An Overview of Recent R&D Initiatives by Wool Research Association

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1.0 Introduction

Woollen textile and clothing sector plays an important role in linking the rural economy with the manufacturing industry, represented by cottage, small, medium and large scale units. The industry is broadly divided between the organized and decentralized sectors. The Organised Industry consists of Composite Mills, Combing Units, Worsted and Non-Worsted Spinning units, Knitwear & Woven Garment units and Machine made Carpet Manufacturing Units. The Decentralised Industry is composed of Hosiery and Knitting, Powerloom, Hand knotted Carpets and Independent Dyeing and processing houses. Besides, there are innumerable manufacturers of shawl, druggets, namdas, hand spun yarns, etc in the cottage industry, particularly in the hilly regions of the northern part of the country. From the complex composition of the wool sector it is well appreciated that R&D inputs and support will per se greatly differ to cater for divergent technological demand of these sub sectors. Another area of R&D activities focuses on the wool fibres from over 6 crores sheep producing coarsest fibre from Indian sheep to finest fibre from pashmina goats. This requires R&D efforts from animal husbandry discipline as well as the efforts from the technological innovation using the wool as the starting raw material. While the R&D on wool breeding, health care of the animal, classification, genetic improvement, etc are mainly carried out by Central Sheep & Wool Research Institute (CSWRI), Avikanagar, the technological research and development are assigned to Wool Research Association (WRA).

Wool Research Association is a co-operative Textile Research Association, established in 1963 by the woollen industry under the auspices of CSIR. At present it is a grantee institute of Ministry of Textiles for last few decades. WRA is the only research body in the country fully dedicated to research, consultancy, testing & evaluation, training & education, etc in the field of woollen textiles. Ever since its establishment, it has been rendering useful services and technical support to both organized and decentralized sectors including cottage, small, medium, and large composite units. With this background, it is intended to discuss R&D activities in the global arena, R&D model followed at WRA, research and development being undertaken by WRA, problem of indigenous R&D assignment, etc.

2.0 R&D activities in Global Arena

Over the centuries, technology became the monopoly of the developed industrialized countries. The industrialized countries control most of the global science and technologies based knowledge and know how. It is a settled fact that technology resulted from R&D, is the necessary condition for economic and social well being for any country, be it developed or developing, and also globalization of technology, so that fruits of R&D cross the national boundaries. However, in reality, the area of R&D based technology is characterized by high degree of structural asymmetry between the developed and developing nations.

While the above asymmetry in free flow of R&D findings is mainly dominated in the field of emerging new and high technologies such as micro electronics, telematics, bio-technology, new high performance materials, R&D in woollens and allied areas also suffers the similar trend to an extent.

R&D initiatives in wool growing countries like Australia, New Zealand, South Africa, etc are mainly restricted to improvement of wool quality and productivity. Manufacturers of woollen end items like U.K., Italy, China, etc have been engaged in the technological areas of product and process development of woollens as well as machineries development.

Front runner in wool research, CSIRO of Australia has been engaged in research of:

- protein fibre science to understand the structure, properties and behavior of wool and other keratinous materials
- modification of fibre properties to produce new products with improved comfort and appearance
- high-performance technical fabrics for extreme sports, protective wear and comfort
- protein fibre processing to shorten the process pipeline and reduce costs
- environmentally sustainable wool production and processing
- advanced fibrous materials and composites of wool-rich products for medical, military, automotive and aeronautics markets.

CSIRO has achieved a significant breakthrough in developing Sirolock ^{TM} Doffer Wire to enhance fibre processing efficiency. They have developed electrically charged wool filters for applications in respirators and air-conditioning. Colorclear ^{TM} wool whitening technology produces fabrics with a comparable whiteness to cottons and synthetics, lifting the competitiveness of wool-polyester blends. Quick Dry Merino, a product developed by CSIRO and AWI makes wool garments easier and cheaper to care for. CSIRO will look for

new technical applications for wool to generate sustained demand for wool. It also has plan to develop new ways of producing commercially viable protein bio-fibres and resolving wools' technical problems as apparel fibres, besides developing high performance product that meet consumer expectations.

Wool Research Organization of New Zealand has identified following research areas:

- Protein fibre intermediate filament structure
- Pneumatic vegetable matter removal
- Wool Textiles as components of safe, functional, built environments
- Non-insecticidal mothproofing of wool
- Amplification of wool surface functionality to create novel textile treatments
- Reducing volatile organic compound emissions from carpet
- Sonochemical Applications in Wet Wool Processing
- Prevention of Photobleaching & Photodegradation in Carpet Wools

Other developed countries like USA, UK, Germany, Italy, etc have reported to be engaged in application of cutting edge technologies like Plasma treatment, Nano-Technology, PCM, Smart Textiles, High-altitude clothing, Protective Textiles, etc, besides product and process development.

3.0 R&D Activities of WRA

As mentioned earlier, India has very divergent and heterogeneous structure of the wool sector. Requirement of each sub-sector is greatly different from the other in many cases. As a result WRA's R&D initiatives have to embrace wide range of activities of offering simple solutions and innovations to SMEs and also complicated developments in product and process inventions for the large scale manufacturers. Besides, identification of appropriate and essential technological gaps often has to be conceived, worked on and finds acceptable and optimum solutions which the industry may adopt, assimilate and transfer in practical production system.

3.1 R&D Model

R&D mechanism through innovation and invention is an effective way of developing dependable technology. R&D as such is the process of translating new ideas into productive reality. While looking for the technique of R&D, first step is to identify the 'new idea' based

on feedback from the industry, literature survey, consumer demand, academic assessment of gap in knowledge, availability of new investigational technique, cheaper production technique, introduction of new raw material, etc. Conceptually, research accomplishes the first break through in solution of a problem and innovation leads to commercial transaction involving product, process, system or device. Mechanism of R&D has been elaborated in figures 1, 2 and 3 below:

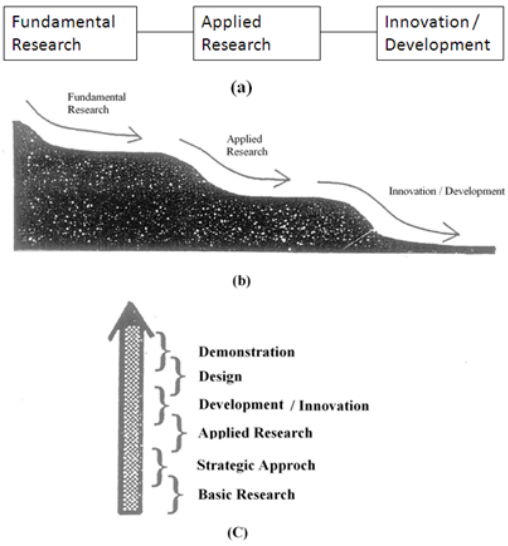

Fig.1 VARIOUS VERSIONS OF LINEAR MODEL OF R & D

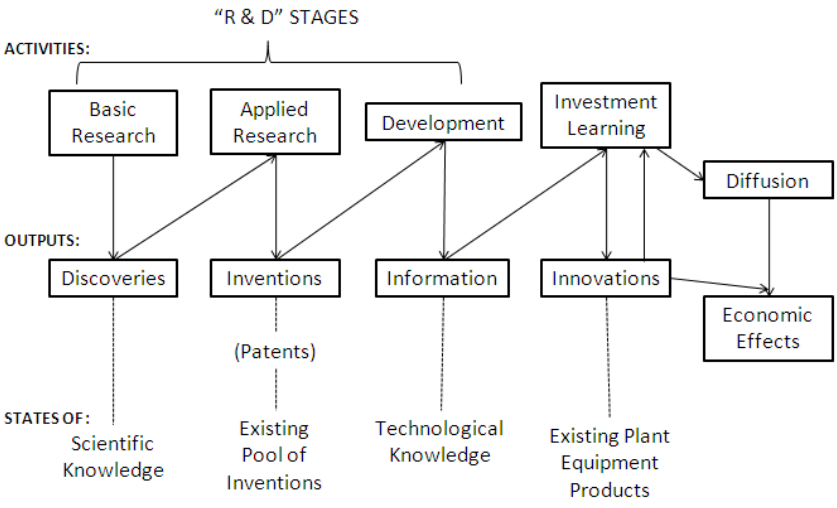

Fig.2 STAGES OF TECHNOLOGICAL CHANGES IN R & D

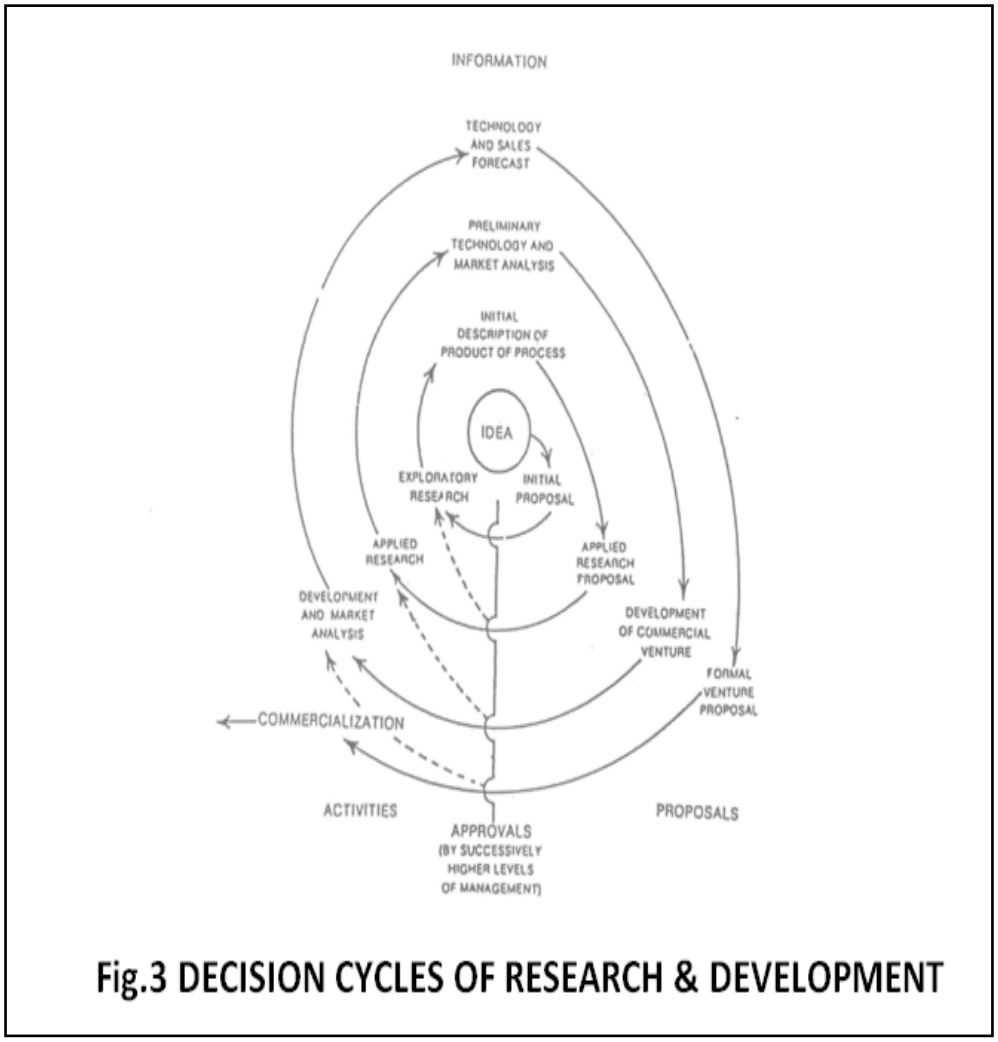

Fig.3 DECISION CYCLES OF RESEARCH & DEVELOPMENT

Various versions of R&D models have been depicted in figure 1(a), (b), (c). Stages of S&T effort as a system is shown by figure 2. Decision cycles of R&D system is schematically elaborated in figure 3 from idea generation to various steps till commercialization of the R&D findings. In our R&D activities of various projects, more or less these models are followed, with adjustments wherever considered expedient.

3.2 Overall R&D achievements in the past

During the early period after establishment, the sector-specific TRAs including WRA had given yeomen service to the respective industries in absorption, assimilation and upgradation of technology, quality assurance, innovation, productivity, machine-/product-/process-development, transmission and selection of appropriate technology, indigenization, waste reduction, pollution control, training & HRD, etc. Focus of the activities of WRA was

concentrated on providing technical, scientific and R&D inputs directly to the member mills as well as the decentralized sector.

WRA is the only research body fully dedicated to research and development, training and education, consultancy, etc in the field of woollen textiles. As mentioned earlier, the R&D need for the organized and decentralized sector including medium, small, tiny and cottage sector of woollen textile industry differed considerably.

WRA pioneered in development and technology absorption in the country in respect of Computer Colour Matching (CCM), Computer Aided Design (CAD), various product and process development, wool based technical textiles, pashmina scouring plant, technology development of wild eri-silk/wool blends, moth-proofing, thermal fabric, ceramic heat resistant yarn, substitutes for carcinogenic asbestos products, fire fighting textiles, characterization of Indian wool, carpet wool, new method of carpet washing, vegetable dyes, enzyme treatment, wool/jute blankets, brake liners, FR treated automotive textiles, eco-friendly carbonization process, elastomeric sports knitwear, etc. Large number of products resulted from R&D findings have been commercialized in the past.

3.3 Recent R & D initiatives

As WRA is required to respond to the R & D need of SMEs on one hand and the organized sector on the other, the projects were selected accordingly. Besides, the organization could not ignore the expediency to venture into the emerging and cutting-edge technology areas for capacity build-up in the country, particularly for the woollen sector.

Following R & D projects have recently been completed successfully :

(i) To develop itch-proof woollens to be worn next to the skin by improvement of surface topography of wool fibres with the help of mechanical/chemical processing and plasma technology.

(ii) Ultra sound assisted scouring and smooth finishing & other speciality animal fibres and their products.

(iii) To synthesize wool dyes with combined moth proofing properties.

(iv) To improve processing performance of fine variety of Indian Wool through enzyme oriented solution in early stage processing.

(v) To assess quality norms of worsted yarn being made by Indian Industry.

(vi) To optimize yarn processing parameters for spun yarn of Eri silk/Wool blends and to design and fabricate suitable machinery for processing such blends for decentralized & cottage industry.

(vii) To develop ecological moth repellent and moth proofing agents for woollen textiles for easy care.

(viii) Design & Development of Interior Textiles with special emphasis of heat resistance and flame retardancy.

Presentation of these completed R & D projects will be made subsequently in this seminar. Details have been incorporated in the book of paper. Action is in hand to patent some of the R & D findings arising out of these projects.

3.4 On-going R & D projects

WRA's scientists have earnestly been working on fourteen major R & D projects sponsored by the Ministry of Textiles and Central Wool Development Board. Department of Science & Technology also has sponsored further two R & D projects on instrumentation recently. These R & D projects pertain to all sub sectors of the woollen industry as follows:

3.4.1 Projects pertaining to Decentralized Sector

R & D initiatives taken by WRA include maximum number of projects pertaining to the decentralized sector of the woollen industry. Projects are undertaken in respect of Coarse Indian Wool for its proper utilization apart from mechanical and chemical processes. Following are the salient features of such projects:

(i) Improvement of pre-loom processes like scouring, spinning, etc. for decentralized wool sector

Under the scheme "Quality Processing of wool and woollens" of Central Wool Development Board, Jodhpur, quite a few entrepreneurs, NGOs and Co-operatives engaged in the wool business have been encouraged to set up common facility centres in cluster areas of wool producing states in the hilly regions of Jammu & Kashmir, Himachal Pradesh, Punjab, etc. for wool scouring, carding and spinning dyeing, etc. as a major preloom activity. Wool Research Association is associated in this venture for the last 2 – 3 years as a technical consultant. From the progress that has been witnessed under the said scheme and the

observations recorded, it is worthwhile to mention here that raw material mix being processed at different cluster areas and the end product be it early stage processing, carding, yarn making vary in considerable extent, requiring a different approach in each case, as far as updating of technology input and/ or processing parameters are concerned which we believe, can be adequately addressed if a fresh study on the technological inputs needed for implementation is taken up as a back up R&D project. It is pertinent mention that early stage processing of wool in the cluster areas needs technological feedback on the soundness of scouring parameters like temperature, duration, detergent concentration etc on one hand and rapid acidification and neutralisation aspect conditions & crushing of burrs in carbonisation for keeping alive fibre properties on the other. Similarly the requirement of machinery and settings in carding and spinning from various mixed blends of wool with other natural and synthetic fibres needs relevant technological input. Such technological breakthrough can only emanate from R&D innovations. Dyeing at various stages upto yarn stage also comes under this preview of pre-loom activity which needs encouragement at CFC level with latest technology backed by R&D support. The present project study aims at filling up these gaps.

(ii) Development of composites from coarse Indian wool for better utilization

India produces mainly coarse wool in the range of 30 microns to 150 micron. The coarsest wool available in the state of Maharashtra and North Karnataka amounts to 7000 tonnes per year. This wool has a very coarse micron value (diameter) of around 50 micron, on average. Owing to its very coarse nature, it cannot be converted into useful yarn on the spinning machine. Though at the cottage level, certain amount of this wool is being spun into yarn by hand spinning, it suffers with many deficiencies in terms of yarn quality and heavy dropage of 60% – 70% on the original wool reducing the yarn yield to 30% – 40%. This creates a high wastage of the fibre which is not used and destroyed resulting national loss. Therefore it is necessary to utilise this unusable coarse wool in creative way to produce value added products. For this reason, process to develop effective methods for utilizing this type of wool has become doubly important technologically and ecologically. One of the most promising areas of application of these coarse fibres containing is the possibility of using them as the substrate materials in the composites.

In this project Deccani wool having diameter of 48 micron was opened on the willowing machine and processed on wool card to get the uniform web. The uniform web was mechanically consolidated using needle punching technique to obtain the required condensed web. This carded web also mechanically consolidated by rubbing in presence of steam and

soap called felting process. Felt densities were between 0.1 to 0.5 g/cc. The various webs so prepared were subjected to different treatments depending on end use application. Different products were prepared using these felts such as rubber coating for electrical insulation mats and vibration dumping mats, POP and gypsum mixing for false ceiling, wool epoxy composites electrical boards and door panel.

(iii) To evolve a feasible alternative herbal carpet washing treatment

Indian hand knotted carpet industry is export oriented. The intrinsic beauty of an oriental carpet improves upon age with maturing of colours and softening of fibers on the pile surface. Advent of synthetic dyes made the colours on a carpet harsh and the chrome colours imported dullness to shades. Consequently, this gave rise to the practice of chemical washing of carpet so as to bleach strong reds to milder rose tones or sober maroon shades with an oriental look. Revival of natural dyes in carpet industry in recent years has the potential of increased export from this country with better value addition. But however, a carpet made from natural colours should not be subjected to the traditional chemical washing treatment using corrosive chemicals like acids, alkalis and bleaching solutions. The natural colours which are soft and soothing to the eyes are also very sensitive to these chemicals; hence it is necessary to evolve a herbal washing treatment for this carpet industry so as to improve the aesthetic and liveliness of the carpet. Even the carpets made of synthetic colours deserve a less severe finishing /chemical washing treatment than corrosive acids, caustic & bleaching powder. The main objective of this project is to work out an eco-friendly, cost effective carpet washing treatment for carpets made with natural dyes. Second objective is to improve the conventionally followed chemical washing treatment for carpets by reducing the consumption of corrosive chemicals such as sulphuric acid, bleaching powder, caustic soda, acetic acid etc.

(iv) Softening of coarse Indian wools for better utilization in value added products with pliable feel & handle

A large amount of wool produced in India is coarse and heavily medulled. Wools from southern and eastern regions (Karnataka, Andhra, Maharashtra, Uttar Pradesh and Bihar) are very coarse, kempy and often short for any apparel or carpet purpose. Their fibre fineness is mostly above 50 microns. Due to brittleness these fibres are prone to heavy breakages and loss during processing. It is mainly used in floor and furniture covering or in felt manufacture. However, considerable quantity of wool produced goes into the making of low end clothing, tweeds, blankets, shawls and knitting garments. However, when wool is used

in such apparel items, there is resistance to the utilization of such item by consumer, since these items are usually stiff, scratchy,droppings due to fibre breakages and are susceptible to shrinkage.

In this project attention is drawn to very coarse wool like deccani wool, having avg. fibre diameter of above 48µ fro their improved processing and utilization. Different softening trials were taken with proteolytic enzymes. It was found that the critical buckling force and flexural rigidity decreases with increase in the enzyme concentration. Fall in flexural rigidity indicates the ease in spinning. The enzyme treated 50% deccani wool was blended with 50% bottle grade polyester fibres and hand spinning was done. This wool polyester blend is used for making blanket, this blanket again treated with softener to render soft handle and feel. Furnishing cloth is made using warp of fine wool/polyester blend and weft of deccani/polyester blend. The furnishing cloth is again softened by the softener treatment.

(v) To develop textile effluent treatment system for power generation

Presently none of the textile mill is utilising waste water treatment for the production of energy. The aerobic treatment currently employed by the textile mills produce obnoxious emissions, odour and pollution in the ambient atmosphere. The application of anaerobic biological system will avoid the gaseous emissions reducing pollution. The conversion of methane gas to electrical energy has direct impact on the reduction of methane and indirect reduction of carbon emissions to the atmosphere and would put the methane gas to the productive use for energy conservation. The project is aimed at introducing methane releasing anaerobic treatment systems for wool textile effluents and to capture the methane generated for producing power.

A 25 litre anaerobic digester has been designed, using the anaerobic culture obtained from the sewage. The digester is filled with wet cow dung water mixture (25%) and grounded. A batch charge of around 10 lit was introduced daily for about one month. A stable flame was observed and the gas continued to ignite in a smooth way. Now, the wool effluent having a BOD of 1000 mg/lit is allowed to enter the digester daily and methane generation was observed. Floating demulsified grease is observed to separate indicating further resistance for anaerobic digester. In order to hasten the anaerobic reaction, aids like Starch, Enzymes and Yeast was added and reaction continued further. Encouraging results were obtained by activating the reaction further. The standardization of digestion to counter the inhibitory nature of the wool grease is under progress.

(vi) To design a cost effective Effluent Treatment Plant for the decentralized woollen and carpet sector

Water consumption and waste generation have become considerable concerns for the textile industry owing to the awareness of the society and the strict regulations by the Government and thus all kinds of waste generated have to be treated before being discharged into public sewerage or surface water on the open land up to certain tolerance limits. The decentralized sector which releases a large amount of effluent most of the times goes untreated due to the lack of treatment plants which are expensive, difficult to maintain, lack of expertise and requires a lot of capital adding to the cost of product. The project's aim is to find a cost effective wastewater treatment technology which have either low installation cost or low operation cost or a balance of both for these small and medium scale units. Under this, various technologies like sequential batch digesters, recent biotechnological advances, use of natural polymers and biosorbents will be evaluated for their cost effectiveness, ease of operation, raw material availability, eco-friendliness and ease of maintenance. On successful completion, the technology and process developed will be patented and promoted for the overall sustainable development.

(vii) Development of Internet Based Color Matching Facility for Small and Medium Dye Houses in the decentralized sector of the country

High cost, imported Computer Color Matching Systems (CCM) is used in the organized sector of the Indian textile industry. However, the cost of CCM System is very prohibitive as main components such as spectrophotometer and color matching software is very expensive for small and medium dye houses. Preparation of database requires a very good Lab facility. Most of the dyeing units in India are not equipped with good laboratory facilities and color technology experts are not available to handle the color technology problems. Taking this into consideration, WRA has taken this project which offers an online colour matching facility affordable to medium and small scale dye houses. Objective of this project is to provide 24×7 Instant Color matching facility through internet for Small and Medium Dye Houses in the decentralized sector of the country.

Under this project WRA will be developing exhaustive database on recipe of wool (with acid, acid milling, 1:1, 1:2 Metal complex dyestuff) and polyester from selected dyestuff manufacturer. WRA Users will just require a hand- held low cost spectrophotometer and access to WRA online colour matching facility through which they will use database created

by WRA for quality control and recipe formulation purpose. This colour matching service is designed to make color management more efficient and affordable to WRA User.

3.4.2 Projects pertaining to organized sector

Organized sectors of the woollen industry is rather less demanding in respect of R & D inputs, as the mills have certain activities of innovation of products/processes. Besides, they have easy access to the latest technologies from the developed countries in current technological environment due to globalization. However, following are the salient features of a few projects undertaken to support the technological requirement of the organized sector.

(i) Blind dyeing of polyester and wool and their blends for Right First Time (RFT) and Right Every Time (RET) vis-à-vis finishing of woollen products from Indian wool

Blind dyeing means no addition dyeing or management of all those factors that affect the coloration of a textile, resulting in a right- first-time dyeing. The technique of blind dyeing not only means that no additions are made, but also requires that the shade should not even be checked until the process is complete. There must be confidence in the way the process is complete, so that a right first time result is the only possibility. A successful blind dyeing operation is concerned with the need for high- quality laboratory recipes that can be reproduced in bulk and give subsequent bulk continuity. Three key factors in blind dyeing are:

(a) Accuracy of laboratory dyeing.

(b) Compatible laboratory dyeing methods that can be reproduced in bulk.

(c) Choice of dyestuffs that are compatible, give level dyeing and are robust to variations in process conditions.

Objective of this project is to achieve exact shade within DE CMC of 0.7 by identifying and introducing controls to avoid batch to batch variation in bulk even after a gap of several months to facilitate mix and match. Under this, extensive work has been carried out to identify factors that influence shade in wool and polyester dyeing and restricting them within the identified domain to achieve Right First Time & Right Every Time by introducing controls and monitoring them to keep DE CMC within 0.7.

(ii) **Up gradation of Indian wool by stretching and Setting means for value addition and use in apparel purpose**

Throughout the worsted industry low micron wool has become almost synonymous with high quality yarn. Market demand is for lightweight garments with the highest possible comfort, and buyers will pay up to 20 times more for fine-textured wool than for coarser type. India produces nearly 45 million Kg of wool per year which is nearly 2.5% of the total world production. But like cotton Indian wool, in common with other Asiatic wools, is considerably coarser than those produce in the other countries like Australia, New-Zealand. Most of the Indian wools are useful for coarser quality goods such as blanket, carpet, cheaper quality felts, and as a lining material. Indian woolen mills, producing worsted quality yarn mostly use foreign wool or blend of foreign and Indian wool of selected Varity from Kashmir and Tibet. On the other hand India also produces world's finest wool pashmina. The production of pashmina wool is however extremely limited. Other hilly wool are little coarser in nature i.e around 32-34 micron. These wools are good for carpet quality. Some modification of this wool can make it useable for apparel purpose also. Mechanical stretching of this wool along with chemical setting process can reduce the diameter, increase its strength and luster without hindering its other property like moisture absorption, drape etc. Slenderized fibers from the mechanical stretching technology create novel wool fibers, and the changes in wool property are highly associated with secondary structure transformation, which have been characterized by the well-established modern testing techniques, such as X-ray diffraction, infrared spectroscopy, Raman spectroscopy, differential scanning calorimetric. The evidences from these historical studies strongly support the view that the super molecular structure of wool fiber is transformed from alpha helix to beta form after stretching treatment, combined with pre-reduction treatment and post-oxidization treatment. This wool can be used in apparel purpose and also increases the value of Indian wool.

(iii) Design and Development of High End Fabrics Using Yarns Made Of Special Wool Fibres (Pashmina /Angora) and Eri Silk Blends

Pashmina and Angora are considered to be special wool fibres as they have smoothed surface and finer than any finest wool available. These two fibres are renowned for good feel and aesthetic properties. At present these two fibres are hand spun and are being used for making products like medium quality shawls and knitwear's as finest yarns produced are in the count range of 30^s to 40^s Nm. Occasionally Pashmina is blended with fine wool for producing suiting fabric. The objective of the present project is to exploit the distinct desirable

properties of these two special fibres it is essential to spin them to finer yarns in the count range of 80^s to 90^s Nm by adopting scientific processes and suitable machineries to achieve better process performance thereby increasing the value addition and marketability of products. As these fibres are weak in strength, which is major impediment in processing, it is proposed to blend them with Eri silk which not only imparts required strength but also enhances the aesthetic properties of products like soothing, luster rich feel and appearance and elegance. The targeted products are fine suiting & shirting, fine kurta material, fine knitwear's and fine shawls for domestic as well as overseas market.

3.4.3 Projects Pertaining To Emerging Area of Science & Technology

Technology is the most powerful instrument for the development of a nation. Role of technology was recognized by the founding leaders of India after the Independence and accordingly commitment to its use was enunciated first in Scientific Policy Resolution in 1958 and subsequent Five Year Plans, for achieving self reliance. Indian industrialization started mainly with the imported technology, but it was also recognized that the development could not rely on technology bought or borrowed from abroad. Self reliance through R & D in science and technology would only ensure sustainable advancement of the country. Indigenization process initially was considered and pursued as substitution of imported products, but such import substitution, was often criticized as 're-inventing the wheel'.

Present international trend has changed the economic and technological environment dramatically. Technology control regime, intellectual property rights, emergence of new technologies, etc. in crucial and sensitive fields, unwillingness of the advanced west to give away the technological monopoly, etc. have only widened technological distance between the developed and developing nations. New cutting-edge technologies, production techniques, availability of newer efficient raw material, chemicals, auxiliaries, etc. have opened up new avenues for India to master over the technology to cope with the global competition and we urgently require to develop indigenous technological capability to ensure a place in the world market and export. To face the challenge in the new world order, R & D efforts in emerging technologies have assumed a new significance.

Despite shortage of resources to invest in R&D in the emerging areas in wool technology and allied field, WRA has not neglected in its effort in R&D. Certain R&D projects have been initiated in the emerging technologies, as follows:

(i) Surface topographical finishing of Indian wools and their products (like carpets, woven & knitted fabrics) for imparting multiple functional properties by utilizing nano-clay and ceramic inorganic powders with ultrasonic and plasma technology

Wool being natural in origin has some inherent limitations like outer hydrophobic cuticle structure, harsh feel in case of coarser Indian wools and lower spinnability in fibres like Angora and few other animal fibres. These limitations act as impediments to enhance features such as anti-wrinkle, anti-shrinkage finishing and dyeing. Wool's water repellency on the surface also hinders its ability to absorb moisture and in humid condition makes wool garments feel sweaty. Current treatments to make wool hydrophilic, shrink proof, antibacterial, corrosion resistant etc. may not last long, may also damage fabric and are not eco-friendly. To overcome these issues, a new eco-friendly method is being developed utilizing ultrasonic and plasma technology. Different types of Indian wools will be imparted functional properties by treating them with aqueous solutions of inorganic nano and micro particles in presence of ultrasonic irradiation. The particles will be used to etch the fibre surface, improve the surface topography and to impart multiple functional properties. Particles like nano-clay and ceramic in-organic particles will impart hydrophilicity, resistance to shrinkage, antimicrobial activity and antistatic properties. Ultrasonic and low temperature plasma treatment can work synergistically to improve dyeability, to soften coarse Indian wools, to improve the coefficient of friction of extremely smooth angora fibres and improve their spinnability. Thus, the successful completion of the project will allow these fibres to be utilized in a variety of fields from itch-free and shrink proof apparels to highly specific Technical Textiles by virtue of added functional properties like increased antistatic property, improved adhesivity and frictional coefficient, hydrophilicity, antimicrobial property etc.

(ii) To impart antimicrobial & feel fresh/odour less finishes to woollen carpets

Carpets provide food material to moths and insects because of the wool, used in the carpet as the pile yarn. Carpet moths (like- Trichophaga tapetiella) eat wool of carpet & release some amines. These amines give a bad odour to carpets. Carpets are supposed to freshen & cleaning the air by binding micro-organism & dirt particles to its surface, which in turn give the bad smell & odour to carpet. Carpets are essentially required to offer aesthetic appeal, elegance, comfort etc over a very long period of its useful existence. However, woollen carpets without proper finishing often exuberate foul smell, particularly in humid and warm climate, closed room without proper ventilation. Generation of foul odour of Indian carpets

while in use and damage by insects/moths pose great hindrance to the Indian carpet industry in the global competition market. Such problems can be overcome by adopting emerging technologies like nanotechnology finishing with newer chemicals with efficacy.

Aim of the project is to impart antimicrobial & feel fresh/odour less finish to woolen carpets. The antimicrobial properties will be induced by using silver nano particles in combination of the chitosan polymer. Chitosan biopolymer is also known for its ability to absorb foul smell. Another mechanism will be based on the grafting of cyclodextin on to the carpet, as it is known to have ability to absorb foul smell causing amines. These cyclodextrin molecules will also be filled by suitable perfumes oil to provide control release of perfume from the carpet surface.

(iii) Enhancement Of Flame Retardancy & Soil Repellency Of Wool Through Plasma Technology

Wool is natural flame retardant fibers as the LOI of wool fiber generally lie between 25-26, which is good as compared to other natural fibres, but we can't use 100% wool fiber in making flame retardant textiles for interior decorative, automotives, cushion covers, carpets, etc. For making all these products, we have to mix the wool with inherent flame retardant material like Kevlar, basofil, FR polyester etc. These synthetic fibres produce health hazardous smoke while burning. Hence, the project is aimed at making to make the wool fibres flame retardant & soil repellant through the grafting / polymerization by Plasma treatment. Plasma technology is used to modify the surface properties because they provide a rich source of chemically active species that react with a short-lived chemical precursors needed for thin film deposition. The deposition of a functional thin film occurs if the plasma–solid surface interaction creates a solid phase material. This remains on the surface and agglomerates over time, to generate a conformal film. This process is called plasma polymerization. In this project, soil repellency will be imparted by using Siloxane coatings derived from organosilicone discharges which is durable, fluorine-free hydrophobic coatings. Siloxane coatings using a Hexamethyldisiloxane (HMDSO) discharge can also be deposited directly on fibres for getting a soil repellent hydrophobic yarn. Tetramethyldisiloxane (TMDSO) and TMDSO/O_2 plasmas will be used for imparting flame retardancy, which rise to a layer of silicon polymer or silica deposited over the surface of the fibres, thus improving significantly the flame resistance & wrinkle recovery properties. Hence, both properties

flame retardancy & soil repellency of wool fiber will be improved through plasma technology.

(iv) Development of thermal responsive high altitude multilayer protective clothing made principally of angora fibre

In high altitude area, the temperature is too low to sustain life. The blood circulation is hampered due to extreme cold conditions. So the people living in these areas suffer more. UV intensities increase with altitude. This is because the amount of atmosphere available to absorb UV is reduced, and so more and shorter wavelength UV is able to reach higher altitude areas. This causes skin diseases like cancer. There is lot of high altitude clothing in market, but they are not much responsive according to our body need. In effect, there is a dire necessity to develop high altitude warm clothing having properties like light Weight, stretchable, wind proof, breathable and UV resistance. Along with other fibres, angora can be used in high altitude clothing as it is very lighter and warmer than sheep wool. The angora fibre possesses cavities in which air is occluded. It is these air occlusions that give angora its characteristic properties, namely its high thermal insulation and its extreme lightness in weight. By this innovative product the demand for angora will be enhanced. In high altitude area, the temperature varies widely. It changes from season to season and also from day time to night time. In Jammu and Kashmir during winter, the temperature varies from freezing point to -30°C or even lower from day to night. As a result, the clothing which are designed for 0°c may not be comfortable at -30°c and vice versa. So, active protective clothing can be designed which can respond at different temperature level keeping the body comfort. This may be possible by using conductive thread with a suitable temperature controller in angora fabric.

4.0 Problems of indigenous R&D

When we consider problems and prospects of indigenous initiatives of R&D in the current national and international environment, impact of various forces have to be examined in totality. When we came out of colonial rule, it was considered that strategy of import of technology would not only facilitate technology transfer, but would also lead to assimilation, adaptation and development of technology indigenously on one hand and on the other, raise industrial dependency on in house R&D effort, productivity, managerial skills and expertise. This trend has still has been continuing in the form of Technology Upgradation Fund Scheme (TUFS) where, per se, it has been conceived that if modern, high speed machines are imported, technology of the textile industry will automatically upgrade. This concept is

fraught with the shortcomings that lack of R&D activities will never help to bring upgradation of technology to the desired level. No technology can be implanted in another country without R&D investment. Japan used to spend large amount of money as a matter of routine every time it would import a technology or sophisticated machineries for effective generation of domestic technology. Smt.Indira Gandhi observed four decades back in her inaugural address of Indian Science Congress, Kharagpur that "Japan had commitantly bought or imported foreign know how, but she spent four times the amount in backing up import of technology. These industrial sectors which have spent the largest amount in importing foreign know how in Japan have also spent the most on research and development. This is in sharp contrast to our country where the import of foreign know how is unrelated to R&D expenditure." Her observation holds good even today.

R&D investment being vital for developing domestic technology and survival in global competition, is yet the lowest priority in most of the Indian industries, particularly in woollen sector of textile industry. Scientific strength already built-up in the country are not being utilized to its full potential, thus affecting technological development.

There is poor linkage between the Academic Institutions, Research Bodies and the Industry. Adequate initiatives for transfer of indigenous technology to industry are not encouraging perhaps due to lack of confidence of the industries in indigenous technology. The public funded R&D institutions hardly conceptualized technology as an instrument of growth, inspite of adequate infrastructure and talent. The industry considers R&D expenditure as a drain of resources rather than an investment in future, thereby hampering the growth of domestic technology.

Quality of research in many areas in India normally does not match that of the developed countries. India hardly has an international patent in demand. Such inadequacies may be attributed to (a) poor or lack of appropriate educational facilities, standards and skill, (b) inadequate R&D infrastructure (c) poor training, (d) cumbersome and unhelpful bureaucracy, (e) lack of entrepreneurship skill (f) subcritical funds (g) mediocrity (h) optimum technology temper and (i) lack of team spirit. Many in the scientific circle are vociferous that bureaucracy and organizational control and regimentation in the project allotment procedure do not encourage R&D initiatives, but kill creativity.

5.0 Conclusion

For a viable and substantially self generating indigenous technology for our wool sector comprising of tiny, cottage, small, medium and large units, there is no alternative but to establish strong and effective research and development, innovation, inventions, with the involvement of all stake-holders like industry, beneficiaries, government, scientific community, etc. There should be a well defined long term national strategy for policy, scope, fund allocation, sponsorship, R&D facilities, etc for development of technological capability. It serves no useful purpose to dissipate funds for imitating mindlessly to 're-invent the wheel' as done in some cases.

The morale of our scientists, engineers and industry is required to be boosted up. The co-ordination and co-operation between the Indian woollen industry, academic institutes and public funded R&D establishments like TRAs at present are far from satisfactory. Industry is generally apprehensive of indigenous technology. Corrective measures should be undertaken for confidence building up and quick utilization of home-grown know how as a result of R&D findings. Industry's investment in R&D in woollens is meagre, which must be increased substantially.