DESIGN DEVELOP AND EVALUATE THE SMART WEARABLE ELECTRONIC FABRIC

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ABSTRACT

Since people everywhere are becoming more "health conscious," there is a pressing need to newline improve the standard of medical treatment available to them. The textile industry is playing a significant new-line role in the development of healthcare safety monitoring systems. New newline techniques have been created in electro-textiles, such as the use of conductive yarns, to produce novel soft newlinetextile interfaces that are widely accepted by the end user. Fabricating these kinds of fabrics and clothing relies heavily on conductive newlineyarns.

Keywords: clothing components; textile technology; wearable textile antennas.

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INTRODUCTION

E-textiles, also known as electronic textiles, are fabrics that include electrical components including batteries, LEDs, sensors, and microcontrollers. Smart textiles, which leverage newly created technologies to bring additional benefits to the user, should not be mistaken with these. The usage of e-textiles is at the heart of many current and future smart clothing, wearable technology, and wearable computing initiatives.

The focus of electronic textiles is on the invisible connection between fabrics and electrical components such microcontrollers, sensors, and actuators, setting them apart from wearable computing. Additionally, e-textiles don't have to be in a wearable form. E-textiles, for instance, are not only for the outside.

Fibretronics is a subfield of textile engineering that investigates the incorporation of electrical and computational functions into fibers of fabric. Cientifica Research has released a new analysis analyzing the markets, businesses, and enabling technologies for wearable technology based on textiles.

Generation or storage of energy, interaction with a user, radio frequency (RF) capabilities, and auxiliary systems are all examples of active functionality. One of the biggest challenges in developing Smart Fabrics is meeting the power needs of all the embedded electrical components. Piezoelectric elements, which harness energy from motion, and photovoltaic elements, which convert light into electricity, are both viable options for power production.

There are two main types of human interfaces for active systems: input devices and annunciation or display devices. Capacitive patches, which act as buttons, and shape-sensitive materials, which detect movement, pressure, and the degree to which an object is stretched or compressed, are all examples of input devices. Fabric speakers, electroluminescent yarns, and yarns treated to incorporate arrays of organic light emitting diodes (OLEDs) are all viable options for use in announcement and display systems. Vibrating or bio-feedback components may also be woven into fabrics. One straightforward use of Smart Fabrics is in fabric-based antennas. cloth antennas may be as easy as stitching or weaving conductive threads of the appropriate length into a non-conducting cloth.

LITERATURE AND REVIEW

D D Xie (2021) Smart clothing has rapidly become an industry standard as a result of rising consumer expectations and technological advancements. Medical monitoring, everyday protection, entertainment, and sports are just some of the many areas where smart clothing is finding widespread use. To accommodate the downsizing and portability of electronic items, sensors are incorporated into clothes based on the original wearing demands. This therefore affects the softness and visual appeal of garment fabrics. Clothing's basic structure and design were modified throughout the R&D process when hardware devices like sensors were woven into the fabric. The smart clothing industry is not governed by a unified set of guidelines. In this post, we'll take a look at how smart clothing has evolved, how it's been categorized, and how its effectiveness has been measured thus far.

Chika O Yinka-Banjo et al (2020) textiles with integrated electronics and interconnections woven into them are known as "smart fabrics" or "smart Textiles," and they provide a level of physical flexibility not possible with current electronic production methods. All the parts and connections are built right into the fabric, so they can't be seen and won't get tangled up with anything else. Power management and situational awareness may both benefit from the ability of smart textiles to rapidly adjust to new sensing and computational demands. The goal of wearable technology is to make electronic systems a regular part of our clothing by creating standards that ensure electronic gadgets can be comfortably worn. One defining feature of wearable systems is their capacity to detect changes in the wearer's activity and behavior, as well as environmental changes, and respond accordingly by modifying the system's configuration and performance. New advances in Smart Fabrics were the primary emphasis of this article, which also discussed the materials and production processes involved.

Chi-Wai Kan et al (2021) Depending on their level of interactivity with the wearer, smart textiles may be either active or passive, and both types can collaborate with the human brain to enhance its reasoning, perception, and motor functions. The fields of medicine, pop culture, and academia all saw rapid expansion thanks to advances in wearable technology. The future of wearable electronics is built on improved electronic textile systems that will prioritize functionality, ease of use, and user acceptability and comfort.

Rebeccah Pailes-Friedman et al (2014) The space industry has found several uses for wearable technology. The integration of electronic sensing, interaction, and computing into ergonomic on-body form factors has the potential to enhance human capabilities in the areas of security, productivity, independence, and comfort. In this work, we present the design process and methodology we used to enhance the E-SEWT (Electronic-textile System for the Evaluation of Wearable Technology) project for NASA's Johnson Space Center's Avionic Systems Division's Wearable Electronics Application and Research Lab (WEAR Lab). The E-SEWT project is a design-driven investigation of a smart, versatile garment's potential uses and configurations aboard the International Space Station. This garment has a base unit and interchangeable sensor pieces known as "swatches." The user may adjust the garment to their own requirements and preferences, making it ideal for use in a variety of situations. The benefits of a smart garment with interchangeable modules include adaptability to different users and jobs, rapid iteration during prototype development, and the potential for mass production. Interaction with people helped shape design solutions that prioritize usability, accessibility, and efficiency without sacrificing mobility or ergonomics or comfort.

Dilan Canan Çelikel (2020) One way in which textiles are made more valuable is via the use of smart textiles. New technology, fibers, and textile materials have given rise to this industry. Nanotechnology, materials science, design, electronics, computer engineering, etc., all play a role in the creation of smart or intelligent textiles. Based on its functionality, smart textiles may be broken down into three categories: passive, active, and super smart textiles. The initial generation of smart textiles are passive, environmental sensors like UV-protective garments and conductive fibers. Ultra smart textiles perceive, react, and customize themselves to environmental factors in the same way as active smart textiles do. Active smart textiles are often used for shape memory materials, chromic materials, heat storage, and thermo-regulated fabrics.

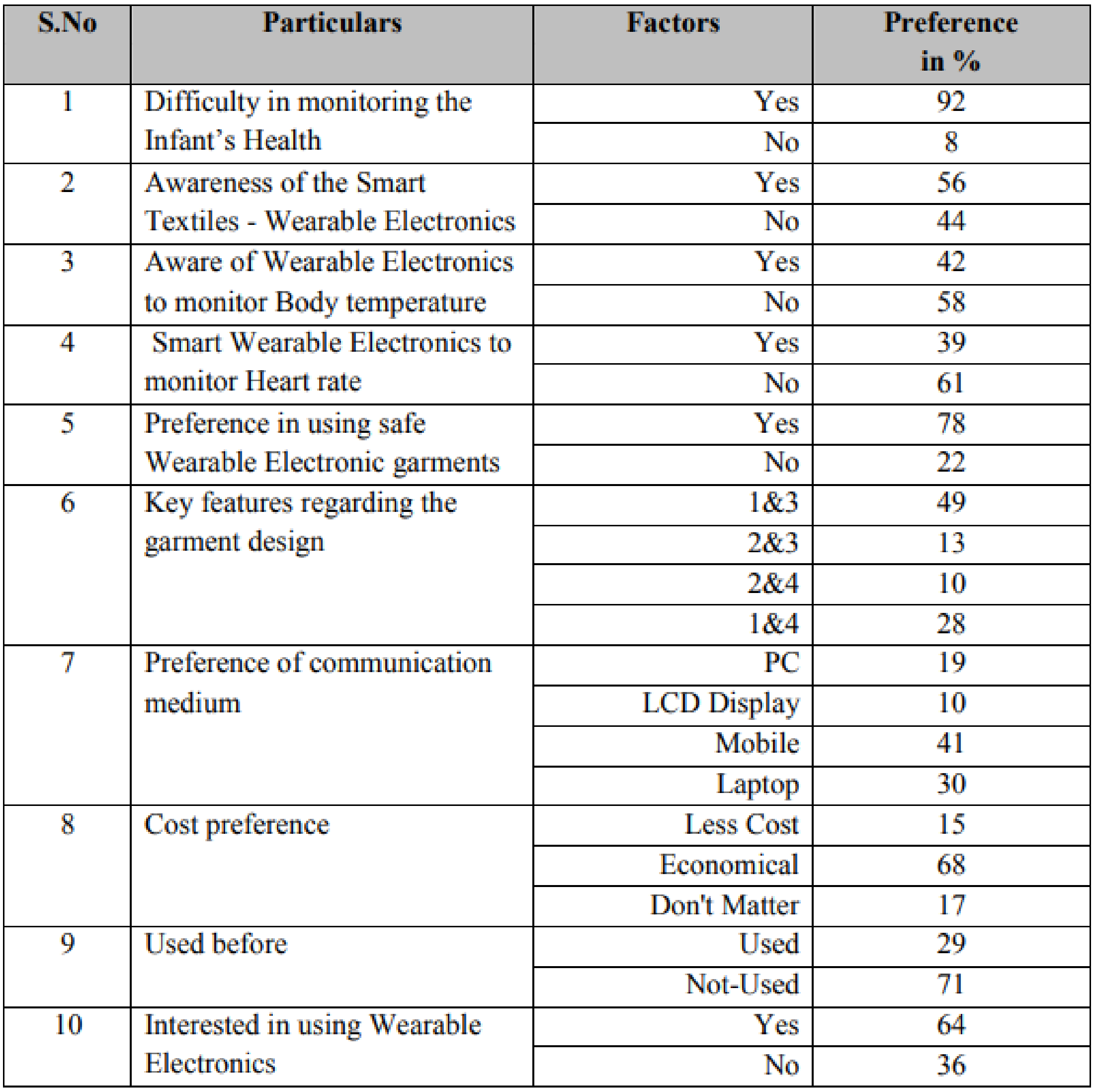
METHODOLOGY

The first step toward a healthy population is to raise a generation of healthy children. The percentage of women who hold paid employment has increased dramatically over the last several decades, particularly in the developed world. As a result, many households are struggling to pay for the rising cost of infant healthcare. A mother's first focus is always on making sure her kid is safe. The stress levels of a new mother increase when she needs to leave her baby for any reason, including her own work, the duties of the household, or an emergency. Approximately 7,000 newborns are born each and every day, but sadly, many of them do not survive. This is owing to the fact that causes of infant death are so widespread. They may be interested in a gadget that promises to help with monitoring and care. One hundred mothers were polled to see how much they knew about and cared about children's smart wearable health monitoring devices. This study informed the design of a garment for use in healthcare monitoring of infants.

Awareness of Smart Wearable kids Health monitoring system

A study was performed to determine the amount of interest in and to raise awareness of smart textiles-wearable electronics among young moms.

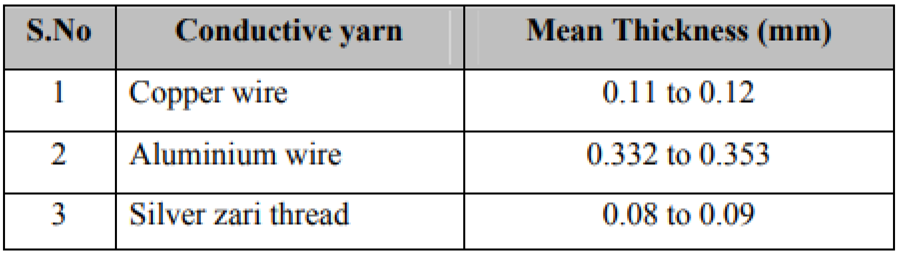
Table- 1 Details about the Awareness of Smart Wearable kids Health monitoring system



S.No	Particulars	Factors	Preference in %
1	Difficulty in monitoring the Infant's Health	Yes	92
		No	8
2	Awareness of the Smart Textiles - Wearable Electronics	Yes	56
		No	44
3	Aware of Wearable Electronics to monitor Body temperature	Yes	42
		No	58
4	Smart Wearable Electronics to monitor Heart rate	Yes	39
		No	61
5	Preference in using safe Wearable Electronic garments	Yes	78
		No	22
6	Key features regarding the garment design	1&3	49
		2&3	13
		2&4	10
		1&4	28
7	Preference of communication medium	PC	19
		LCD Display	10
		Mobile	41
		Laptop	30
8	Cost preference	Less Cost	15
		Economical	68
		Don't Matter	17
9	Used before	Used	29
		Not-Used	71
10	Interested in using Wearable Electronics	Yes	64
		No	36

Thickness gauge readings were used to determine the average thickness of the conductive yarns used in the experiment.

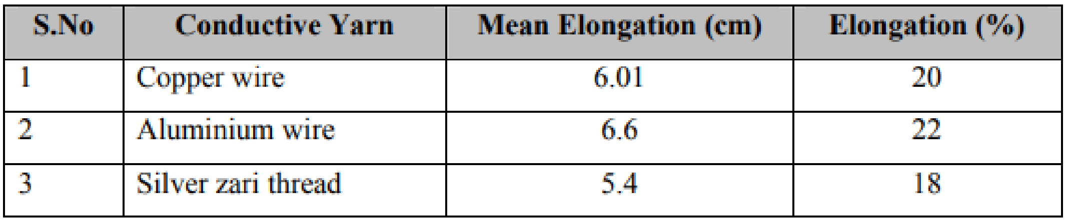
Table 2 Yarn thickness



S.No	Conductive yarn	Mean Thickness (mm)
1	Copper wire	0.11 to 0.12
2	Aluminium wire	0.332 to 0.353
3	Silver zari thread	0.08 to 0.09

Each conductive yarn's elongation was measured independently using mechanical investigation by comparing the shattered length to the standard length of 30cms. Conductive yarn elongation percentages, as estimated.

Table 3 Yarn Elongation

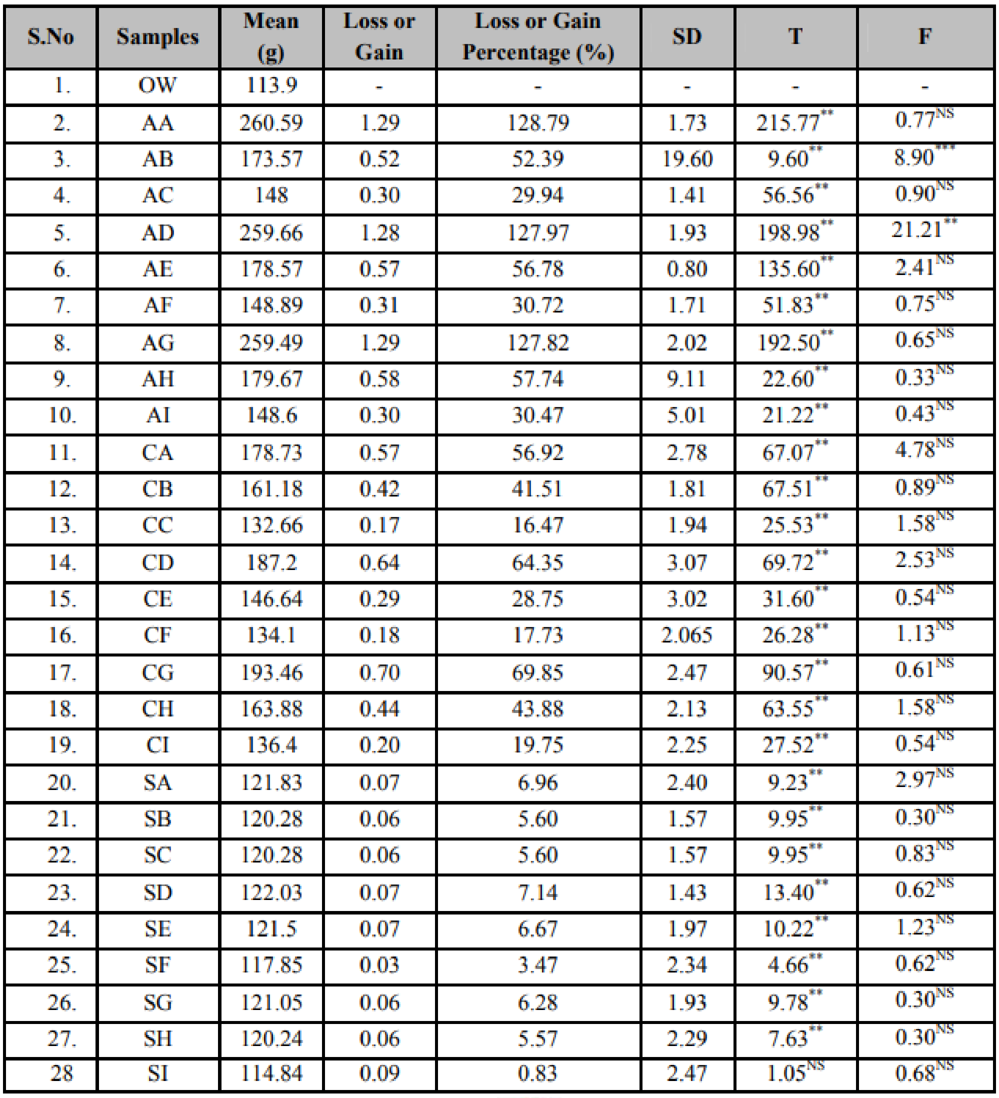


S.No	Conductive Yarn	Mean Elongation (cm)	Elongation (%)
1	Copper wire	6.01	20
2	Aluminium wire	6.6	22
3	Silver zari thread	5.4	18

Evaluation of the Physical Properties of the Woven Conductive Fabric

The table below provides a quick comparison of the original woven fabric's weight to that of the aluminum conductive woven, copper conductive woven, and silver conductive woven samples.

Table- 4 Fabric Weight of Woven Conductive Fabric

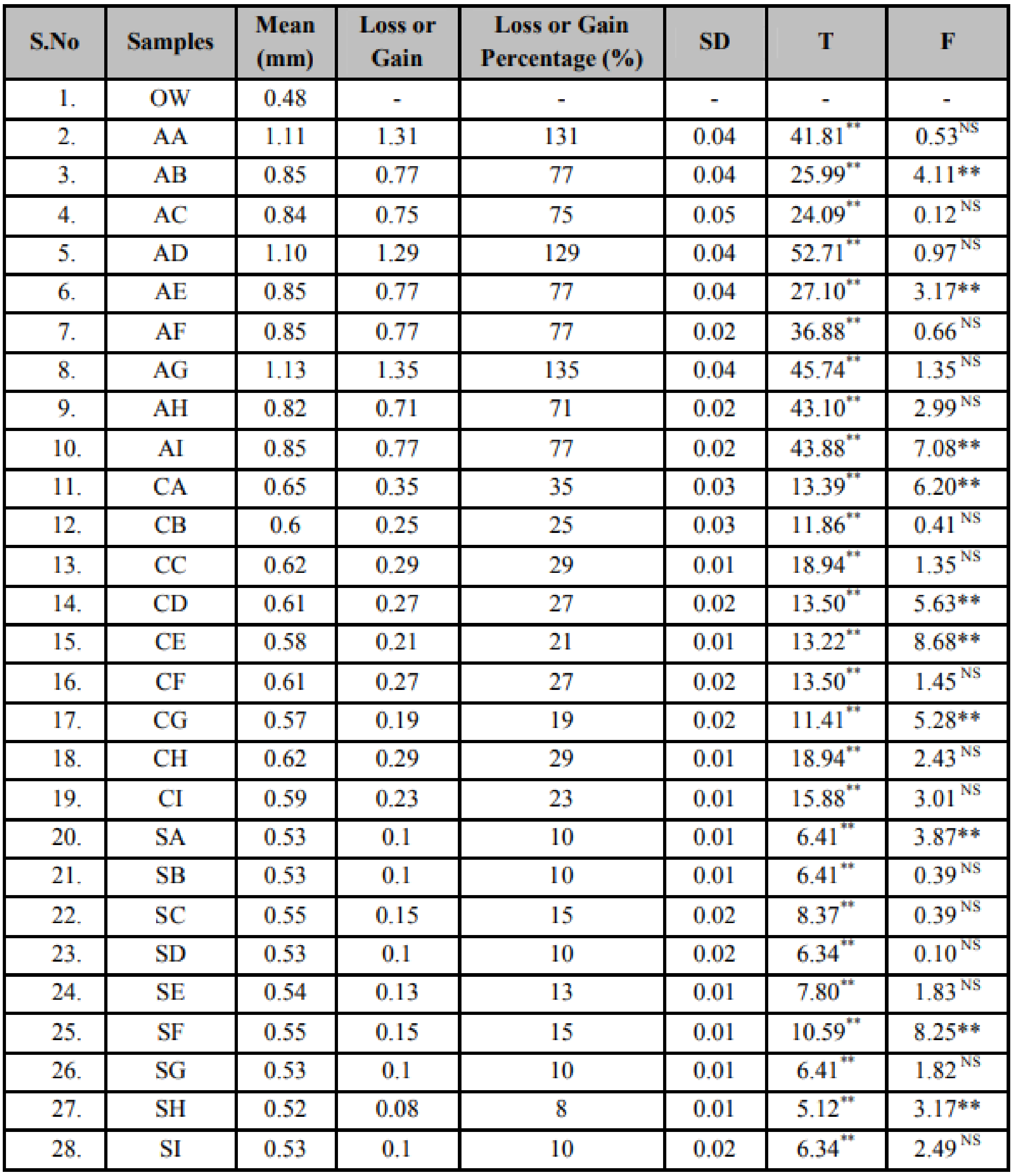


S.No	Samples	Mean (g)	Loss or Gain	Loss or Gain Percentage (%)	SD	T	F
1.	OW	113.9	-	-	-	-	-
2.	AA	260.59	1.29	128.79	1.73	215.77^{**}	0.77^{NS}
3.	AB	173.57	0.52	52.39	19.60	9.60^{**}	8.90^{***}
4.	AC	148	0.30	29.94	1.41	56.56^{**}	0.90^{NS}
5.	AD	259.66	1.28	127.97	1.93	198.98^{**}	21.21^{**}
6.	AE	178.57	0.57	56.78	0.80	135.60^{**}	2.41^{NS}
7.	AF	148.89	0.31	30.72	1.71	51.83^{**}	0.75^{NS}
8.	AG	259.49	1.29	127.82	2.02	192.50^{**}	0.65^{NS}
9.	AH	179.67	0.58	57.74	9.11	22.60^{**}	0.33^{NS}
10.	AI	148.6	0.30	30.47	5.01	21.22^{**}	0.43^{NS}
11.	CA	178.73	0.57	56.92	2.78	67.07^{**}	4.78^{NS}
12.	CB	161.18	0.42	41.51	1.81	67.51^{**}	0.89^{NS}
13.	CC	132.66	0.17	16.47	1.94	25.53^{**}	1.58^{NS}
14.	CD	187.2	0.64	64.35	3.07	69.72^{**}	2.53^{NS}
15.	CE	146.64	0.29	28.75	3.02	31.60^{**}	0.54^{NS}
16.	CF	134.1	0.18	17.73	2.065	26.28^{**}	1.13^{NS}
17.	CG	193.46	0.70	69.85	2.47	90.57^{**}	0.61^{NS}
18.	CH	163.88	0.44	43.88	2.13	63.55^{**}	1.58^{NS}
19.	CI	136.4	0.20	19.75	2.25	27.52^{**}	0.54^{NS}
20.	SA	121.83	0.07	6.96	2.40	9.23^{**}	2.97^{NS}
21.	SB	120.28	0.06	5.60	1.57	9.95^{**}	0.30^{NS}
22.	SC	120.28	0.06	5.60	1.57	9.95^{**}	0.83^{NS}
23.	SD	122.03	0.07	7.14	1.43	13.40^{**}	0.62^{NS}
24.	SE	121.5	0.07	6.67	1.97	10.22^{**}	1.23^{NS}
25.	SF	117.85	0.03	3.47	2.34	4.66^{**}	0.62^{NS}
26.	SG	121.05	0.06	6.28	1.93	9.78^{**}	0.30^{NS}
27.	SH	120.24	0.06	5.57	2.29	7.63^{**}	0.30^{NS}
28	SI	114.84	0.09	0.83	2.47	1.05^{NS}	0.68^{NS}

Note : ** - Significant at 1% level; * - Significant at 5% level; NS – Not Significant

Original woven fabric thickness, aluminum conducting woven fabric, copper conductive woven fabric, and silver conductive woven fabric are all mentioned.

Table- 5 Fabric Thickness of Woven Conductive Fabric



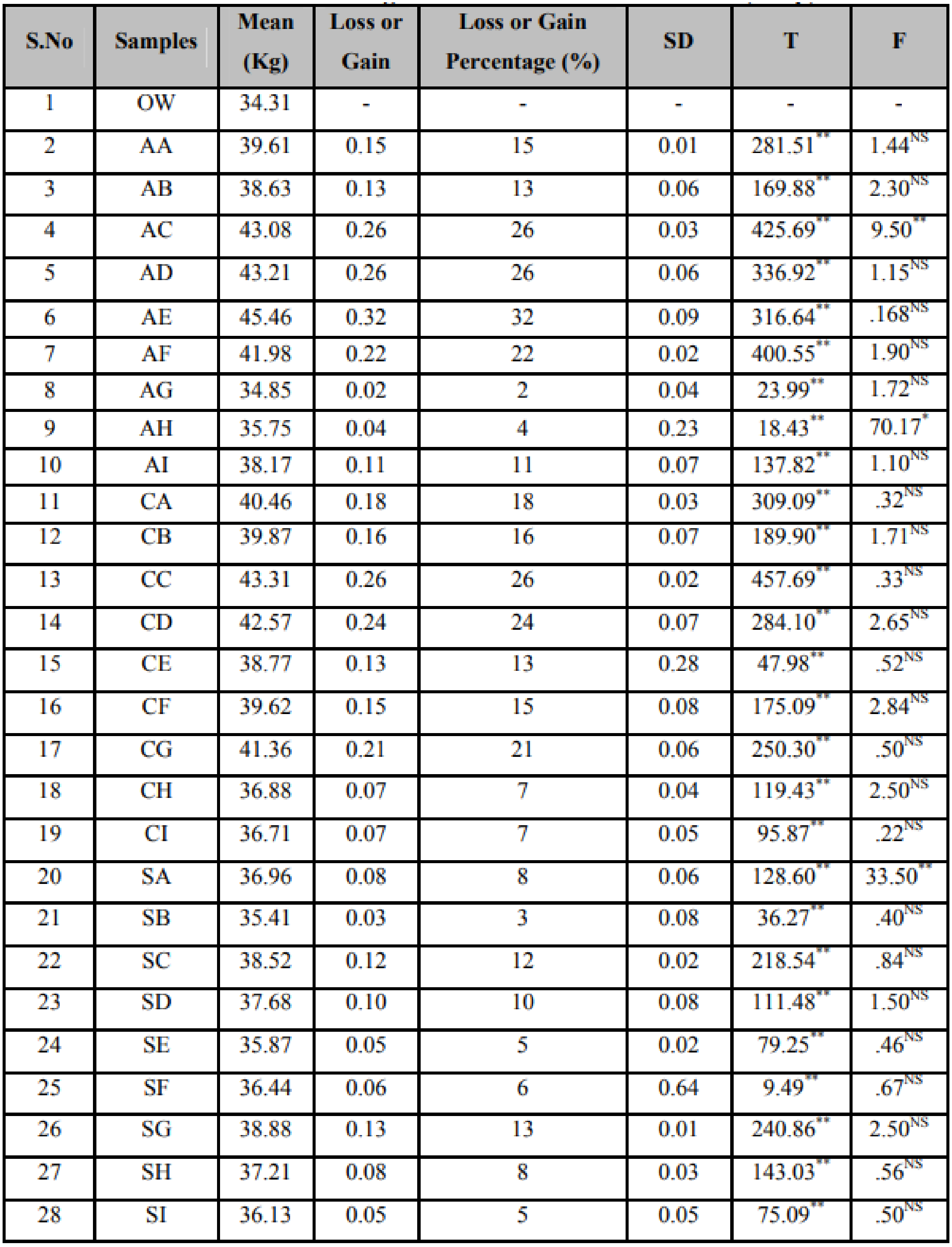
S.No	Samples	Mean (mm)	Loss or Gain	Loss or Gain Percentage (%)	SD	T	F
1.	OW	0.48	-	-	-	-	-
2.	AA	1.11	1.31	131	0.04	41.81**	0.53^{NS}
3.	AB	0.85	0.77	77	0.04	25.99**	4.11**
4.	AC	0.84	0.75	75	0.05	24.09**	0.12^{NS}
5.	AD	1.10	1.29	129	0.04	52.71**	0.97^{NS}
6.	AE	0.85	0.77	77	0.04	27.10**	3.17**
7.	AF	0.85	0.77	77	0.02	36.88**	0.66^{NS}
8.	AG	1.13	1.35	135	0.04	45.74**	1.35^{NS}
9.	AH	0.82	0.71	71	0.02	43.10**	2.99^{NS}
10.	AI	0.85	0.77	77	0.02	43.88**	7.08**
11.	CA	0.65	0.35	35	0.03	13.39**	6.20**
12.	CB	0.6	0.25	25	0.03	11.86**	0.41^{NS}
13.	CC	0.62	0.29	29	0.01	18.94**	1.35^{NS}
14.	CD	0.61	0.27	27	0.02	13.50**	5.63**
15.	CE	0.58	0.21	21	0.01	13.22**	8.68**
16.	CF	0.61	0.27	27	0.02	13.50**	1.45^{NS}
17.	CG	0.57	0.19	19	0.02	11.41**	5.28**
18.	CH	0.62	0.29	29	0.01	18.94**	2.43^{NS}
19.	CI	0.59	0.23	23	0.01	15.88**	3.01^{NS}
20.	SA	0.53	0.1	10	0.01	6.41**	3.87**
21.	SB	0.53	0.1	10	0.01	6.41**	0.39^{NS}
22.	SC	0.55	0.15	15	0.02	8.37**	0.39^{NS}
23.	SD	0.53	0.1	10	0.02	6.34**	0.10^{NS}
24.	SE	0.54	0.13	13	0.01	7.80**	1.83^{NS}
25.	SF	0.55	0.15	15	0.01	10.59**	8.25**
26.	SG	0.53	0.1	10	0.01	6.41**	1.82^{NS}
27.	SH	0.52	0.08	8	0.01	5.12**	3.17**
28.	SI	0.53	0.1	10	0.02	6.34**	2.49^{NS}

Note : ** - Significant at 1% level; * - Significant at 5% level; NS – Not Significant

Evaluation of the Mechanical Properties of the Woven Conductive Fabric

All the samples of woven cloth were tested for tensile strength in both the warp and weft directions.

Table-6 Tensile Strength of Woven Conductive Fabric (warp)

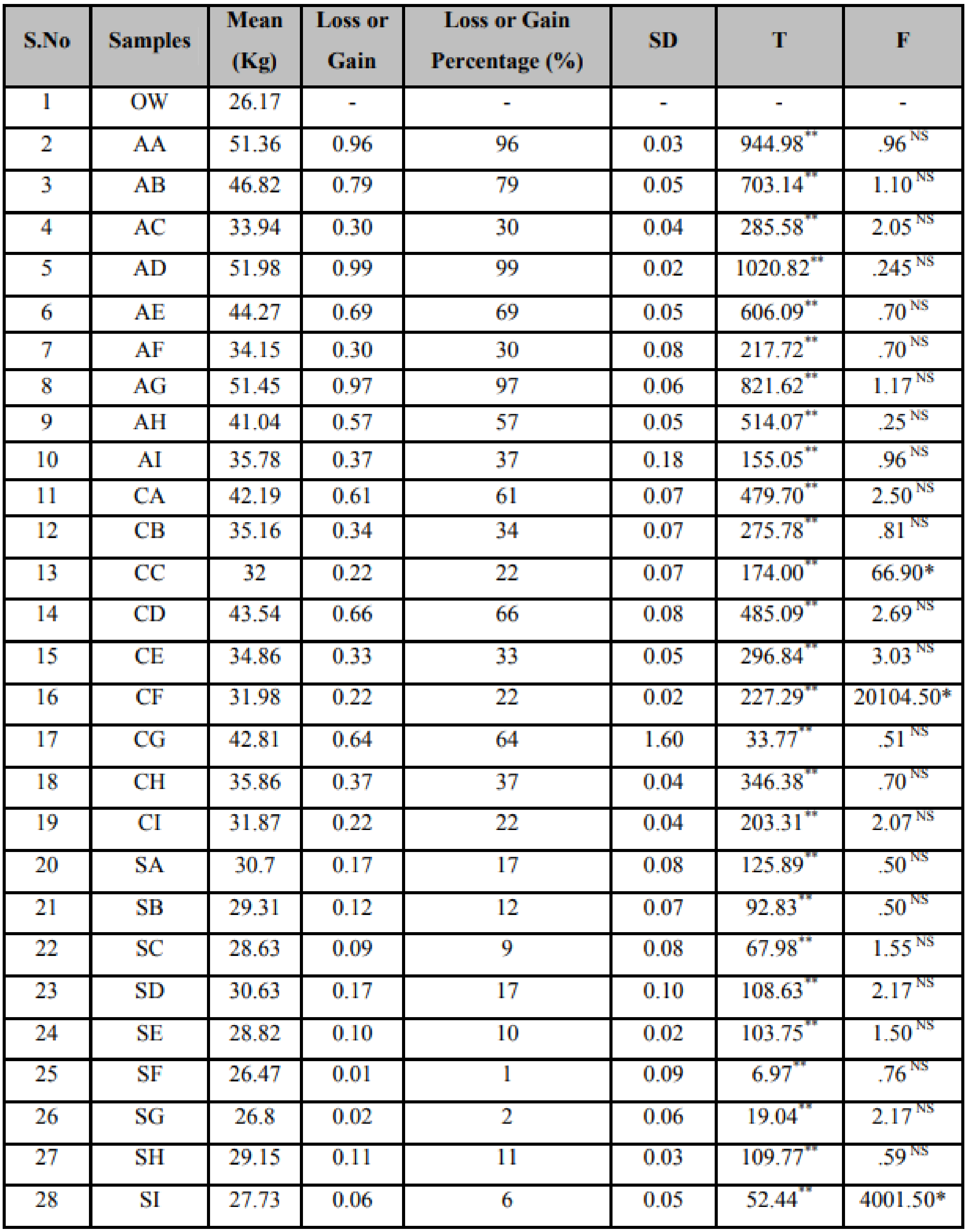


S.No	Samples	Mean (Kg)	Loss or Gain	Loss or Gain Percentage (%)	SD	T	F
1	OW	34.31	-	-	-	-	-
2	AA	39.61	0.15	15	0.01	281.51**	1.44^{NS}
3	AB	38.63	0.13	13	0.06	169.88**	2.30^{NS}
4	AC	43.08	0.26	26	0.03	425.69**	9.50**
5	AD	43.21	0.26	26	0.06	336.92**	1.15^{NS}
6	AE	45.46	0.32	32	0.09	316.64**	.168^{NS}
7	AF	41.98	0.22	22	0.02	400.55**	1.90^{NS}
8	AG	34.85	0.02	2	0.04	23.99**	1.72^{NS}
9	AH	35.75	0.04	4	0.23	18.43**	70.17*
10	AI	38.17	0.11	11	0.07	137.82**	1.10^{NS}
11	CA	40.46	0.18	18	0.03	309.09**	.32^{NS}
12	CB	39.87	0.16	16	0.07	189.90**	1.71^{NS}
13	CC	43.31	0.26	26	0.02	457.69**	.33^{NS}
14	CD	42.57	0.24	24	0.07	284.10**	2.65^{NS}
15	CE	38.77	0.13	13	0.28	47.98**	.52^{NS}
16	CF	39.62	0.15	15	0.08	175.09**	2.84^{NS}
17	CG	41.36	0.21	21	0.06	250.30**	.50^{NS}
18	CH	36.88	0.07	7	0.04	119.43**	2.50^{NS}
19	CI	36.71	0.07	7	0.05	95.87**	.22^{NS}
20	SA	36.96	0.08	8	0.06	128.60**	33.50**
21	SB	35.41	0.03	3	0.08	36.27**	.40^{NS}
22	SC	38.52	0.12	12	0.02	218.54**	.84^{NS}
23	SD	37.68	0.10	10	0.08	111.48**	1.50^{NS}
24	SE	35.87	0.05	5	0.02	79.25**	.46^{NS}
25	SF	36.44	0.06	6	0.64	9.49**	.67^{NS}
26	SG	38.88	0.13	13	0.01	240.86**	2.50^{NS}
27	SH	37.21	0.08	8	0.03	143.03**	.56^{NS}
28	SI	36.13	0.05	5	0.05	75.09**	.50^{NS}

Note : ** - Significant at 1% level; * - Significant at 5% level; NS – Not Significant

The tensile strength of the base fabric, as well as aluminum conductive, copper conductive, and silver conductive versions, are shown.

Table-7 Tensile Strength of Woven Conductive Fabric (Weft)



S.No	Samples	Mean (Kg)	Loss or Gain	Loss or Gain Percentage (%)	SD	T	F
1	OW	26.17	-	-	-	-	-
2	AA	51.36	0.96	96	0.03	944.98**	.96^{NS}
3	AB	46.82	0.79	79	0.05	703.14**	1.10^{NS}
4	AC	33.94	0.30	30	0.04	285.58**	2.05^{NS}
5	AD	51.98	0.99	99	0.02	1020.82**	.245^{NS}
6	AE	44.27	0.69	69	0.05	606.09**	.70^{NS}
7	AF	34.15	0.30	30	0.08	217.72**	.70^{NS}
8	AG	51.45	0.97	97	0.06	821.62**	1.17^{NS}
9	AH	41.04	0.57	57	0.05	514.07**	.25^{NS}
10	AI	35.78	0.37	37	0.18	155.05**	.96^{NS}
11	CA	42.19	0.61	61	0.07	479.70**	2.50^{NS}
12	CB	35.16	0.34	34	0.07	275.78**	.81^{NS}
13	CC	32	0.22	22	0.07	174.00**	66.90*
14	CD	43.54	0.66	66	0.08	485.09**	2.69^{NS}
15	CE	34.86	0.33	33	0.05	296.84**	3.03^{NS}
16	CF	31.98	0.22	22	0.02	227.29**	20104.50*
17	CG	42.81	0.64	64	1.60	33.77**	.51^{NS}
18	CH	35.86	0.37	37	0.04	346.38**	.70^{NS}
19	CI	31.87	0.22	22	0.04	203.31**	2.07^{NS}
20	SA	30.7	0.17	17	0.08	125.89**	.50^{NS}
21	SB	29.31	0.12	12	0.07	92.83**	.50^{NS}
22	SC	28.63	0.09	9	0.08	67.98**	1.55^{NS}
23	SD	30.63	0.17	17	0.10	108.63**	2.17^{NS}
24	SE	28.82	0.10	10	0.02	103.75**	1.50^{NS}
25	SF	26.47	0.01	1	0.09	6.97**	.76^{NS}
26	SG	26.8	0.02	2	0.06	19.04**	2.17^{NS}
27	SH	29.15	0.11	11	0.03	109.77**	.59^{NS}
28	SI	27.73	0.06	6	0.05	52.44**	4001.50*

Note : ** - Significant at 1% level; * - Significant at 5% level; NS – Not Significant

CONCLUSION

The history of textiles is one of the oldest of all human occupations, spanning thousands of years and including a wide range of materials, from animal skin and leaves in ancient times to a dizzying array of modern yarns and fabrics. Also, developments in science and technology have allowed for the creation of 'Smart' or 'Intelligent' textiles, which are a far cry from the woven animal skins and reeds used by early cavemen for protection.

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