not as durable.
- **Polyurethane (PU):** A synthetic material that can be used to create a variety of different textures and finishes. PU is often used in combination with other materials, such as mesh or nylon, to create a more durable and water-resistant upper [6-9].

Other materials:

- **Rubber:** A durable and water-resistant material that is often used for boots and other outdoor footwear. Rubber can be quite heavy, so it is not always the most comfortable option for everyday wear.
- **EVA:** A lightweight and flexible material that is often used for sandals and other casual footwear. EVA is not as durable as some other materials, but it is very comfortable to wear [6-9].

1.5 Various Testing Methods

- Tensile Strength: Evaluates the material's resistance to tearing and breaking under stress. This is important for ensuring durability, especially in areas like seams and straps.
- Water Resistance: Determines how well the shoe keeps water out, especially important for boots and outdoor shoes.
- Flexing Endurance Test: Assesses the shoe's flexibility and range of motion, crucial for comfort and performance in athletic shoes.
- Electrical Hazard Protection: Tests the shoe's ability to insulate the wearer from electrical hazards, required for specialized footwear.
- Moisture content test: This is a process that determines the amount of water present in a material relative to its dry mass, typically expressed as a percentage. It's a crucial measurement across various industries, impacting material properties, processing, quality, and shelf life [6-9].

2. Related Work

Charles E. Weir examined and compared the physical properties of six different types of leathers commonly used in Bangladesh. The research included assessments of shoe upper leathers, lining leathers, and suede leathers, encompassing both cow and goat varieties. Employing standardized ISO and SATRA testing protocols, the study evaluated key physical attributes such as tensile strength of material, tear strength, flexing endurance, color fastness, and bond strength. The results consistently showed that cow leather exhibited superior physical performance compared to goat leather, particularly in tensile and tear strength, as well as flexing endurance. However, significant variation was also observed within each category of leather, highlighting the influence of leather type and processing methods. The findings offer valuable insights for leather manufacturers, designers, and consumers within the Bangladeshi market, emphasizing the importance of selecting appropriate leather types for specific applications. Despite its contributions, the study presents a notable research gap in its localized focus. While it provides a robust comparison within Bangladesh, it does not account for broader influences such as differences in processing techniques, tanning practices, and environmental conditions across various geographical regions. This limitation restricts the generalizability of the findings, indicating a need for future studies that incorporate a more global perspective to validate and expand upon these results. Ricardo Tournier's work offers an insightful overview of the evolution of tanning practices and their critical role in determining leather strength. The paper provides essential background on the historical development of tanning methods, while focusing on the mechanical integrity—specifically tensile strength—of vegetable and chrome-tanned leathers. The study identifies multiple factors that contribute to the deterioration of tensile strength, such as the type of tanning agent, the pH level of the tanning bath, temperature, and processing time. Additionally, intrinsic variables like animal species and the presence of hide defects are highlighted as influencing factors. In comparing different tanning methods, the study observes that vegetable tanning generally yields stronger leather compared to chrome tanning, though the latter remains more prevalent due to its

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operational efficiency and cost benefits. It also briefly explores alternative tanning methods, including aldehyde-based and synthetic tanning agents. From a critical perspective, the review underscores a significant knowledge gap in understanding the molecular interactions between tanning chemicals and collagen fibers. The author calls for deeper scientific investigation to clarify how various tanning materials impact collagen structure, which is vital for optimizing the strength and performance of leather. To address this, the author advocates for the establishment of standardized testing protocols—potentially under the guidance of the International Union of Leather Technologists and Chemists Societies (IULTCS)—that would enable tanneries to evaluate the strength effects of their formulations consistently. Overall, Tournier's study not only reinforces the importance of tanning in defining leather quality but also identifies a clear research gap in the mechanistic understanding of tanning–collagen interactions, laying the foundation for future improvements in leather processing and product development. Mutlu et al. recognized that leather's anisotropic, non-homogeneous structure poses a challenge for garment cutting and performance. Their study set out to quantify directional variations in strength and extensibility across chromium-tanned sheepskin intended for apparel. A total of 2 147 specimens were prepared from ten sheepskin hides, with samples taken both parallel and perpendicular to the backbone line. Each specimen's thickness, tensile strength, and elongation-at-break were measured using a SATRA thickness gauge and a Shimadzu AG-IS tensile tester, and data were processed in Trapezium-2 software. Strength "maps" were then generated in MATLAB R2011a, plotting spatial gradients of mechanical properties over each hide. The results revealed a clear decrease in tensile strength from the central backbone region toward the butt and belly edges, with notably lower strength around the kidney area compared to the neck region. These directional and locational patterns have immediate implications for pattern placement in garment manufacture, enabling cutters to orient panels to maximize performance and reduce waste. In conclusion, this work provides a practical, data-driven framework for optimizing sheepskin cutting layouts in the apparel industry. By linking measured property gradients to hide anatomy, Mutlu et al. furnish both researchers and manufacturers with actionable insights for improving garment fit, durability, and material utilization. Md. Farhad Ali investigated how the intrinsic mechanical properties of leather interact with common footwear-upper manufacturing processes, with the goal of informing both physical prototyping and virtual simulation workflows. Using a factorial design of experiments, various leather samples were tested to determine the minimum number of replicates needed for statistically robust measurements of Young's modulus and Poisson's ratio. Key processing variables included the number of leather layers, choice of lining material (natural versus synthetic), overlapping width at joints, stitch count, and the presence and pattern of perforations. Tensile tests revealed that stitching and punching operations lead to a marked reduction in effective Young's modulus—attributable to stress-concentrating cut outs and altered fiber alignment—while the application of a natural leather lining tends to increase Poisson's ratio, indicating greater volumetric deformation under load. These findings were synthesized into a constitutive model that captures the altered stiffness and lateral contraction behavior of processed leather panels. When incorporated into virtual prototyping software, this model enables accurate simulation of upper deformation under both manufacturing and gait cycles. By quantitatively linking manufacturing parameters to changes in leather mechanics, this work provides footwear designers and engineers with precise material definitions for virtual product development. The model supports the digitalization trend in the footwear industry, facilitating rapid iteration, customization, and optimization of uppers without costly physical trials. O'Leary and Attenburrow presented a detailed experimental investigation into the distinct mechanical behaviors of the grain and corium layers in bovine leather. Employing trouser-tear and single-edge-notch tests, they measured tearing energy, notch sensitivity, and mapped strain fields around the advancing tear tips. High-resolution optical imaging captured the mechanisms of fiber pull-out and tear-tip blunting that govern crack propagation in each layer. Their results demonstrate that the corium layer exhibits substantially greater tearing energy and lower notch sensitivity than the grain layer. This disparity is attributed to the corium's looser, multidirectional fiber architecture, which more effectively dissipates tearing stresses through progressive fiber pull-out and crack-tip blunting. In contrast, the denser, more aligned fibers of the grain layer lead to localized stress concentrations and rapid crack growth once initiated. These findings enhance our understanding of leather's hierarchical structure–property relationships and offer practical guidance for product design: for applications demanding high tear resistance, utilizing corium-facing orientations or hybrid constructions can improve durability. Moreover, the study underscores the need to tailor processing and composite assembly techniques to exploit the

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complementary strengths of both layers in engineered leather goods. Wang and Attenburrow investigated how intrinsic animal and skin parameters influence the tensile strength of Brazilian goatskin leather, with the aim of guiding breed selection and improving leather quality. Recognizing a paucity of similar studies in caprine materials, the authors sourced raw skins from fifty goats of varying breed, age, and sex at the Sobral Experimental Station. Each skin underwent comprehensive chemical, biochemical, biophysical, and histological characterization—including assays for collagen, fat, and glycosaminoglycan content, plus measurements of shrinkage-stress relaxation—before standardized tanning and tensile testing. Statistical analysis revealed significant inter-breed and regional variations in leather strength, with collagen content and specific breed markers emerging as the strongest predictors of tensile performance. Skins from breeds with higher collagen density consistently produced leather with superior strength, whereas elevated fat or glycosaminoglycan levels correlated with reduced mechanical robustness. These correlations held after controlling for age and sex, underscoring the primacy of breed-dependent skin composition. This work establishes clear, quantifiable links between goat skin biology and finished-leather mechanics, offering tanneries actionable criteria for herd management and raw-material specification. Future studies should expand the breed and geographic scope to confirm these relationships in other caprine populations and explore the mechanistic basis of collagen-mediated strength enhancement. Ilda Kazani was applied to conventional leather substrates to impart electrical conductivity under controlled environmental conditions. The primary objective was to quantify the leather's electrical resistivity (ρ) as a function of air temperature, relative humidity (RH), and absolute water-vapor concentration (H). A novel multiple-step resistivity measurement protocol was introduced, which compensates for sample geometry and compressibility, yielding an intrinsic resistivity parameter independent of specimen mass or shape. Leather specimens were coated via successive pyrrole polymerization cycles, then conditioned at various combinations of temperature (10–40 °C) and RH (20–90 %). Resistivity was measured in both flat and rolled sample geometries over a one-year period of natural exposure, ensuring real-world relevance. Data analysis revealed a strong inverse power-law relationship between water-vapor concentration and resistivity, described using the formula ρ = 1.3103H−1.04Ωm, with a correlation coefficient of 0.87. Plotting ρ against RH and H demonstrated consistent trends across both sample shapes and ambient conditions. These findings establish that the electrical performance of pyrrole-coated leather is highly sensitive to atmospheric moisture content, and they validate the multiple-step method as a robust tool for characterizing conductive polymers on soft substrates. The long-term field measurements underscore the practical stability and environmental dependence of conductive leather, informing its integration into wearable electronics, smart garments, and humidity-sensing applications. Richard provided a comprehensive update on the evaluation and testing of protective clothing and equipment designed for electric arc exposure in industrial environments. The study characterizes electric arc behavior, including arc power, incident energy, and environmental influences, through three-phase arc testing at 600 volts combined with acoustic measurements. Performance assessments focus on flame-resistant materials, specifically cotton ignitability and aramid protective clothing systems. Key findings demonstrate that safety glasses alone reduce incident energy exposure to the eyes by approximately 60%, while adding a polycarbonate face shield further decreases eye and mouth energy exposure to about 25% and 48%, respectively. The inclusion of a gold-coated layer on the face shield provides additional protection, lowering energy exposure to approximately 10% for the eyes and 20% for the mouth. These results underscore the critical importance of proper protective equipment for electrical personnel. Moreover, the study emphasizes the significant risk posed by high sound pressure levels generated during arc events, advocating for the mandatory use of personal hearing protection devices (PHPDs) that comply with OSHA regulations. The paper highlights the need for comprehensive hearing conservation programs and administrative and engineering controls to mitigate chronic hearing damage risks. It concludes by identifying gaps in incident energy estimation and advocates for further testing to refine protective strategies and enhance safety protocols in arc exposure scenarios.

2.1 Research Gaps

S. No.	Research Focus	Identified Research Gap
1	Regional comparison of	Lack of global perspective on processing methods and tanning

S. No.	Research Focus	Identified Research Gap
	leather properties	practices; limits generalizability.
2	Impact of tanning chemicals	Insufficient insight into molecular mechanisms of tanning agent–collagen interactions.
3	Strength variation in sheepskin	Unexplored effect of strength variation on garment fit and real-world performance.
4	Mechanical properties of leather	Absence of study on influence of different stitching types on overall model integrity.
5	Tearing behavior of grain vs. corium	Need for analysis of processing and environmental effects on tearing differences.
6	Brazilian goatskin strength analysis	Limited breed and regional scope; requires validation with diverse goat breeds and locations.
7	Conductive leather via in-situ polymerization	No assessment of long-term durability and environmental performance in practical scenarios.
8	Arc exposure and safety measures	Lack of long-term data on health impacts, especially hearing damage from chronic noise exposure in electrical personnel.

3. Preparation of Test Specimen for different tests

3.1 Creation of Dumbbell shape Specimen for Tensile strength testing

Assessing the tensile strength of leather specimens is pivotal for understanding the material's capability to withstand stretching forces. This involves subjecting a standardized leather sample to gradual tension until it reaches the point of rupture. By measuring the force applied and the corresponding elongation, one can calculate the tensile strength—providing essential insights into the material's durability and suitability for applications requiring resistance to pulling forces, such as in belts or load-bearing components. This testing process is fundamental in ensuring the reliability and performance of leather products across diverse use cases [11].

PROCEDURE

- **Material Selection** Choose defect-free, uniform leather.
- **Sample Dimensions** Use a cutting tool for standardized length and width.

Size	A	B	C	D	R
Standard	110	20	30	10	5
Large	190	40	45	20	10

Table3.1 Sample Dimension

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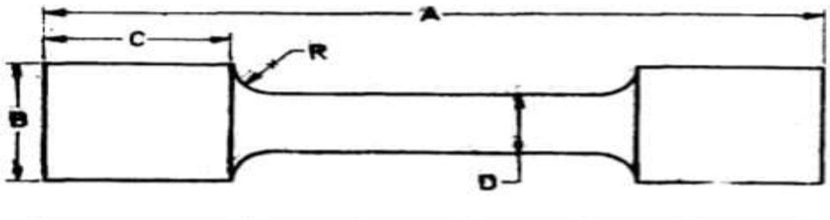

Fig3.1 Dumbbell shape test specimen [4]

- **Gauge Length** Mark the portion for tensile testing.
- **Edge Care** Ensure straight, parallel edges to prevent premature failure.
- **Moisture Content** Standardize to maintain consistent properties.
- **Mounting** Secure one end in the fixed grip, attach the other to the movable grip.
- **Alignment** Properly align the specimen for even force distribution.

Sample Preparation A small strip of leather is cut from the hide, typically following standardized dimensions.

Fixing the Sample The leather strip is securely clamped in a testing machine, with one end held in place while the other is pulled.

Application of Force A controlled force is applied to the leather strip, gradually increasing until the strip begins to stretch and eventually breaks.

Measurement The testing machine records the maximum force applied (tensile strength) and the point at which the leather strip broke.

Analysis The results are analyzed to determine the leather's tensile strength, which is crucial for assessing its durability and suitability for various applications, such as in manufacturing leather products.

This test helps ensure that leather meets quality standards and can withstand the stresses it may encounter in its intended use, such as in the production of garments, accessories, or upholstery [4,11].

Figure 3.2 Testing Machine [a]

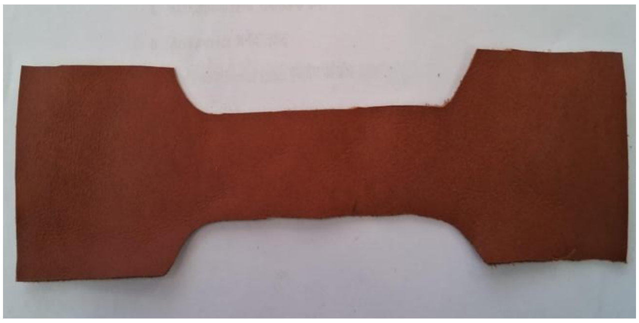

Figure 3.3 Test Specimen for Tensile Testing

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Table 3.2 Before Testing for standard size

Sr. No	Portion of Hide	Initial Thickness	Width	Area	Peak Stress(N)	Tensile Strength
1	Lower Butt1	1.2	10	12	132.1	11
2	Lower Butt2	1.19	10	11.9	146.6	12.31
3	Middle Butt1	1.03	10	10.3	102.41	9.95
4	Middle Butt2	1.06	10	10.6	85.55	8.07
5	Middle Butt3	1.06	10	10.6	85.94	8.1
6	Shoulder1	1.14	10	11.4	189.23	16.59
7	Shoulder2	1.17	10	11.7	178.16	15.22
8	Shoulder3	1.14	10	11.4	189.53	16.62
9	Shank1	1.03	10	10.3	44.49	4.31
10	Shank2	1.03	10	10.3	56.84	5.51
11	Shank3	1.04	10	10.4	76.24	7.33
12	Neck1	1.07	10	10.7	149.64	13.98
13	Neck2	1.12	10	11.2	158.66	14.16
14	Belly1	0.95	10	9.5	63.01	6.63
15	Belly2	1	10	10	73.01	7.3
16	Fabric Cloth1	0.86	10	8.6	71.34	8.29
17	Fabric Cloth2	0.58	10	5.8	16.66	2.87
18	Fabric Cloth3	0.43	10	4.3	79.38	18.46

Table 3.3 After Testing for standard Size

Sr. No	Portion of Hide	Final Thickness	Breaking	Area	Tensile Strength
1	Lower Butt1	1.28	8	10.24	12.9
2	Lower Butt2	1.28	7.5	9.6	15.27
3	Middle Butt1	1.12	7	7.84	13.06
4	Middle Butt2	1.14	8	9.12	9.38
5	Middle Butt3	1.16	8	9.28	9.26
6	Shoulder1	1.24	8	9.92	19.07
7	Shoulder2	1.28	7	8.96	19.88
8	Shoulder3	1.21	8	9.68	19.57
9	Shank1	1.16	8	9.28	4.79
10	Shank2	1.15	7.5	8.62	6.59
11	Shank3	1.06	7.5	7.95	9.58
12	Neck1	1.33	7	9.31	16.07
13	Neck2	1.24	6.5	8.06	19.68
14	Belly1	1.09	7	7.63	8.25
15	Belly2	1.16	8	9.28	7.6

16	Fabric Cloth1	0.98	5	4.9	14.55
17	Fabric Cloth2	0.54	10	5.4	3.08
18	Fabric Cloth3	0.43	10	4.3	18.46

Table 3.4 %Elongation of standard samples

Sr. No	**Portion of Hide**	**Strain**	**Initial Length**	**Final Length**	**Avg. Elongation (in %)**
1	Lower Butt	32.1	50	82	64
2	Middle Butt	24.2	50	75	51.3
3	Shoulder1	20.7	50	73	49.3
4	Shank	64.1	50	82	66.6
5	Neck	37.1	50	87	77
6	Belly	28.1	50	81	66
7	Fabric Cloth1	85.8	50	138	176
8	Fabric Cloth2	35	50	90	80
9	Fabric Cloth3	8.3	50	57	14

Table3.5 before Testing of Large samples

Sr. No	**Portion of Hide**	**Initial Thickness**	**Width**	**Area**	**Peak Stress(N)**	**Tensile Strength**
1	lower Butt-1	1.19	20	24	189.53	7.96
2	lower Butt-2	1.21	20	24	157.87	6.52
3	Middle Butt-1	1.1	20	22	312.32	14.19
4	Middle Butt-2	1.13	20	23	207.074	9.16
5	Shoulder1	1	20	20	302.82	15.14
6	Shoulder2	0.99	20	20	266.85	13.47
7	Neck	1.14	20	23	285.86	12.53
8	Belly1	1.13	20	23	238.72	10.56
9	Belly2	1.04	20	21	162.09	7.79
10	Shank1	1.08	20	22	209.03	9.67
11	Shank2	1.04	20	21	189.04	9.08

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Table3.6 After samples of large sample

Sr. No	Portion of Hide	Final Thickness	After Breaking	Area	Tensile Strength
1	lower Butt-1	1.23	18	22.14	8.56
2	lower Butt-2	1.26	17	21.42	7.37
3	Middle Butt-1	1.2	18	21.6	14.46
4	Middle Butt-2	1.15	18	20.7	10
5	Shoulder1	1.21	17	20.57	14.72
6	Shoulder2	1.16	18	20.88	12.78
7	Neck	1.24	18	22.32	12.8
8	Belly1	1.16	18	20.88	11.43
9	Belly2	1.1	18	19.8	8.18
10	Shank1	1.27	18	22.86	9.14
11	Shank2	1.21	17	20.57	9.19

Table3.7 %Elongation of large sample

Sr. No.	Portion of Hide	Strain	Initial Length	Final Length	Elongation (%)
1	Lower Butt1	54.4	110	165	50
2	Lower Butt2	47.6	110	161	46.36
3	Middle Butt1	52.4	110	165	50
4	Middle Butt2	43.6	110	155	40.9
5	Shoulder1	79.5	110	190	72.73
6	Shoulder2	66.5	110	178	61.81
7	Neck	51.3	110	161	46.36
8	Belly1	50.5	110	162	47.27
9	Belly2	40.9	110	152	38.18
10	Shank1	64.8	110	176	60
11	Shank2	60.5	110	170	54.54

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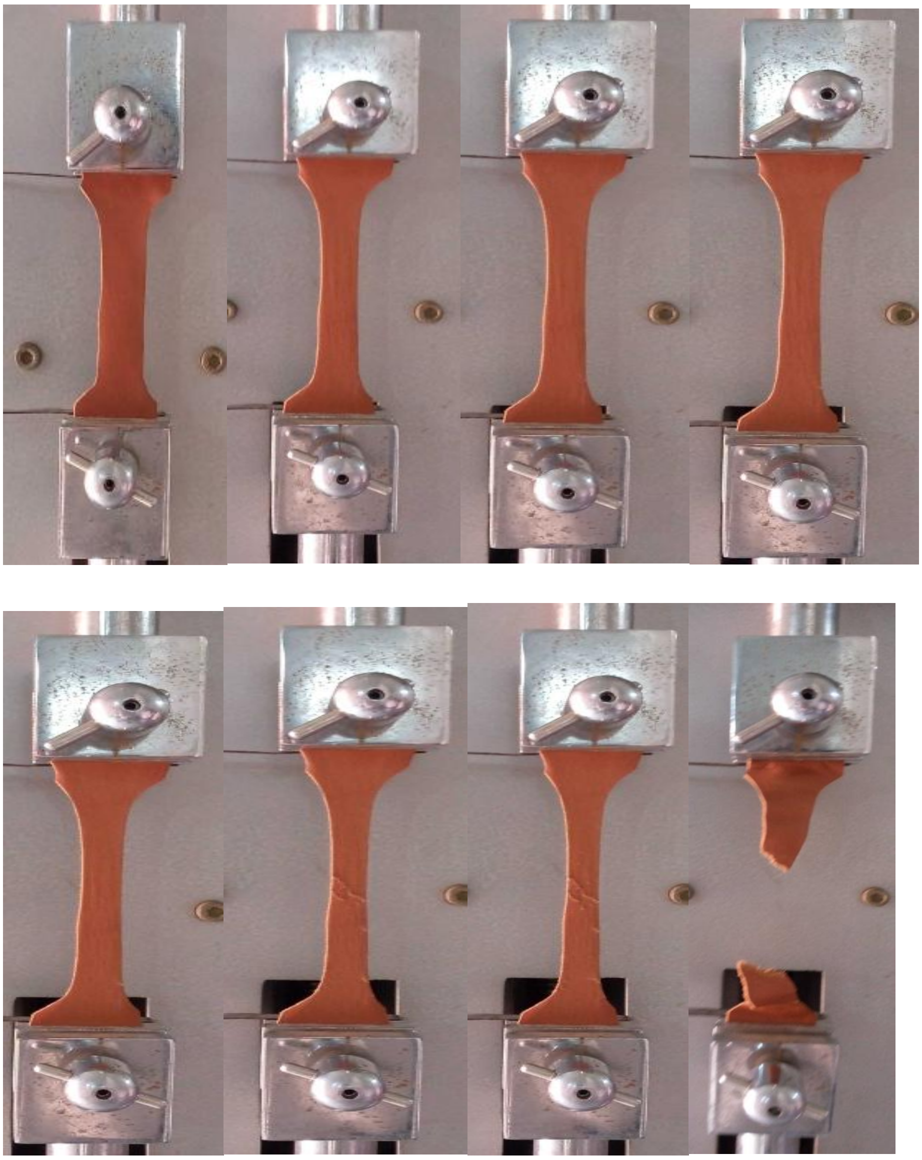

Figure 3.2 on-going process of Tensile Testing

3.2 Square specimen for High voltage Testing

High voltage testing of leather specimens involves subjecting the material to elevated electrical potentials to assess its dielectric strength and insulation properties. This is crucial for ensuring the safety and reliability of leather in applications where exposure to high voltage is a concern, such as in electrical gloves or other protective gear.

The testing process includes measuring dielectric strength, insulation resistance, and surface leakage to evaluate the leather's ability to withstand and insulate against electrical stress. These tests contribute to the development of reliable electrical protective equipment by providing insights into the leather's performance under high voltage conditions [15].

Procedure

Sample Preparation A small leather sample is cut from the hide and prepared for testing.

Electrode Placement Two electrodes are positioned on the leather sample. One electrode is applied to the top surface, and the other to the bottom surface.

High Voltage Application A high voltage (usually in the form of an electrical arc or spark) is applied between the two electrodes. This high voltage tests the leather's ability to resist electrical conduction and insulates it from electrical current.

Measurement The test measures the electrical resistance of the leather and identifies any weaknesses or defects that may allow current to pass through.

Analysis The results are analyzed to ensure that the leather meets electrical resistance standards and is safe for use in applications where electrical insulation is required.

High voltage testing is crucial when leather is used in electrical or industrial applications to ensure it can protect against electrical hazards. This test helps prevent potential safety risks and product failures [15,17].

Samples are prepared at room temperature 35°C and Humidity 70%

Avg. Di-electric strength = **11.19 kv/mm**

Figure 3.3 Electrical Resistance Tester [c]

Figure 3.4 Test specimen for high voltage testing

3.3 Flexing Endurance Test on upper materials

The flexing endurance test is a crucial step in evaluating the durability and quality of footwear upper materials. It simulates the repeated bending and flexing that occurs during normal wear, helping predict how well the material will hold up over time.

Method

There are several standardized methods, but a common one is based on ISO 20344 and SATRA TM 25:2020. In this method-

- Use a knife to cut pieces of test pieces by 70 mm in length and 45mm in width on grain side (take parallel and perpendicular to the backbone)
- A square sample of the material is clamped between two V-shaped plates.
- The plates move back and forth, repeatedly flexing the sample at a specific angle and speed (usually 22.5° at 60 cycles per minute).
- This process continues until the material breaks, shows visible damage like cracks, or reaches a predetermined number of cycles.

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Figure 3.3 Specimen for flexing endurance

Table 3.8 Readings of Flexing Endurance

S. No.	No. of Cycles	Result Obtained
1	10,000	After 10,000 cycles there was no change found in the colour, texture and in their grain structure
2	20,000	After 20,000 cycles there was no change found in the colour, texture and in their grain structure
3	30,000	After 30,000 cycles there was no change found in the colour, texture and in their grain structure
4	40,000	After 40,000 cycles there was no change found in the colour, texture and in their grain structure
5	50,000	After 50,000 cycles there was no change found in the colour, texture and in their grain structure
6	60,000	After 60,000 cycles there was no change found in the colour, texture and in their grain structure
7	70,000	After 70,000 cycles there was no change found in the colour, texture and in their grain structure
8	80,000	After 80,000 cycles there was no change found in the colour, texture and in their grain structure
9	90,000	After 90,000 cycles there was no change found in the colour, texture and in their grain structure
10	1,00,000	After 1,00,000 cycles there was no change found in the colour, texture and in their grain structure
11	1,10,000	After 1,10,000 cycles there was no change found in the colour, texture and in their grain structure
12	1,20,000	After 1,20,000 cycles there was no change found in the colour, texture and in their grain structure
13	1,30,000	After 1,30,000 cycles there was no change found in the colour, texture and in their grain structure
14	1,40,000	After 1,40,000 cycles there was no change found in the colour, texture and in their grain structure
15	1,50,000	After 1,50,000 cycles there was no change found in the colour, texture and in their grain structure

3.4 Determination of moisture content by loss and drying method

The loss on drying (LOD) method is a common technique for determining the moisture content of a material. It works by measuring the weight loss of a sample after drying it at a (200-220) temperature for a defined period. In this method, a sample of leather is weighed and then heated in an oven at a specific temperature for a set period of time to evaporate the moisture content. After the heating process, the leather sample is weighed again to determine the loss in weight, which is directly related to the moisture content. This method provides a quick and accurate way to quantify the moisture content of leather, which is essential for assessing its quality and making any necessary adjustments in the production process.

3.5 CALCULATION

Weight of Empty crucible = 46.8 gram

Total weight of crucible with leather samples = 52.5gram…………………(i)

Weight of leather samples = 5.7 gram

Reading 1 Weight of sample = 51.5 gram

Reading 2 Weight of sample = 51.5 gram ………………………………...(ii)

Subtracting equation (ii) from (i) i.e.,

52.5gram – 51.5 gram = 1gram

5.7gram of leather contain moisture content = 1

1gram of leather contain moisture content = 1/ 5.7

100g of leather contain = (1/5.7) *100%

% of moisture content present = 17.54 %

4. **Result and Observation**

4.1 OBSERVATION AND CALCULATION OF TENSILE STRENGHT OF STANDARD SAMPLES

Table4.1 Final Result of standard Size

Portion of Hide	Tensile Strength	New Tensile Strength
Neck	14.07	17.87
Shoulder	16.14	19.5
Middle Butt	8.7	10.56
Lower Butt	11.65	14.08
Shank	5.71	6.98
Belly	6.96	7.92
Fabric Cloth-1	8.29	14.55
Fabric Cloth-2	2.87	3.08
Fabric Cloth-3	18.46	18.46

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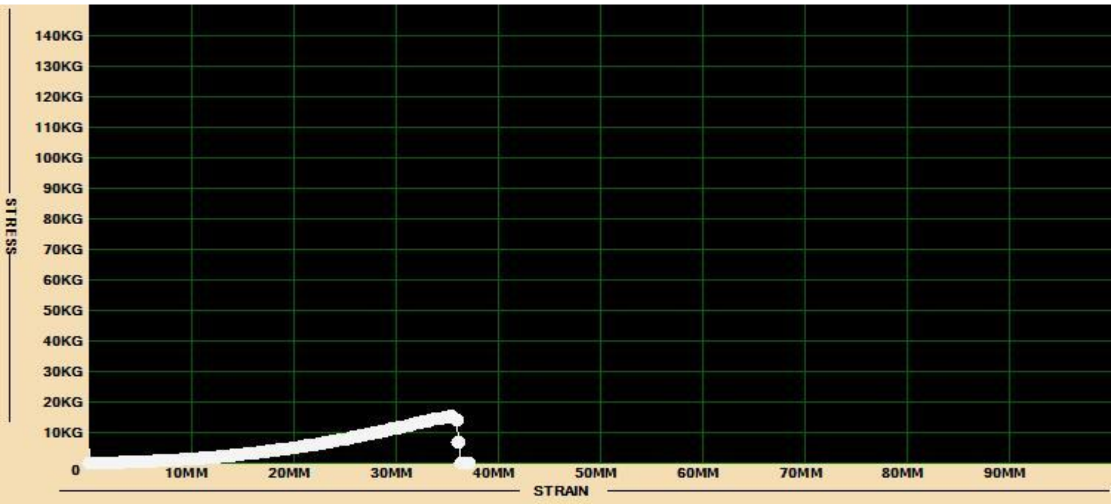

Figure 4.1 Graph of neck portion (Standard)

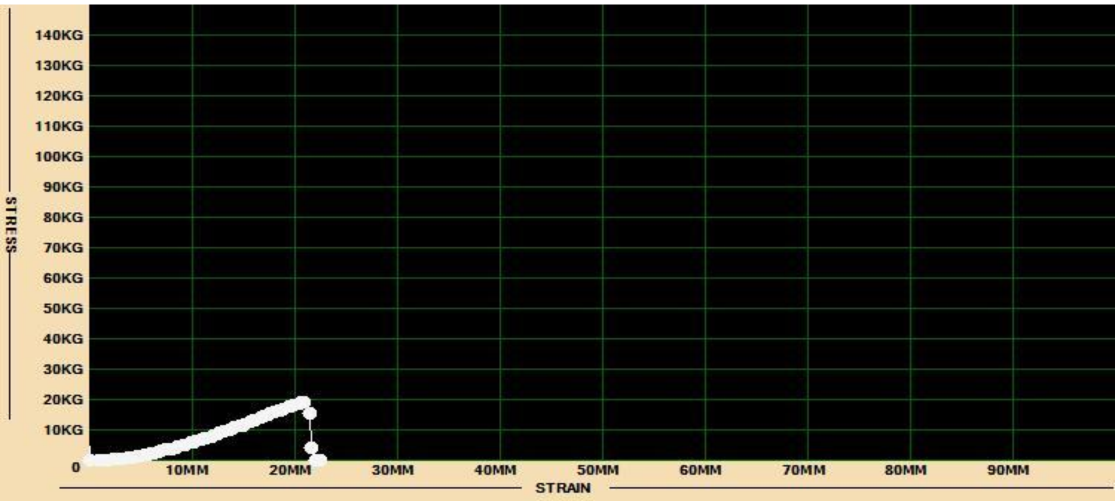

Figure 4.2 Graph of shoulder portion (Standard)

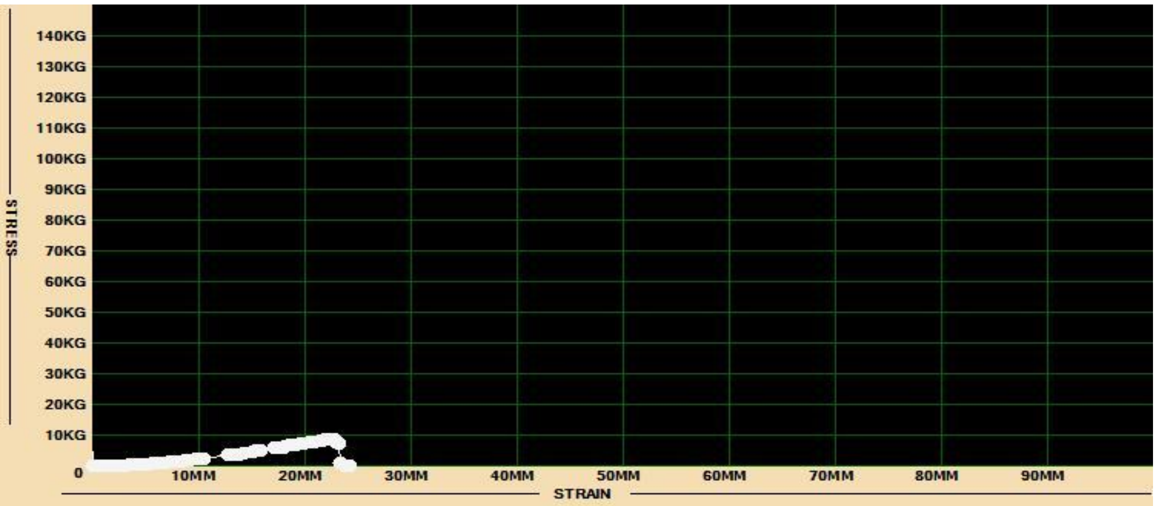

Figure 4.3 Graph of middle butt (Standard)

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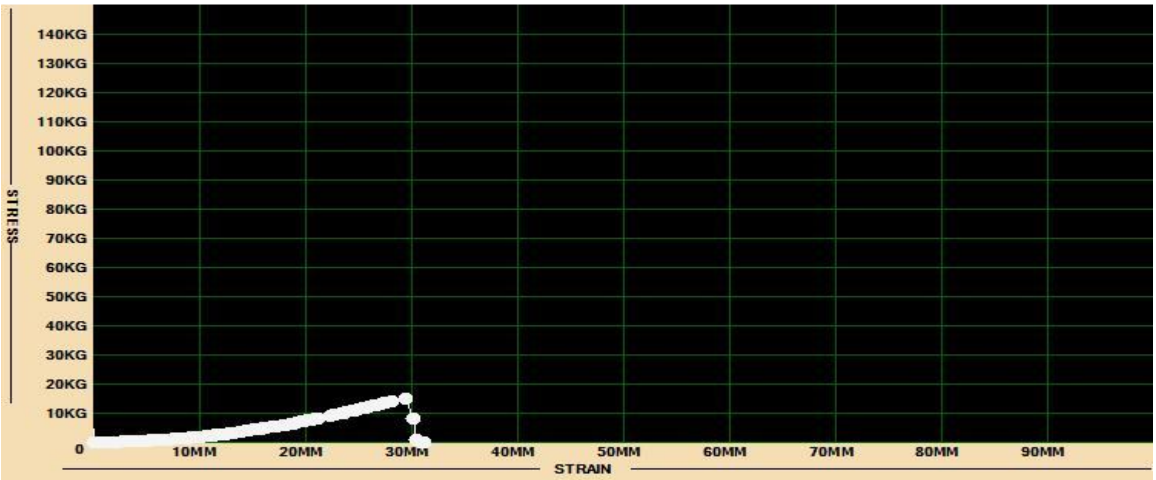

Figure 4.4 Graph of lower Butt (Standard)

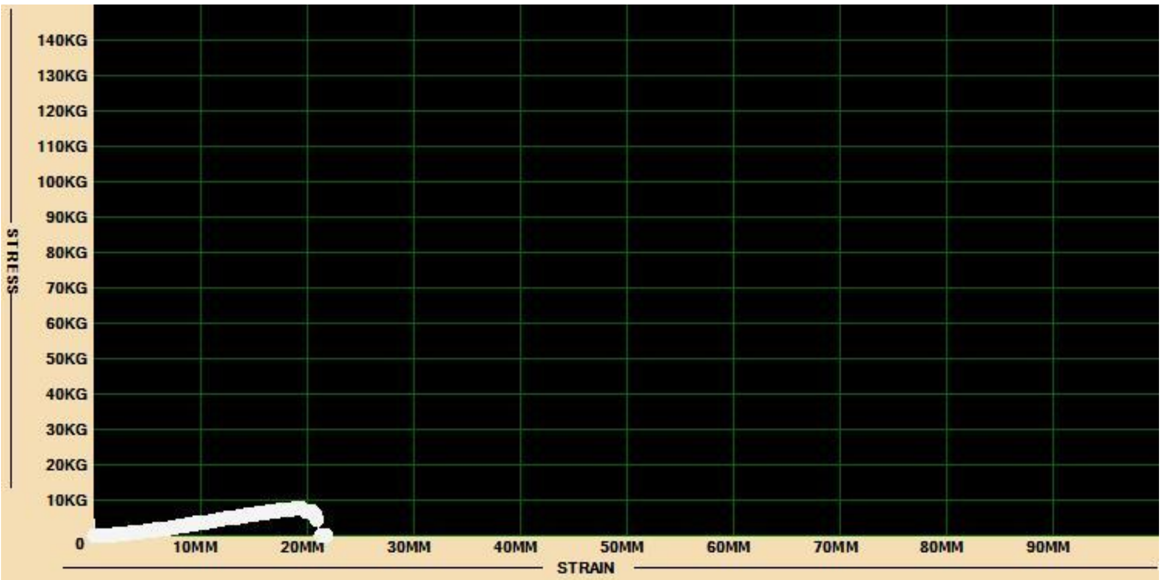

Figure 4.5 Graph of Shank (Standard)

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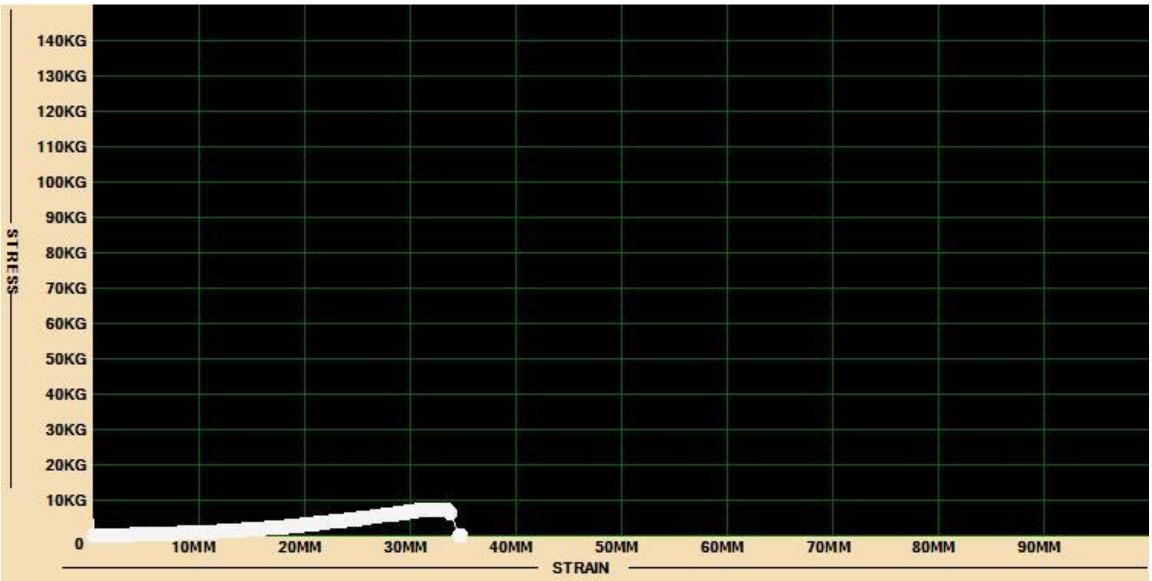

Figure 4.6 Graph of Belly (Standard)

4.2 OBSERVATION AND CALCULATION OF TENSILE STRENGHT OF LARGE SMPLES

Table 4.2 Final Results of large Samples

Portion of Hide	Tensile Strength	New Tensile Strength
Lower Butt	7.24	7.96
Middle Butt	11.67	12.23
Shoulder	14.3	13.75
Belly	9.17	9.8
Shank	9.37	9.16
Neck	12.53	12.8

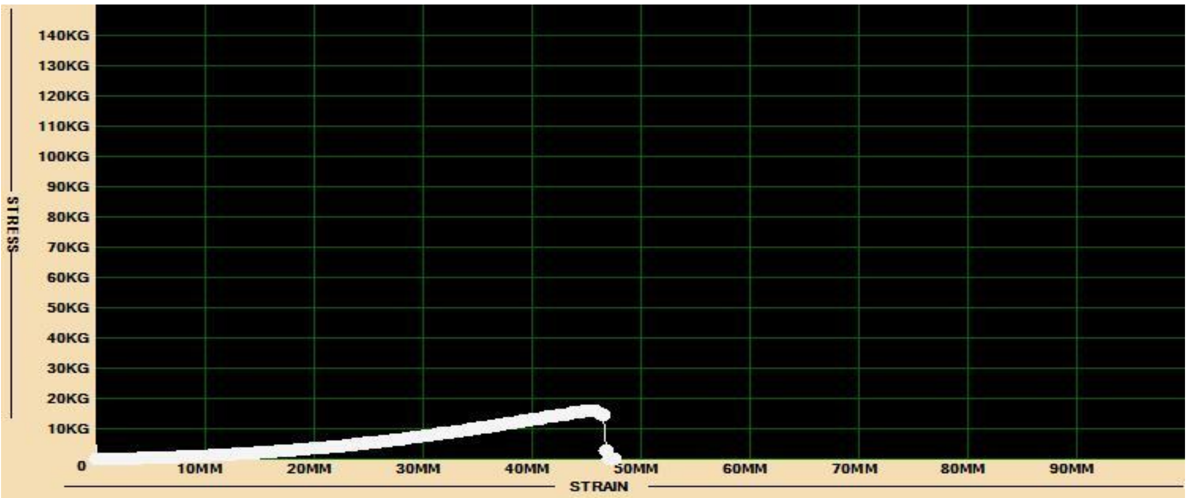

Figure 4.7 Graph of Lower Butt (Large)

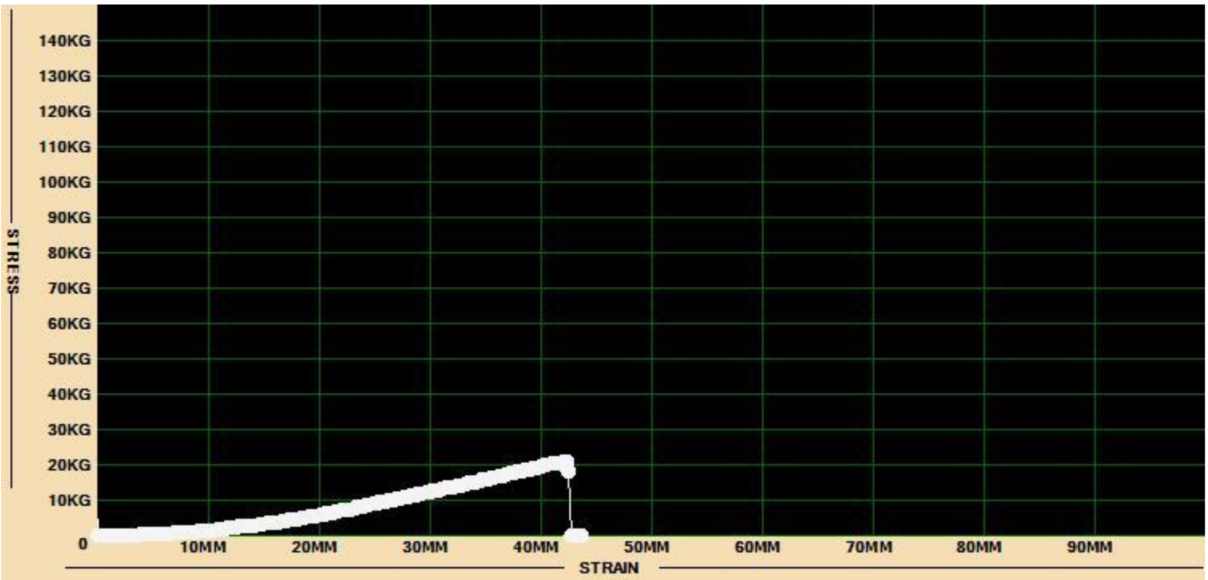

Figure 4.8 Graph of Middle Butt (Large)

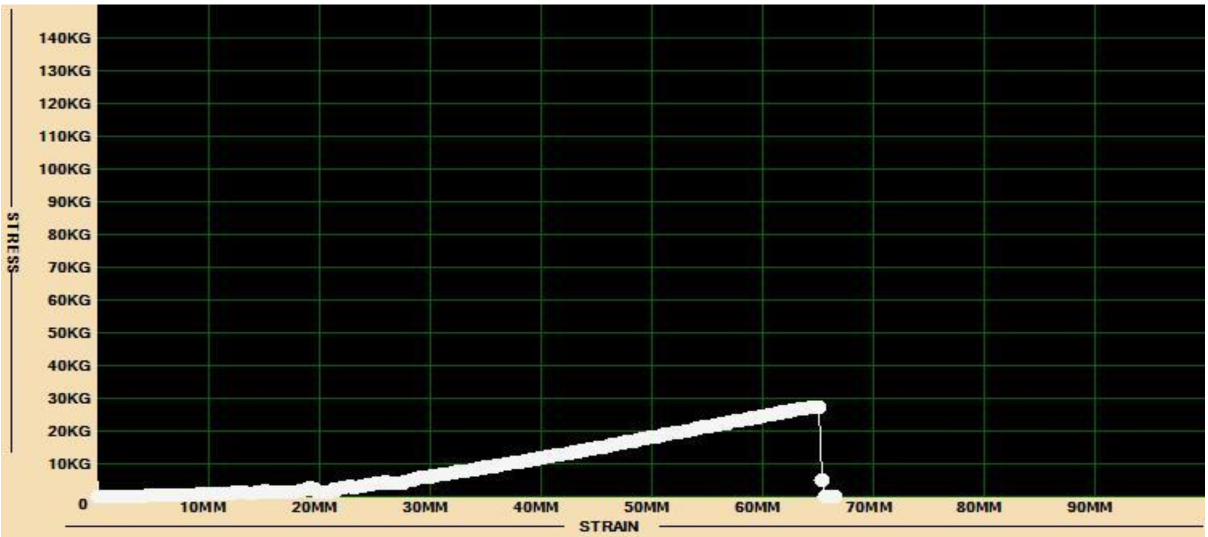

Figure 4.9 Graph of Shoulder (Large)

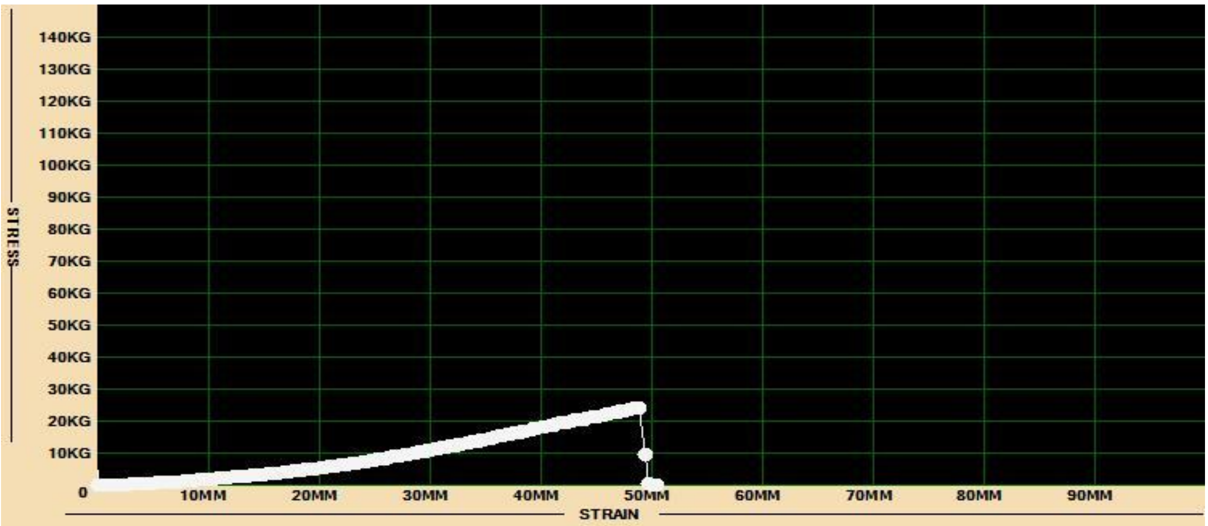

Figure 4.10 Graph of Belly (Large)

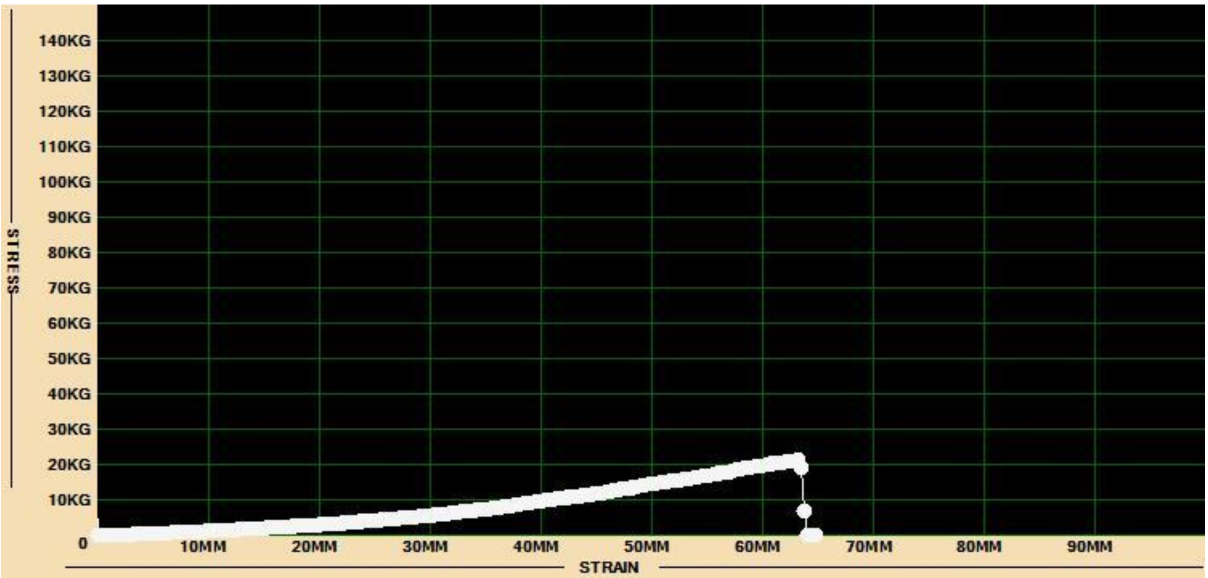

Figure 4.11 Graph of Shank (Large)

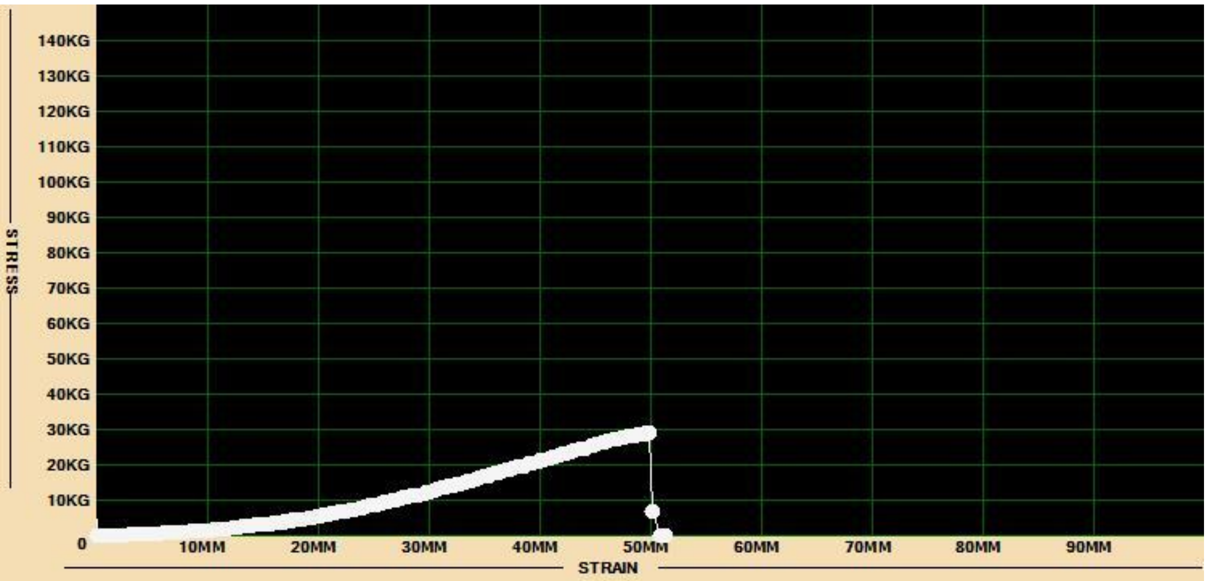

Figure 4.12 Graph of Neck (Large)

Conclusion

While significant progress has been made in understanding the influence of various factors on leather's tensile strength, further research is crucial to optimize its safety, performance, and sustainability in the footwear and garment industries. This combined conclusion highlights the key takeaways from both paragraphs:

Advancements- The first paragraph celebrates the progress made in understanding how different factors affect leather's tensile strength, potentially leading to safer and more reliable footwear.

Research Gaps- The second paragraph identifies critical areas needing further investigation, such as processing methods, chemical interactions, tearing behavior, stitching types, and worker well-being.

Overall Goal- Both paragraphs emphasize the importance of continued research and collaboration to achieve responsible and sustainable practices in the leather industry, ultimately benefiting both product quality and worker health.

By merging these aspects, the final conclusion provides a comprehensive overview of the current state of knowledge, acknowledging both achievements and future research needs.

Future Scope of work

Future research on leather tensile strength and its impact on footwear and garments should focus on global variations, including diverse tanning practices, processing methods, and animal breeds, to enhance the generalizability of findings. Exploring advanced materials like bio-based and conductive leathers is crucial for understanding their suitability and durability. A multi-disciplinary approach involving material science, engineering, chemistry, and sustainability will optimize leather processing for performance and environmental impact. Deepening the understanding of tanning chemistry and collagen interaction, tearing behavior, and stitching techniques will ensure optimal garment fit, construction, and durability. Additionally, addressing chronic health effects and advancing non-destructive testing, computational modeling, and artificial intelligence will further enhance leather research efficiency and sustainability. Prioritizing sustainable tanning methods, animal welfare, and transparency in the supply chain will promote ethical practices while meeting industry demands.

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Declaration

This work has neither been published previously nor is it being considered for publication elsewhere. If accepted, it will not be published in any other form, language, or medium, including electronically, without the explicit written consent of the copyright holder. The author has not received any funding for this work.

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Website for Images

a) [Tensile Testing] https //images.app.goo.gl/YipP75Z52mPEj9uS8
b) [High Voltage Breakdown Tester] https //images.app.goo.gl/XhLbH4hwmGBPrnqa8
c) [Electrical Resistance tester Machine] https //m.indiamart.com/proddetail/electrical-leather-resistance-tester-23595531588.html