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A STUDY ON THE APPLICATION OF POLYURETHANE (P.U.) AS MATERIAL TO ENHANCE UTILITY AND FASHION TREND OF SPORTS SHOE

"A NEW GENERATIONMATERIAL"

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Abstract:

Aim of the Research:

Selection of the footwear material in the past few yearshas become very complex and monotonous process due to customer's increasing demand for fashionable and durable footwear. Now customer prefer to buy those footwear which are designed with using lubri-crativeor fancy colors, good design and quality which are not only suits their personality and reflects their personality in the society.

Customers are willing to spend additional price, if they get sports shoes which providethem additional comfort in terms of shock absorption, fit, durability, color, motion controland suits their overall attire. In leather made sports shoe, there is always a chance of scarcity of leather, due to reducing cattle stock day by day and prohibition on animal killing in the country. On the other hand P.U. polyurethane is easily available in the country in all the quality and price ranges. There are many other unique and important characteristics of P.U which made it the first choice of sports shoe manufacturing be-national and international brands. Hence, the aim of the research paper is

to identify how the Polyurethane P.U (which is extremely versatile elastomer having an excellent property of damping i.e., absorption of pressure) as material is gaining importance in construction of upper and bottom components of footwear as to meets both the expectations of the end user.

Research Methodology:

The research methodology is based on review and analysis on secondary data – cases, literature review and government reports. A comparative report will be made on the basis of the past literature keeping in mind the need of future. A research design is completelyrely of descriptive research.

Key Findings:

The outcome of the study enlightened how P.U. has been most demanding material in present as it meets the expectation level of customers due to its scientific properties and easy to processed as per the current trends prevailing in the market, moreover it provide additional benefits like cushioning, flexibility, tensile strength.

Contributions:

1. Sports shoe Manufacturer:to understand the benefits of polyurethane for production of sports shoe.
2. Customers: to understand and the selection the quality and benefits of P.U. in sports shoe and get desired level of performance & meeting cost elements.

Keywords: Polyurethane (PU), Fashion, Footwear, Sports shoes, Comfort, Materials.

Introduction:

Today, fashion is everything; i.e. style, culture, religion, just everything for our society. We live fashion in ourselves, while working, playing or doing any activity and without it we feel in-complete. Fashion industry, is very versatile in its nature & in this industry changes took place very fastly, due to changing moods ,taste and preferences of customers. It gives a psychological impact of on our basic nature, behaviour and working. Very well said that today will not be part of our wardrobe tomorrow and it is very much applicable on footwear material selection.

Fashion is composite of two major areas – out attire and shoes. Whatever, customer wear, dress required footwear to complement their dressing . One cannot identify fashion with only upper garments. Sports shoes usually protects and supports the foot, the running shoe goes beyond what one would expect of the ordinary shoe.

Its advantages have been the subject of intense scrutiny, a focus that results from an increasingly health- and leisure-conscious population. As more people have become involved in the sport, more and more varied equipment has become available to runners.

In 1900, the first sneaker, or all-purpose athletic shoe, was designed, primarily of canvas material; this sneaker featured a rubber rim made possible by **Charles Goodyear's 1839**discovery of vulcanized rubber.

Rubber was finally rendered commercially useful when Goodyear heated and combined it with sulfur, thereby preventing it from hardening and losing its elasticity. In athletic shoes, rubber helped to cushion the impact of running on hard surfaces.

We have gone tremendous changes in the construction patterns and materials of the sports shoes, started with the traditional materials like leather which was highly successful in the formal shoe but not a real performer in sports shoes.

Whether your workout involves running, walking, sports or gym equipment, sport shoe is a must. Sports shoe can help you to prevent foot injuries and ankle damage, and gives a good motion control. Right sports shoes can be selected or manufactured for the certain running gait and the specific biomechanics of a player. In this material plays a vital role in the construction of the sports shoes.

Polyurethane P.U. is the revolutionary material which used in the both the upper material composites i.e. Synthetic leather, P.U. coated fabric and in the soling materials i.e. Synthetic rubber, EVA, Phylon of the sports shoes. P.U is having several characteristics and properties of which made it so important than other materials used for making sports shoes.

Table: 1: Raw Material Polyurethane for Sports Shoes with its Significance

Attributes of Polyurethane P.U. as a Raw Material of Sports Shoe.		
S. No	**Characteristics**	**Beneficial for Sports shoes**
1.	It is considered as tough materials for sports shoe.	The classification of hardness for polyurethane relies on the pre-polymer's molecular structure.
2.	It has a high load capacity in both tension and compression.	Polyurethane may undergo a change in shape under a heavy load, but will return to its original shape once the load is removed with little compression set in the material.
3.	It performs very well when used in high flex fatigue applications.	Flexural properties can be isolated allowing for very good elongation and recovery properties for better grip and motion control.

4.	Sports shoes must be built to include a variety of physical attributes.	It includes attributes like better grip, abrasion resistance and shock absorption which are all available in polyurethane soling material required for sports shoes.
5.	They are fully water proof material and can resist even at low temperatures.	So excellent in making of the hiking boots.
6.	It possesses high tear resistance along with high tensile properties	Both are best for upper making fabrics for sports shoes.
7.	Polyurethane's material properties will remain stable (with minimal swelling) in water.	Low water absorption on the water containing surfaces like AstroTurf.
8.	It is very light weight.	Best for light weight sports shoes.
9.	Resilience is generally a function of hardness.	For shock-absorbing elastomer applications, low rebound compounds are usually used (i.e. resilience range of 10-40%). For high frequency vibrations or where quick recovery is required, compounds in the 40-65% resilience are used. In general, toughness is enhanced by high resilience.
10.	Polyurethane bonds to a wide range of materials during the manufacturing process.	These materials can be plastics, metals and wood. So ideal material for wheels, rollers and inserts.
11.	It exhibits good electrical insulating properties.	Good for making sports shoe free from shock absorption.
12.	Varying color pigments can be added to P.U. in the manufacturing process	Ultraviolet shielding can be incorporated into the pigment to provide better color stability in outdoor applications.
13.	It is often used to manufacture high volume, repeat production runs which made it to a low cost material.	Easily available raw materials at low cost.

Research Methodology:

The research methodology is based on review and analysis on secondary data – cases, literature review and government reports. A comparative report will be made on the basis of the past literature keeping in mind the need of future. A research design is completely rely of descriptive research.

On the basis of above cases and recommendations it can be recommended that PU on the basis of its properties is most preferred material for the footwear manufacturing units.

Review of Literature:

The paper was written to analyse the benefits of P.U as material that not only improve the usability of footwear, as well as enhance the style of the footwear, keeping such aspects in mind various cases and reports where analysed. Some of the reports undertaken in current research are:

Table: 2: Category of Cases & Reports undertaken for the study

S. No.	Duration of Reports and Cases	Title of the Reports and Cases
1.	2014	Engineers India Research Institute -"P.U. footwear manufacturing.
2.	2015	A study about Polymers applications in footwear. (By – Md. Hajbour Rehman khan).
3.	2018	A case study in productive improvement in footwear industry(By – Noor Ali)
4	2019	UVex X- pert blog "why do shoe soles disintegrate? (by PPE essentials Soft shoes)

A Footwear company may enhance its productivity by adopting suitable changes in its manufacturing processes and materials. These types of changes brought strength and improve the product attribute, stated by **Thiban and Raju 2008**, in survey report on footwear material selection.

Table: 3: Case Studies With its Implications & Recommendations

Title of the project	Publication year	Brief of the cases & reports	Outcome of the study	Recommendations
Engineers India research Institute "P.U. footwear manufacturing.	2014	Most of the footwear concern organization related to the construction of footwear & other related product have faith on P.U material because they believe that it is cost effective & having long durability and it is easy to processed as per the requvisition of the customer.	The finding of the study reveals that footwear manufacturing concern using PU as material enjoy the economy of price and capable of sharing their margins with potential customers to retain in the competitive structure of the industry.	PU material based footwear are easy to construct, consuming less energy, time and Cost, profit margins can be improved.
A study about Polymers applications in footwear. (By – Md. Hajbour Rehman khan).	2015	They thesis provide comprehensive insight about the use of polymer in footwear manufacturing industry. It also highlights what type of adhesives and the other materials are	It clearly reflects the comparison b/w the footwear materials – based on demand pattern of material among leather and polymer. The study reveals those	Maximum emphasis has been given on materials which are recycling by its property to reduce the level of security of materials. Application of P.U

		used by the industry to improve the durability and cost factors at the time of selecting material for the manufacturing og light weight footwear.	adhesives extracted by P.U. are majorly in demand due to its various properties that provide additional strength and durability to the product. Moreover, it represents the various types of materials used in sole manufacturing, insole console construction out of P.U to provide additional comfort, fit, color combinations to suits the current fashion trends.	has replaced most of the other materials due to its cost and availability factors. It is significant advised by most of the health sector industries that natural adhesive and P.U materials are skin friendly, hence it can be used without any certifications of hazardous therefore its demand has grown multiple folds
A case study in productive improvement in footwear industry(By – Noor Ali)	2018	The study emphasizing on improving productivity steps adopted by footwear industry. The example of Bangladesh footwear industry has	The industry survey has represented that material plays significant role in enhancing the	Application of cost saving materials, light weight properly and durability is todays necessity .the best material for

		been undertaken to carry out the study where industry has been analysed from various prospects to understand the determinants plays vital important role in improving the overall productivity of the industry.	productivity. Here, material selection is one of the important criteria, which not only improve the quality parameters of the footwear, but also improve the expectations of the customers by adding additional features such as: light weight, fashion based design, finishing attributes. Therefore material selections now a days is not that much easy as of earlier.	designing and reducing the wastage level as natural material it could by natural rubber, adhesives, PU based other material helps in attaching technological aspects, hence leather is generally not acceptable by most of the footwear industries and other materials like P.U & plant skins, animals protein are well adaptable materials to improve qualities & production process due to its availability.

Review of Articles:

Many of the footwear manufacturing companies have come forward to minimize the waste emission , hence they have moved towards a new category of material called polyurethane which not only helps in designing customized footwear and also supports in attaining the goals of sustainability.

With the use of single material for manufacturing of footwear reduce huge amount of carbon emission in the environment where as companies using multiple materials for manufacturing footwear, continuously spreading multiple toxic gases in the environment where as companies using single materials for the manufacturing of footwear has low propoertion of pollution extract as compare to multiple applications&materils used by the manufacturing units. Further footwear designed with TPU which is 100% recycle property and adopted by the most of the sports companies like Adidas. More over scrap of such units can be utilized in designing various accessories that can enhance the outer face of the kid's footwear.

Access research insights 2019: CAGR has mentioned is one of their survey report that methylene diphenyledisiocynate**(MDI)** provide higher degree of stiffness resilience improves the durability factor of the footwear which become core determinant for the driving the demand of such PU materials

According to the survey of **Junior ScientistHuntsman** on the sports shoes materials, manufacturuersprefered those materials which not only increase the productivity but also bring synergy in production & quality parameters. Modern PU and TPU based footwear manufacturing technologies provide better synergyamong both the aspects (high productivity & quality parameters) hence adoption of P.U and TPU materials is the best choice for existing & new players entering in this section.

Review of Government & Non- Govt. Reports:

UNIDO 1999: the core objective of this organization was to clarify the opinion among various techniques used by manufacturing which leads to riser in the final cost of finished of footwear. **ICC (Dwarka) Indian International convention and expo center** also emphasized on the same aspects that on what basis footwear manufacturing units can minimize the production cost & improve the quality of footwear . Accordance to **DPII** notification the product would meet all the specified standard and bear all the customer valuable information . In all the aspects including sole designing to complete design of customized footwear

As per **ICIS** :**CPI polyurethane technical conference 7-9, Oct 2019, Orlando , Florida Govt**.Polyurethane helps in making the movement of players more stable, comfortable, durable and more energy efficient, which also made domesxtic market of Indiaself efficient to attain the capacity of producing PU based materials nearly25% in various footwear production zones) basis in the an hour which estimated turnover of the Rs. 16000 Cr.

According to **Engineers India research institute** "PU footwear manufacturing 2014, EVA soles are better than PU soles is much more preferred in case of sports shoes because of extremely low density which makes it highly elastic and soft under the feet, which lacks in PU but still on the other side PU provides long lasting strength, hence combination of both much more preferred and acceptable in the manufacturing unit.

As per the various footwear manufacturing units PU as footwear material is gaining more popularity over other materials, specifically in sole construction PU is one of the competitive material some though has been shared **Md.**

Majbour (2015) , who has highlighted the beneficial properties of PU in his case study and sole manufacturing companies preferred PU because they also want such material which is not only long lasting but also comfortable and can be mix with any of the color and design that enhance the life style of the customer due to creating product that suits the expectation of the customers. Thirdly, PU materrial are more affordable than other options available.

Hence, the key factor that pushes PU based footwear material at the top of the preference list for shoe maker's is its long list of benefits and its adaptability to different footwear.Physical attributes gives a glimpse and accurate resemble with potency advantage of any material selected **(World Footwear 3013).**

Due to remarkable properties of polyurethane, as a material getting most preference among other available footwear materials, as PU can be easily "tailored made to meet specific demand"

PU Significant Functions Which Make It Most Preferred Materials:

Function Based on Anti- Fouling P.U: Fouling is the accumulation of unwanted material on solid surfaces. A anti fouling P.U has the properties which never let the accumulation of unwanted material on the surfaces.

Function Based on Self- Healing P.U: Become a new development trend due to the internal ability to restore physical failures and micro-cracks. Self-healable polyurethanes can be produced through dynamic covalent bonding.

Function Based on Anti- Bacterial PU: It generally focus on designing antibacterial surfaces to repel or resist bacterial attachment through incorporation or coating with antibiotic agents or surface modification in order to impart an anti-bio fouling effect or a bactericidal effect.

Function Based on Shape Memory PU: Shape memory polymer is a stimuli-responsive polymer, which has ability to fix a temporarily deformed shape. It returns from deformed shape to its original permanent shape while induced by an external stimulus such as thermal, humidity, pH, light, magnetic energy and external stimulus.

Table: 4: On Following basis PU is the Considered as one of the Finest Material in Footwear

1) Light Weight: PU is considered very valuablethan any other material, hence it is mot most suitable material for the construction of sole, due to its light weight property.
2) **Chemical & Water Resistance**: PU based designed footwear used in the most of the industry due to its property based on its resistance capacity from various chemicals, solvents, water and dust. Hence in the most of the mechanical industries PU materials based footwear are mostly preferred.
3) **Finest Grip:** PU having property of excellent grip, even the most slippery surfaces with make it alluring enough to be used in nearly all kinds of footwear.

4) **Comfort & Durability:**One of the best advantages of PU application based footwear is its comfort and durability, as it has long durability and easily mold as per the need & design required.
5) **Shock Absorption:** for the sports where players needs to stand or walk around for long, the footwear should have good shock absorption properly, the PU serves as the ballet fit to be used due this phenomenon.

Number of Cases Reviewed: The information has been collected from various sources which has been discussed in details, the major contribution of the research paper was based on the information collected from various government & no- government agencies that is (46%), these reports has played the significant role in enlisting why P.U is gaining importance in day to day footwear manufacturing concern. Secondly, the indebt informative source was cases, which not only helped the researcher to analyze on what parameters P.U has gained the demand in the material selection category (36%).

Table 5: Following secondary data has been analyzed to gain the insights in debt

Particulars	Count
No. of cases Reviewed	4
No. of Articles Reviewed	2
No. of Reports GOI/ Non- GOI Reviewed	5

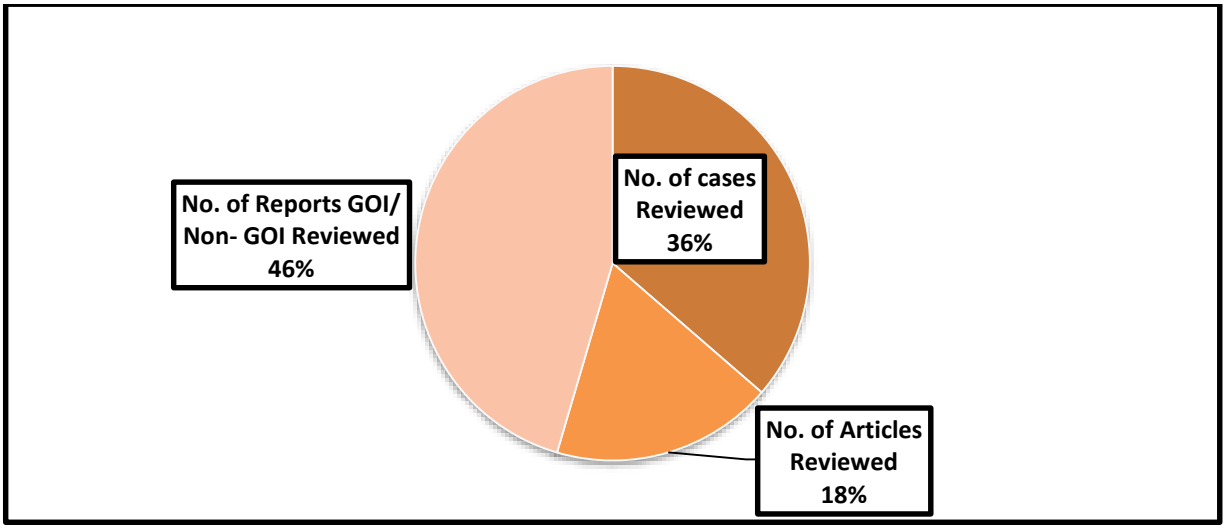

Figure: 1: Percentage of secondary data used for collecting information from different sources

Case study are the fact finding concept which practically proved the concept with the help of statistical tools, hence data obtained from cases undertaken in the research are much more reliable and authentic. Lastly, various articles and blogs were reviewed to understand the opinion of various practicing managers or industry concerns about their mindset towards the application as of PU footwear material, and it contribution in the research was

(18%). In nut shell as a researcher after conducted intensive study on various aspects of raising demand of PU as best preferred material for the construction of footwear based on following recommendations:

- Low cost & re-cycled material.
- Ease of manufacturing & durability.
- Water proof material with less fraction i.e. excellent ground grip.
- Can be transformed in any shape with color or texture.
- High shock absorption capacity.

Limitation of the study:

- According to one of the report of PBDES in 2005, PU in shoes inserts can accumulate high fire retardant materials which also emit toxic material in environment.
- IF PU based shoe not used for longer period of the its sole may worn out.

Summary :

In this paper completely based on the polymeric material - polyurethane P.U, which is now becoming the most prominent material for the sports shoe making in different parts.The paper has analisedthrough various research paper published and records which proves the P.U. is the most magical materials in the modern world of sports shoe making. In various aspectslike comfortabilty, durability, flexibility and with different colors and features P.U is the best and still most economical cost in comparison to all the others materials available. It is the futuristic materials but we have to control its overusage, in the environment for the benefit of society.

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