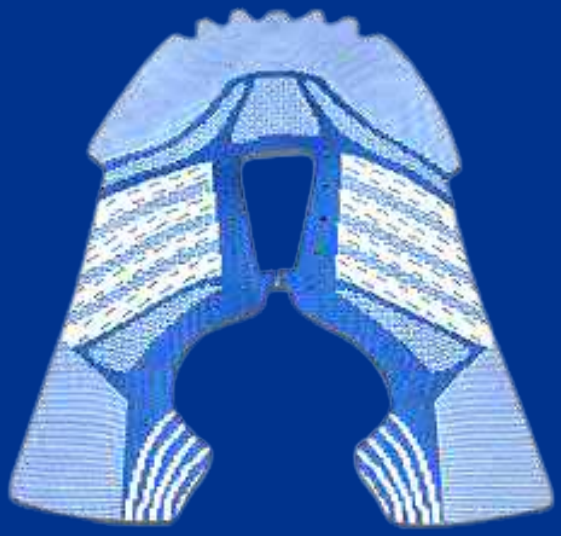
White Paper– Advance technologies in non-leather footwear

Technology Cluster Manager (TCM)

Technology Centre System Program (TCSP)

Office of DC MSME, Ministry of MSME

21st December 2020



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Abbreviations

AFMEC	Agra Footwear Manufacturers Exporters Chamber
BDS	Business Development Services
CAD/CAM	Computer Aided Design and Manufacturing
CAGR	Compounded Annual Growth Rate
CFTI	Central Footwear Training Institute
CLE	Council for Leather Exports
CLRI	Central Leather Research Institute
CPSC	Consumer Product Safety Commission
CTCP	Centro Tecnológico do Calçado de Portugal
DPIIT	Department for Promotion of Industry and Internal Trade
DIC	District Industries Centre
EVA	Ethyl Vinyl Acetate
FDI	Foreign Direct Investment
FOB	Free on Board
HR	Human Resource
HRM	Human Resource Management
HS	Harmonized Commodity Description and Coding System
INR	Indian Rupee
ISF	Indian Shoe Federation
ITPO	India Trade Promotion Organization
JV	Joint Venture
MSME-DI	Micro, Small and Medium Enterprises-Development Institute
MSME	Micro, Small and Medium Enterprises
PU	Polyurethane
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
TC	Technology Centre
TCM	Technology Cluster Manager
TCSP	Technology Centre Systems Programme
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar

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1. Objective of the White Paper

Technology Centre Systems Programme (TCSP) is a national programme undertaken by the Ministry of Micro, Small and Medium Enterprises with the assistance of the World Bank. The programme seeks to enhance the technological and skill base of MSMEs in certain manufacturing sectors to improve the competitiveness of MSMEs, via upgraded and new Technology Centers (TCs).

The objective of the programme is to enhance the productivity of selected MSME clusters by improving their access to manufacturing technology, establishing strong focus in providing business & technical advisory services and improving availability & employability of skilled workforce through TCs[1]. As part of the programme, KPMG has been appointed as the Technology Cluster Manager (TCM) to support TCs and undertake technology and cluster development activities.

The objective of TCM is to increase business opportunities for MSMEs through market linkages, enhance competitiveness of the cluster business environment, increase the number of MSMEs utilizing the services of TCs, develop a financially self-sustainable business model for cluster related services provided by TCs, identify technologies (Industry 4.0) of selected sector for TCs, evaluate existing training programs & develop new training programs for roll out at TCs, conduct gap analysis of TCs, strengthen the capabilities of TCs to provide technical advises to their clients, increase awareness amongst stakeholders on Environmental, Health, and Safety (EHS) requirements[2].

Central Footwear Training Institute (CFTI), Agra is one of the TCs selected under the TCM project. CFTI, Agra was established to support the leather footwear and allied industries. CFTI aims at developing human resources for the leather footwear industry through various tailor-made training programs, introduction of modern technology in footwear designing & manufacturing and provide consultancy & job work services to the enterprises in the sector.

This White Paper focuses on the non-leather footwear sector. With the advent of globalization and deep internet penetration, even in far flung rural areas of India consumers are exposed to various types of footwear products. This has led to major section of consumers especially the millennial youth to explore cheap and trendy footwear products which in turn is shifting the overall consumer preference from leather to non-leather footwear. This paper aims to showcase the advanced technologies in non-leather footwear manufacturing, highlighting the degree of alignment of the current services of the TC with the market needs, and recommend a future course of action for the TC to support MSMEs thereby serving the footwear industry not only in leather footwear but also in non-leather footwear.

2. Footwear industry

2.1. Footwear industry – Global

Based on materials, Footwear products can be classified into two categories i.e. leather and non-leather footwear. The footwear industry is expected to grow at 5.5 percent between 2020 to 2027 and increase from USD 365 billion to USD 530.3 billion[3] during the period, with non-leather footwear segment dominating the global footwear market. The global footwear market is segmented into material, end users, type, region, and distribution channel. The distribution channel is classified into brand outlets, hypermarkets, specialty stores, online e-commerce portals, and others. Though historically, the footwear market used to be driven by developed countries but with increasing penetration of global footwear designers and producers in new upcoming markets developing countries has taken the lead. Moreover, stringent environmental laws are also playing a prominent role in shifting of footwear manufacturing

[1] http://www.dcmsme.gov.in/tcsp/TCSP%20-%20Concept%20Note.pdf
[2] http://www.dcmsme.gov.in/tcsp/Program%20Overview/Technology_cluster_man.html
[3] Allied market research 2020

industry towards developing economies. The phenomena can be witnessed in the Asia-Pacific region where the footwear market dominated in both consumption and production in 2018. It is to be noted that not only leather footwear, but non-leather footwear segment has received renewed focus all over the world over the years. In terms of worldwide footwear consumption, 86 percent in terms of volume is non-leather footwear[4] whereas leather footwear enjoys a higher share in terms of the total value.

Global footwear production reached 24.2 billion pairs in the year 2018 with a growth of 2.7 percent over that of the year 2017[4]. It is to be noted that 07 out of the top 10 countries producing footwear in the year 2018 were Asian countries. China is the leading producer of footwear in the world. Though in the year 2018 its production fell by 2 percent and that of India, Indonesia and Vietnam rose.

Rank	Country	Pairs (Millions)	World Share
1	China	13478	55.8 percent
2	India	2579	10.7 percent
3	Vietnam	1300	5.4 percent
4	Indonesia	1271	5.3 percent

Table 1:Top footwear producers countries (quantity) 2018[4]

Footwear consumption is highest in Asia as compared to that of the rest of the world. Asia's share of total world footwear consumption has increased by 5 percent since 2010 and that of Africa's by 4 percent. The top four footwear consumer countries are Asian countries jointly representing almost 60 percent of the world's consumption.

Rank	Country	Pairs (Millions)	World Share
1	China	4110	18.4 percent
2	India	2608	11.7 percent
3	Vietnam	2391	10.7 percent
4	Indonesia	997	4.5 percent

Table 2: Top footwear consumers countries (quantity) 2018[4]

Again, Asian countries dominate the **world's footwear exports**. 4 out of every 5 pairs of footwear exported worldwide have Asian origin. As per the world footwear yearbook 2019, the remaining of the continents only account for 3 percent of the world's footwear exports. China has emerged as the hub of footwear exports with a world share of 64.7 percent[4].

Rank	Country	Pairs (Millions)	World Share
1	China	9543	64.7 percent
2	Vietnam	1272	8.6 percent
3	Indonesia	406	2.8 percent
4	Germany	314	2.1 percent
5	Belgium	284	1.9 percent
6	India	262	1.8 percent

Table 3: Top exporter countries (quantity) 2018[4]

The value of global footwear export of footwear for the year 2018 is valued at USD 142 billion. It is to be noted that there has been an increasing trend towards textile footwear. The percentage of textile footwear exported globally is 32 percent for the year 2018[5].

[4] World Footwear Yearbook 2019
[5] World Footwear Yearbook 2019

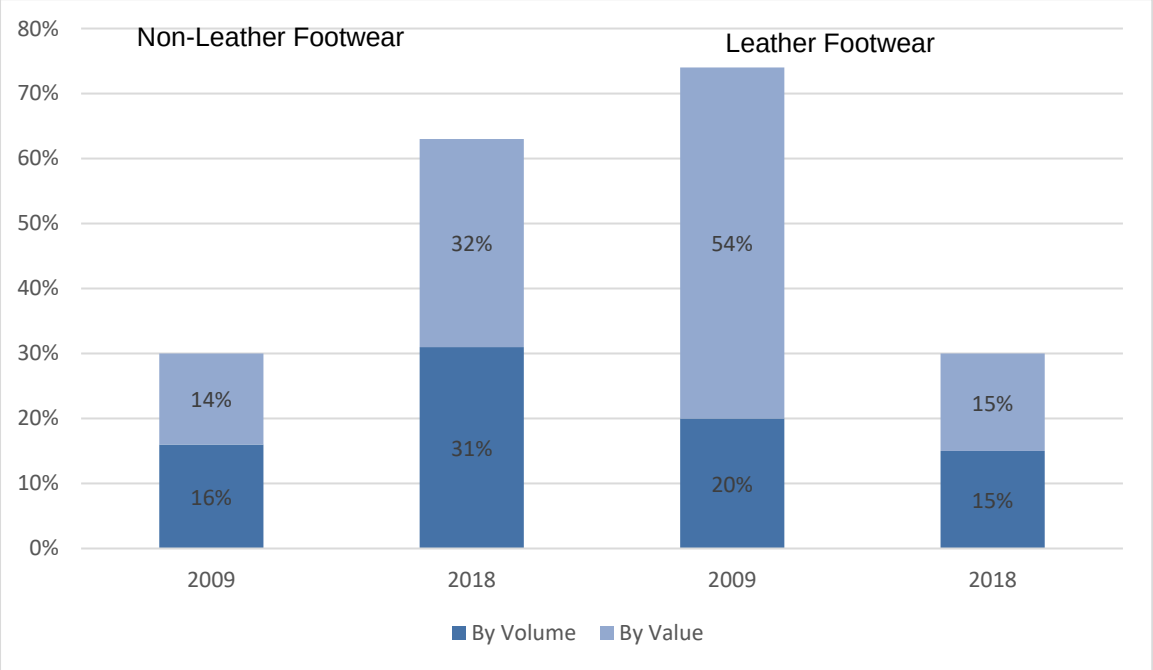

Figure 1: World global footwear export-Leather vs Non-leather footwear

In terms of **world footwear imports**, Europe is the leading continent for footwear imports accounting for more than one-third of the world share. The United States of America is the largest importer of footwear with a world share of 18.9 percent followed by Germany with 5.6 percent and Japan with 5.2 percent. India stands at the 10th rank with a world share of 2.2 percent of the import of footwear[4].

Rank	Country	Pairs (Millions)	World Share
1	USA	2450	18.9 percent
2	Germany	721	5.6 percent
3	Japan	670	5.2 percent
4	France	513	4.0 percent
5	UK	511	3.9 percent

Table 4: Top 5 countries with footwear import (quantity) 2018 [4]

2.1.1. Key Trends- Global non-leather footwear market

- Textile footwear represents **one-third of all the global footwear trade** in the year 2020, up from 14.6 percent in 2010 (value). Since 2010, the number of pairs exported fell slightly for rubber and leather footwear but increased by 80 percent for textile footwear

- Leather footwear is increasingly being replaced by synthetic footwear especially in women's and sports footwear due to the flexibility offered by synthetic products

- Major leading companies such as Puma, Adidas, Bata, Nike etc. are using knitted uppers for their latest collections. Footwear with knitted uppers are easy to be manufactured are comfortable and lightweight

- Worldwide 86 percent of the footwear in terms of volume consumed are non-leather footwear[6]

[6] N. Mohan, CEO Clarks India

2.2. Footwear industry – India

India is the 2nd largest producer as well as consumer of footwear in the world.[7] The footwear industry in India provides livelihoods to approximately 2 million people. For the year 2019, the market size of Indian footwear industry is estimated to be USD 10.6 billion and is expected to grow to USD 15.5 billion by 2024. The total number of shoes produced in India for the year 2018 was 2579 million pairs which was 10.7 percent of the global footwear production. As already stated, India is the 2nd largest consumer of footwear with a share of 11.7 percent[8]. The percentage share of the global footwear export for India in the year 2018 was 1.8 percent[8] . It is to be noted that footwear holds the major share of 47.59 percent in the total exports of leather and non-leather products for the year 2018. India is the 10th largest importer of footwear with world share of 2.2 percent[9]. For the financial year 2018-19 the largest growth percentage was registered by non-leather footwear with an increase in export of 13.7 percent[10]. As per the KSA Technopak analysis, the overall footwear market in India is estimated to grow at 11 percent over the next five years boosted by growth in the non-leather footwear segment. Globally non-leather footwear industry is growing rapidly and India is also following the same trend. Also, the growth in demand and consumption for non-leather footwear has propelled the employment generation scenario in India.

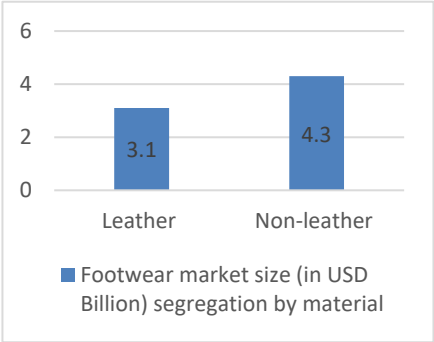

Figure 2: Footwear market size segregated by material

As per industry estimates the non-leather footwear market is around 59 percent of the total footwear market in India[11]. This 59 percent share is subdivided into textile and other footwear with 46 percent and athletic footwear with 13 percent. The athletic footwear in India is expected to grow annually by 5.3 percent (CAGR 2020-2025)[12] where as textile and other footwear in India is projected to reach USD 632 million in 2020 grow and expected to grow annually by 12.8 percent (CAGR 2020-2025)[13].

As per TSA Technopak analysis 2018, the consumer preference is shifting towards casual footwear. The footwear market in India is dominated by men's footwear with a percentage share of 58 percent but women footwear market is also catching up and has shown a much faster growth CAGR of 20 percent.

2.2.1. Non-Leather Footwear Clusters in India

Nowadays consumers are increasingly becoming aware of the subjects such as climate change, global warming, and sustainable materials which have led to a rise in demand for non-leather footwear which is strongly emerging as an alternative to leather footwear. Though the non-leather footwear industry in India is fragmented and close to 75 percent of non-leather footwear production comes from the unorganized sector. Kanpur and Agra in Uttar Pradesh; Chennai, Ranipet, and Ambur in Tamil Nadu; Pune, Mumbai in Maharashtra; Jalandhar and Ludhiana in Punjab; Karnal, Sonepat and Faridabad in Haryana; Delhi; Kolkata; Ernakulam and Calicut in Kerala are some of the major non-leather footwear production centres in India.

Figure 3: Sample non-leather footwear manufactured by a household unit in Agra

Agra leather footwear cluster in Uttar Pradesh is largely known for leather footwear manufacturing with semi-mechanized and export-oriented units in Agra major stakeholders in the manufacturing of leather footwear. Workshop and household units are unorganized and basically involved in non-leather

[7] Council for Leather Exports 2019
[8] World Footwear Yearbook 2019
[9] World Footwear Yearbook 2019
[10] World Footwear article, India's leather footwear exports up by 1%, 2019
[11] Council for Leather Export 2019
[12] Statistica India Athletic Footwear Report 2020
[13] Statistica India Textile & Other Footwear Report 2020

footwear manufacturing. Chennai leather footwear cluster in Karnataka is also predominantly involved in leather footwear manufacturing for the international market but the cluster also comprises household and workshop units that are involved in non-leather footwear manufacturing.

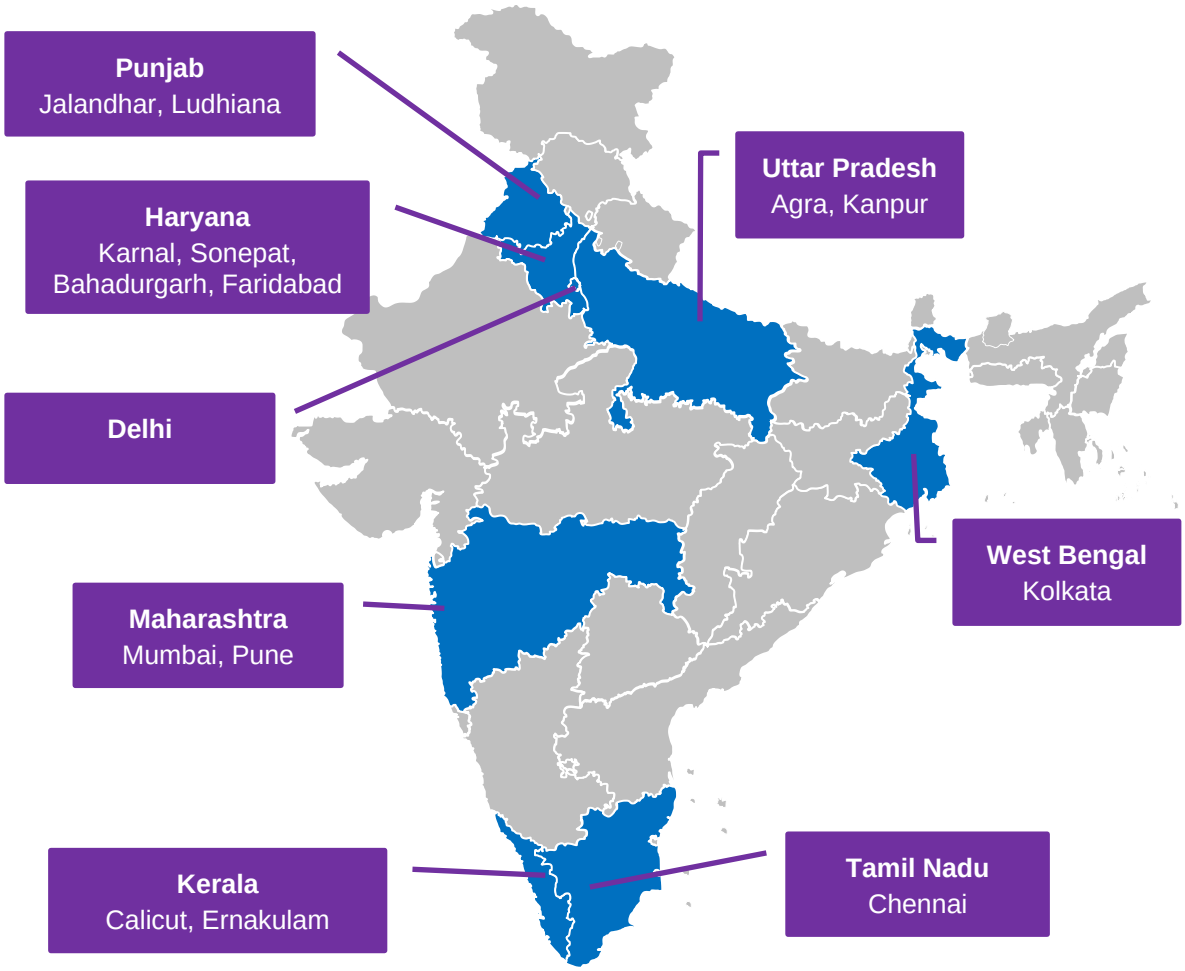

Figure 4: Major non-leather footwear production centres in India

The footwear industry in Haryana is poised for exponential growth with the majority of the footwear units involved in non-leather footwear manufacturing. Bahadurgarh footwear cluster is one of the major footwear cluster along with Karnal, Gurgaon and Faridabad. The major product from the clusters is open and closed non-leather footwear.

Figure 5: A non-leather household footwear unit in Jalandhar

Kolkata footwear cluster is the main hub of footwear manufacturing in West Bengal. The cluster manufactures a diverse range of products ranging from finished leather, leather and non-leather footwear, leather goods and industrial gloves.

Jalandhar & Ludhiana are the major hub for footwear production in the state of Punjab. Jalandhar is a major production centre for leather goods, finished leather, leather & non-leather footwear and leather garments, contributing a share of more than 80% of the exports from Punjab. Jalandhar is also the main cluster for sports goods industry in Punjab which contributes to 55-60% of the total sports goods exports from India[14]. Ludhiana is mainly into production of textiles footwear.

[14] Diagnostic Study Report on Jalandhar Footwear Industry 2019

Calicut and Ernakulam are the main hub of footwear manufacturing in Kerala. The cluster is involved in manufacturing of leather and non-leather footwear. Mumbai and Pune in Maharashtra are the major production centre in west India. Some of the key player in the state involved in footwear manufacturing are METRO Brands, PUMA, Paragon, KIWI International, Reliance Footprint, Bata India Ltd., Relaxo Footwear, ASICS India Pvt. Ltd.

2.2.2. Key trends – Indian non-leather footwear market

- Revenue in the Textile and other footwear segment is projected to reach USD 632 million in the year 2020 with the market is expected to grow annually by 12.8 percent (CAGR 2020-2025)[15]
- Revenue in the Athletic footwear segment is projected to reach USD 1530 million in the year 2020 with the market is expected to grow annually by 5.3 percent (CAGR 2020-2025)[16]
- Revenue in the sneaker segment is projected to reach USD 2353 million in 2020 with the market is expected to grow annually by 7.1 percent (CAGR 2020-2025)[16]
- Indian consumer preference is shifting towards lifestyle and casual footwear with 67 percent of the retail market is captured by casual footwear in the year 2020[17]
- Due to an increase in awareness about sustainability and leather being an expensive material leather is consistently being replaced by non-leather materials
- Drastic change in the import of non-leather footwear is observed, from just 2.5 percent in the year 2010 to over 62 percent in the year 2018[18]

2.3. Technology Center – CFTI overview

Central Footwear Training Institute, Agra (CFTI) is a pioneer institute in footwear technology under Ministry of MSME and was established in the year 1963 to support and enhance the competitiveness of footwear industry in India. Under the modernization programme of UNDP's National Leather Development Programme (NLDP), the institute was equipped with state-of-the-art infrastructure in early 1990s. In the year 1996, CFTI Agra was converted into a Government of India Society for smooth functioning of the institute and greater autonomy. CFTI Agra provides services in three verticals i.e. i) job work ii) short term and long terms trainings, outreach programs; and iii) consultancy services. Each vertical is aligned with a department having a set of machines that are used for training as well as job work related services.

CFTI Agra undertakes various long- and short-term training programs ranging from 1 month (out-reach training programs) to 2 years training programs. The minimum qualification for these training programs ranges from 8th class pass to graduate degree, which depends upon the eligibility criteria of the respective courses.

CFTI Agra also offers job work services to support the footwear industry of Agra. Footwear industry in Agra comprises of household units that use hand tools and minimal machines for footwear manufacturing, semi-mechanized units that use some basic machines required for day to day operations of footwear manufacturing, and export-oriented units which use advanced machinery and conveyor system for footwear manufacturing. Sustainable source of revenue is a major challenge for the tool room facility with a high dependency on running the training programs. Design and Consultancy division contribution to the revenue of CFTI Agra is very low. With the footwear industry inclining from leather to non-leather footwear, it opens doors for Design and Consulting opportunities for CFTI Agra. The institute is also having physical

[15] Statistica India Textile & Other Footwear Report 2020
[16] Statistica India Athletic Footwear Report 2020
[17] TSA Technopak Analysis 2018
[18] Comtrade, KPMG analysis

testing facility which is currently being used to provide hands-on training on testing equipment. The testing lab is not NABL certified hence, MSMEs are unable to utilize the testing services.

3. Alternative materials in non-leather footwear manufacturing

The market demand for alternative materials, technology, and manufacturing processes is increasing gradually. Technology in machinery to attach soles for the recommended HS code 6404 is at an advance stage and continuous research is also going on how to make comfortable shoes within a minimum timeline and using optimal resources. Various technologies like direct sole attaching thru stitching, injection molding of soles etc are available and all are well proven, reliable construction for factories and customers alike. Most recent technical developments in materials for Uppers and Solings in the last decade is the development of materials for uppers and soling which are the main components for footwear manufacturing.

3.1. Upper materials

This product requires the use of a range of non-leather upper materials across basic woven canvas textiles provided by different manufacturers. The range of upper materials in non-leather is quite vast varying from eco-friendly natural origin materials from cotton plants to non-eco-friendly materials manufactured from petrochemicals like PVC or PU coatings on different base materials like cotton, polyester etc. Their physical properties are good with high abrasion performance and high tensile strength and are cost-effective also to keep the product competitive.

New generation non-leather types are emerging every year based on recycled materials like plastics to the use of nature's gifts like amoebas, kelp in the sea, various plant derivatives, etc.

Material	Description
Microfibers	**Microfibers** can vary greatly in appearance, strength, feel and composition. The defining feature of microfiber is that it is a material or fabric manufactured from either synthetic or natural fibers. Commonly used fibers in the production of microfiber are polyamide, polyurethane (PU) or cotton. By varying its composition, a wide range of characteristics can be achieved. For example, it can be very soft, like soft Nubuck leather or suede. The fine pores also make this material especially breathable and lightweight
Polyurethanes	PU (also known as bi-cast leather, PU leather or split leather) is a thick foam-like material that can be shaped into many forms. PU fibers (a microfiber) are especially popular, as opposed to the solid foam, as these fibers can be used to create a durable material that is both flexible and breathable, and perfect for shoe uppers. PU foam in its natural, solid-state, tends to be used more often for the soles of shoes.
Hemp	Hemp is a plant fiber that was used to make fabric for various applications for over 10,000 years. Due to the development of a natural enzymatic process in the 1980s, it is now possible to produce soft-yet-strong hemp for clothing and footwear purposes. Environmentally, hemp offers a few major advantages over other materials. It is a fast-growing, renewable resource and incredibly easy to care for, not necessitating any herbicides or pesticides. Hemp as a material is very durable, light, and breathable, with an appealing, slightly raw natural feel and it takes up the colors in natural dyes very easily due to its high porosity.
Cotton	It is a renewable resource that is easy to manage and can be grown under organic conditions. The major disadvantage is that its production requires a lot of water, although this water consumption is many times smaller than

Material	Description
	the water consumed in the production of leather through the production of animal feed, water provision to animals, and tanning. As a material, cotton is soft, comfortable and breathable.
Goretex	It is not a fabric, but a lightweight, windproof, waterproof, and yet breathable membrane that allows water vapor to pass through. This makes Gore-Tex especially well-suited to outdoor and hiking shoes. Commonly listed as a high-performance material in wet conditions for footwear and body protection. This synthetic and (therefore vegan material) was originally patented by Robert W. Gore, although the patent has since expired, and similar products have come to market such as Sympatex/Aquatex. The original Gore-Tex is only supplied to manufacturers who are certified to make products according to Gore's standards.
Mesh fabrics	Mesh fabrics are made using variety of techniques depending on the types of fiber from which it is manufactured. Mesh material is recommended for sneakers or running shoes because of its breathable properties. Spandex yarn is also used in mesh fabrics for elasticity. The different types of mesh fabrics and their uses are i) Polyester Mesh- used in sports footwear and athletic apparel, ii) Nylon Mesh-used as beekeeping veils and in sports footwear, iii) Tulle-used in brightly colored dance garments, iv) Power Mesh- used in sportswear and shapewear garments, v) Powernet- fabric with relatively dense weave used in shaping apparels
Knitted uppers	Synthetic yarns are used in the manufacturing of knitted uppers and this upper material is emerging as a popular new technology article due to its durability, lightweight and easy to manufacture shoes.

Figure 6: Upper materials

3.2. Soling

Soling material is one of the most important components for footwear manufacturing.

Materials	Description
Rubber	Rubber continues as one of the most popular sole options due to its high performance in wear and ease of manufacture. Rubber soles were first developed by the Goodyear company in 1800 at USA. Rubber can be categorized into Natural Rubber and Synthetic rubber. Generally, the 2 ingredients can be mixed to make a durable soling material that can be molded to shape. A rubber sheet is a molded item. The only natural rubber soling is Crepe rubber which is produced from the latex "milk" taken from the rubber tree sap and treated with ammonia to help its stability. It is poured into trays and placed in the sun to produce a sheet of crepe which can be used in footwear sole manufacturing. All other rubbers are made from a mix of natural rubber with some Synthetic rubber (SBR) and other chemicals to give it high durability and life. Sulphur is added to the mix to produce a chemical reaction called slow curing. The semi-cured rubber is cut to shape and placed in a hot mould under high pressure for up to 10 minutes at 180 c. This process is known as Vulcanizing and changes the physical properties of the rubber to a shoe sole. The vulcanizing

Materials	Description
	of the rubber mix can be performed directly to the shoe bottom OR it can be molded as a sole and then stuck to the shoe bottom.
Thermo Plastic Rubber (TPR) & PVC	TPR and PVC materials are derived from petrochemical polymers. PVC was the first injectable thermo material to be developed for shoes. As the name implies it is melted under high temperature 140 – 160c and injected into a mould under high hydraulic pressure. It sets up (or cures) fast (within 2 minutes) inside the mould which is then opened to remove the moulded article. TPR was then developed as an alternative to PVC again being an injectable thermo material with more rubbery properties. TPR is slightly expensive than PVC and can be injected in the same machinery as PVC for sole making.
PU (Polyurethane)	Polyurethane is a light weight and good abrasion resistance; it is a form of direct on pouring machine which allows to attach soles to lasted uppers. PU should be a continual process and polyurethane is used. The machine to deliver the PU is a very basic" banana" shaped type machine.
EVA (Ethylene Vinyl Acetate)	EVA stands for Ethylene-Vinyl Acetate is an elastomeric polymer that produces materials which are "rubber-like" in softness and flexibility EVA is a non-injectable casting system that relies on the material being poured into a mould cavity and the shoe is placed over the molten material to allow it time to expand or "blow". It is a plastic material being very lightweight made by combining ethylene and vinyl acetate to create rubber-like properties which can be used for shoe soles.

Figure 7: Soling material

3.3. Other shoe components

The range of other components needed to make non-leather shoes is compatible with most shoe constructions whether the uppers are leather or non-leather. Customized colorful midsoles are created using microwave technology in less than a minute. Colored pallets are used to fuse midsole in a microwave to get midsoles of various colors and designs. There will be a few limitations for heat sensitivity, for example in linings, but alternatives are available**.**

Figure 8: Illustrative figure of ASICS microwave sole

4. Advanced technologies in non-leather footwear manufacturing

India's footwear consumption is growing at a CAGR of 7.6 percent[19] with per capita consumption improving to 2 pairs per person per annum leading to increase in demand in the domestic market. Again, consumer preference is shifting from leather to non-leather footwear. The non-leather footwear industry has huge potential in both domestic as well as international market, but it has to move along with customer needs. The government needs to focus on non-leather footwear sector where technology is changing very fast, for example if new technology such as knitting upper is not adopted then the MSMEs will lag behind in catering to the customer requirements. Non-leather footwear industry is very dynamic, and the type of raw material often changes hence there is a need to innovate faster and at lower cost. Currently, the Indian footwear manufacturing industry is largely dominated by micro, small and medium enterprises that are vastly relying on traditional methods of production using outdated equipments and machines.

[19] Statistica India Footwear Report 2020

Footwear MSMEs in India should grab the opportunity in non-leather footwear sector by adopting and upgrading to non-leather footwear technology to ensure that they are not ceding the space to foreign players.

4.1. Knitted Upper Technology

Footwear manufacturers are exploring technologies having the potential to automate production, reduce labor and inventory costs, and localize production. Knitted uppers have brought a revolution in footwear manufacturing, the rise of the Sneaker type shoes has created a surge in the numbers being sold globally. The changes in the numbers can be driven by changes in fashion demands from the market.

The most common data which can provide a clear guide to movements in the market are identified by the HS code for all products traded around the world. This system was introduced to provide a Harmonized System in trading commodities around the world. It was introduced in 1974 and is accepted by all exporting/importing nations as a single method to identify their goods.

4.1.1. 2D Flat (Wrap) knitted upper machine

2D flat (wrap) knitted uppers machines were originally developed by Japanese engineers and German for Europe. These are still widely used machines that have been upgraded over the past 20 years or more and still dominate the knitted upper market in India. The machine is new for the footwear industry of Agra.

Currently, flat knitted uppers are sourced from other states (Kolkata, Delhi, Noida etc.) of India. These manufacturers use a variety of more expensive Japanese and European machines and cheaper Chinese versions. Knitting technology has been used in the garment field for many years so it is well developed in India. The shoe upper knitted by the CNC upper knitting machine has the unique features of lightness, comfort, and air permeability. They are in high demand because they are cheap and fashionable.

Figure 9: Illustrative figure on 2D flat (wrap) knitted uppers

The SME's making traditional leather shoes can attach overlays and other decorations to the flat knit upper and continue using the lasting and sole attaching to complete the shoemaking process. This is also economical for SMEs as they are required only to change the upper material and rest of the production operation remains same.

4.1.2. 3D Circular Knitted upper machine

3D circular knitted upper machine is used for the tubular socks making. The machinery developed for footwear are shoe specific. Leading machine players are mainly in Italy which has adopted this technology for their shoe sector. Spain is also graduating into it. There are two versions on offer:

The **single-cylinder** can knit countless combinations of colour and design – with six colours integrated into the design, plus background colour, mesh, tuck and float stitch, plain knit or plating terry, also in areas

with laid-in elastic, selected heel with the possibility of jacquard design-, plus it has reciprocated heel and toe in adjustable dimensions and 3D effects; all features that make it ideal for the non-branded fashion industry. This would be suitable for the Indian domestic market.

The double cylinder is an extremely technical machine, which allows for the different rib, links patterns and links jacquard, shadow stripe and open-work knitting, with a brushless motor incorporated in the column with variable heel and toe reciprocating motion, selection points instead of pickers and needle droppers, and it is especially suited to the technical-sports industry.

Figure 10: Illustrative figure of 3D upper knitting machine

Seamless circular knit uppers can be produced at a rate of 5 – 7 minutes per pair. The users claim to create shoe upper material that offers better breathability, more design possibilities and less waste compared to flat (or warp) knit. The seamless knitting technology has been adopted by major sportswear brands and this technology has put an end to the cutting process and has reduced labor to a great extent. Threads used can vary from standard polyester to ECO based threads. Foot comfort is enhanced by the use of a spacer fabric to combine both layers. This fabric is highly breathable as well as being functional in providing excellent last shape. A benefit for sports shoes. Flat knit tends to use more toxic density foams as an interlayer spacer.

A circular knitting machine knits multi-colored spacer fabrics and structures using design software. Fast changes in design features are made quickly meaning smaller batches in the desired colour combination can be produced profitably on a circular knitting machine. China is making a lot of cheaper options. Design changes in the upper require extensive downtime on the machine to change the thread cones setting.

It is more productive for long runs of a single design. Higher productivity and lower energy consumption per piece produced on a circular knitting machine (about five times lower than on a flat knitting machine is advantageous to manufacturers. Standard polyester threads can be recycled.

Process after knitted upper production to a complete shoe:

Flat knit uppers:

Flat (Warp) knitting machines produce large stretches of flat fabric at a time, which means the fabric still needs to be cut and sewn after production. This process is time-consuming, and also generates a significant amount of waste – as much as 25%, according to some estimates. Flat knit must be processed through lasting on conventional shoemaking equipment. Metal lasts are used if it goes through DIP for sole attachment.

Figure 11: Illustrative figure of 2D knitted upper

Circular knit uppers (3D- Seamless Knitting)

These uppers do not need to travel through the cutting or stitching room after the knitted tube upper is completed. They are transferred directly for lasting.

Figure 12: Illustrative figure of circular knitted upper

The uppers need to move through 3 – 5 operations to be transformed into a complete shoe. Knitted Upper needs no further operations to be performed on it. It is transferred to a lasting line. The lasted upper is placed in a preheating oven for 1 minute at 200c then transferred to a vacuum pressure bladder to set the upper shape. Hot lasted uppers are placed in a chiller to set the shape. The lasted shoe can be removed from the last and ready for sole attachment as per the unit sole method. Metal or aluminum lasts are generally used if going for the DIP soling process.

4.2. Lasting and sole attaching technology

In Knitted upper technology the soles are attached with glue in a normal stuck sole process on existing machinery. The TC should invest in an alternative injection process. DIP is a Direct Injection Process to attach PVC or TPR sole to shoe. It links to an alternative lasting system called String lasting.

4.2.1. String lasting

This system is not a new technology, but it has been used extensively in non-leather manufacturing globally. It involves the addition of a pull string overlocked into the edge of upper. The upper will be heated to soften the material making it easy to pull into position on the last. This string system can be used with Flat knitted uppers if required. This might appeal to SME's who adopt to buy flat knitted uppers from TC. The upper is drafted on to its last and the pull is drawn tight to secure the upper to the underside of last. The string is secured in a tight position with upper drawn tight to the top of last.

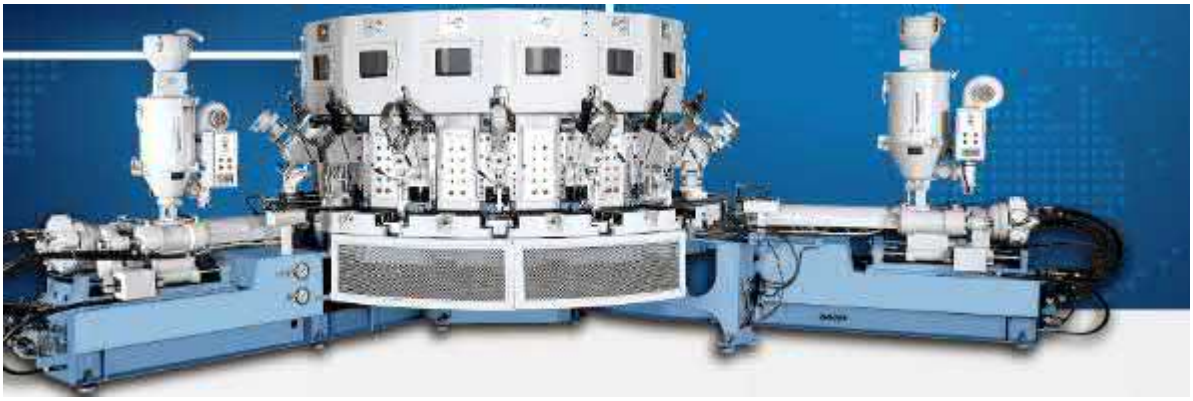

Figure 13: Illustrative figure of DIP Technology

The lasting of the shoes can be done in two processes: -

Direct Injection Process (DIP): DIP is the process where the upper is lasted on a metal moulding last and is inverted into a mould cavity which closes on to bottom of last. The sole material is then injected automatically into the cavity in liquid form to fill the cavity, form the sole shape, and start the curing process

which will take 2 – 3 minutes. The mould will open automatically and shoe is removed from last. Each

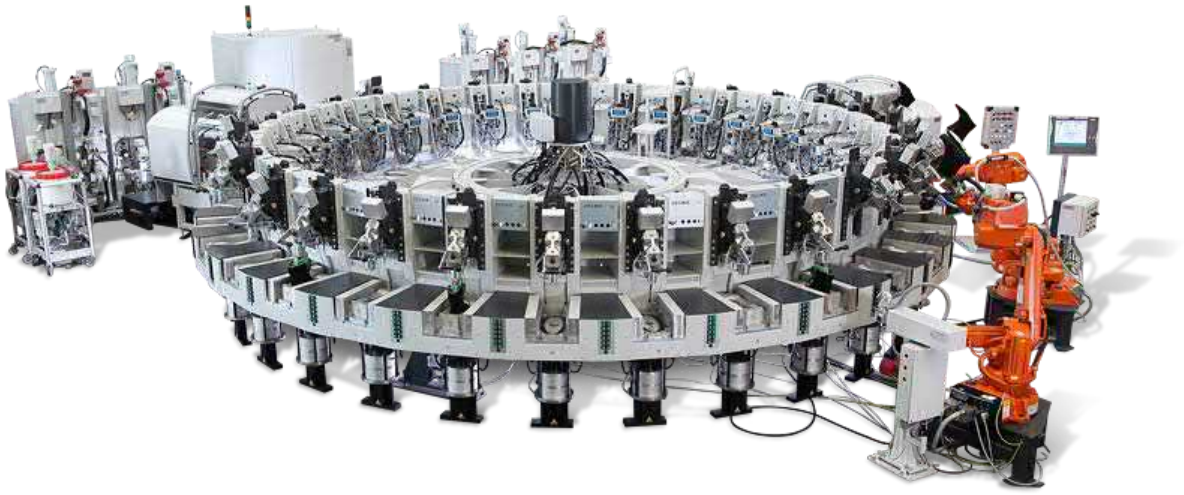

Figure 14: Illustrative figure of Direct Injection Process (DIP)

mould station on 12 station machines will carry a single size and foot mould cavity. The shoes are then transported to the finishing section to be cleaned and footbed type sock inserted in the shoes to cover the string assembly underneath. The sole materials which are capable of direct injection moulding are PVC and TPR.

Summary of DIP operation:
Attaching last string to edge of the upper –

- Place upper in pre heated cabinet for 5 mins to soften upper. (NOT knitted uppers)
- Remove upper and place over metal last drawing string tight and secure
- Place metal last over mould cavity and close mould on to last
- Injection process on rotary moulding machine
- Remove lasted/moulded shoe from last and transfer to Finishing
- Complete finishing 3 step process – clean upper/ Insert footbed sock/ Apply finishing treatment cream or spray.

Traditional process of shoe lasting: Alternatively, the lasted upper on the selected plastic last can be processed through the traditional 10 operation process to attach a pre-bought in sole unit.

Summary of the lasting operation:
Attaching last string to edge of the upper –

- Place upper in pre-heated cabinet for 5 mins to soften upper (Not knitted upper)
- Remove upper and place over plastic last drawing string tight and secure
- Glue shoe bottom
- Glue sole
- Dry glue and activate to 60 – 70 c
- Spot sole to shoe bottom by hand
- Place in suitable sole press to attach for 10 seconds
- Place shoe in chiller

5. TC and non-leather footwear

The volatile market situation posts the COVID-19 pandemic presents not only challenges but also opens doors for new opportunities for the footwear industry of India. There is a great chance to conquer new markets, improve the market share, and project 'Brand India' in the global stage. The non-leather footwear industry requires a big thrust to create a strong roadmap for the future. The key areas that must be reinforced by the institutional bodies and industry giants at a priority level can be demonstration of the new age technologies in non-leather footwear, product and process engineering, research and development, and hands-on training on non-leather footwear.

Design development initiatives: Though there are many institutions to enable support to the footwear MSME in the areas of technological development, design and product development and human resource development but TC should play a proactive role and function to upgrade the knowledge of footwear MSMEs on the newest trend and technology, innovative material in the non-leather footwear sector to support the industry.

Continuous modernization and technology up-gradation: When sustainability is questioned against the vision to excel globally, it gives the way to grow. Whether upgrading process or technology the end result must be satisfying the future need of the global market and as the recent trends in the domestic and international markets suggest, is shifting towards non-leather footwear technology. Hence, TC should conduct exposure visits to leading non-leather footwear units in India for MSMEs willing to explore non-leather footwear market. TC should also take a lead in implementing the technologies at their institute as pilot demonstrations to guide the footwear MSMEs towards modernization and technology up-gradation not only in leather but also in non-leather footwear technology.

Constant human resource development programme to enhance productivity: To enable the non-leather footwear industry and serve to the domestic and global need, TC can explore collaboration with national/international institutes having vast amount of experience serving the footwear industry in developing training courses in non-leather footwear. Details of leading research/ training institutes involved in leather/non-leather and orthopedic footwear have been highlighted in Annexure I with possible areas of collaboration with TC. It will result in providing highly talented, skilled and trained professionals to the Indian non-leather footwear industry. TC should also promote multi-skilling of shop floor workers among MSMEs both in leather and non-leather technologies.

Shorter prototype development time: Today fashion is changing more frequently than ever, to win this competition and align with the trend within the value chain, TC along with footwear MSMEs should attempt to minimize the process of new product development, prototyping to launch the product in the market earlier than anyone else and enjoy the wider life cycle of the product.

Delivery compliance: The continued footwear (leather & non-leather) product safety is a top issue for the entire footwear industry. There are many different global chemical and physical testing standards depending on the country and footwear product (age, use, etc.). TC should ensure that companies must be aware of these laws and ensure their compliance standards meet or exceed standards from CPSC to REACH requirements and many other U.S. state and global laws. It is essential to understand and become accustomed to the changing landscape of product safety standards and regulations that impact the footwear industry.

Promote the development of the domestic market for non-leather footwear: Indian footwear industry have distinctive strength and enough potential to produce high-quality footwear. According to the TSA Technopak analysis 2018, roughly 59 percent of the footwear market in India is non-leather footwear and 76 percent of the non-leather footwear is produced by the unorganized sector in India. There is a need to create an eco-system for the promotion of non-leather footwear. A consortium

exclusively of non-leather footwear industry should be created to promote the interest of non-leather footwear manufacturers.

6. Conclusion and Way Forward

India has established its identity as one of the leading force in leather footwear sector but the same cannot be said about the non-leather footwear sector With the customer requirements moving towards non-leather footwear, the TC is lagging as compared to large non-leather footwear players operating in India to support the eco-system of non-leather footwear sector. The existing infrastructure at the TC only caters to the leather footwear segment, which has resulted in the creation of a huge gap in the adoption of non-leather footwear technologies by MSMEs willing to explore the growing non-leather footwear market. To address the issue, TC should collaborate with national/ international footwear institutes and develop training courses on non-leather footwear. TC should also promote multiskilling of shop floor workers in both leather and non-leather footwear technology. On developing the ecosystem for the non-leather footwear sector, TC should explore the promotion of a separate association/consortium of non-leather footwear manufacturers. On the technology front, knitted upper technology and lasting & sole attaching technology should be adopted by the TC in order to support the footwear MSMEs.

Most of the leading footwear manufacturers of Agra are into leather footwear and it will require a lot of effort to convince them to invest in non-leather footwear technologies. As a starting point, TC should conduct exposure visits of MSMEs willing to explore the non-leather footwear market to leading non-leather domestic footwear players. TC should also install the non-leather footwear technologies as a demonstration unit for the MSMEs. The demonstration system will work as a revenue model in the form of job work for the TC to support the footwear MSMEs. Moreover, TC can plan a short-term training capsule of 7 days including exposure visit to industry and technical know-how on setting up of factories in non-leather footwear manufacturing for budding entrepreneurs. It will add revenue to TC consulting domain.

Hence CFTI Agra must act as a torchbearer in showcasing not only leather footwear-based technologies but gradually should also focus on non-leather footwear technologies in order to increase the competitiveness of footwear industry in Agra both nationally and globally.

7. Annexure

7.1. Annexure I: Leading global research/training institutions

Institution	Dealing with type of footwear	Major Services offered	Potential Areas of Collaboration with TC
German college of Footwear Design and Technology	Leather/Non-Leather	• The DSF is unique in Germany and one of the most prestigious schools in the world offering training in footwear design and technology	• Use of modern equipments for footwear design & Technology
China Leather & Footwear Research Institute	Leather/Non-Leather	• Offers comprehensive scientific research in the leather and non-leather footwear	• Application and evaluation of footwear biomechanics applications • Footwear and sputum data, standardization, technical data series research, provision and analysis. • Leather waste recycling technology
University of the Arts London, London College of Fashion	Leather/Non-Leather	• Incubation support for footwear entrepreneurs • Fashion education in leather/non leather footwear	• Connecting Fashion Technology with Footwear
Italian Fashion & Design Academy	Leather/ Non-Leather	• Certificate courses in Fashion and Design	• Incubation program for designers in leather/ non-leather footwear
De Montfort University, Leicester	Leather/ Non-Leather	• Expertise in the art of shoe designing	• 3D CAD • To gain knowledge on practical application, research, design and development, biomechanics, bespoke and model prototyping skills
CTCP, Portugal	Leather/Non-Leather footwear	• Education and customized training for footwear companies • Industry support (Consultancy) for productivity improvement, quality, environment, social responsibility, innovation, OSH, Energy Management • Testing & Design • R&D&I for creation of new technologies,	• Research & Development & Innovation (R&D&I) in sustainable materials/components for footwear • Customized joint training programs for footwear industry

Institution	Dealing with type of footwear	Major Services offered	Potential Areas of Collaboration with TC
		process, products, materials	
INESCOP, Spain	Leather/Non-Leather footwear	• Training programs • Software for footwear (Icad3D solutions) • Adhesive research • R&D in digital manufacturing, additive manufacturing, nanotechnology, leather and textiles, chemical substances in footwear	• Jointly exhibiting Industry 4.0 for the footwear sector • Training program on customized footwear
Southern Cross University, Lismore, Australia	Orthopedic footwear	• Training courses (Bachelor of Pedorthics, Bachelor of Podiatry)	• Joint training programs on Pedorthics
International Shoe Competence Center (ISC), Pirmasens, Germany	Orthopedic footwear	• Education and Customized training • Supplier of footwear testing machines • R&D in model and process optimization, Biomechanics/optimized fit/wearing comfort • Biomechanical laboratory	• Customized training programs in Orthopedic footwear

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