ABSTRACT:

“To Camouflage is To Disguise”, this is a major part of the defense sector. The clothes that the defence personnel wear always need to serve the most possible. On the battlefield if a soldier is in disguise he/she is close to invisible, which may guard him/her from the possible dangers.

Military textiles need to be customized in such a way that they camouflage in the critical conditions, special dyes or pigments are used to pattern the uniforms. Whereas special procedure is followed during the fibre forming process for IR(infrared camouflage). Camouflage textiles is being developed since the world war period and still invites further research and development. The paper is an attempt to review the topic in a segregated manner.

1. INTRODUCTION:

The word camouflage has its origin in the French word camoufler. The purpose of camouflage is preventing the detection and identification of objects, in the broad sense of the word, by misinforming, pretence and hiding. The development of modern detection means which work in a wide range of electromagnetic radiation stimulates the development of camouflage agents, including paint, screens, and camouflage cover.

Camouflage helps an organism blend in with its surroundings. Camouflage can be colours or patterns or both. Camouflage
textiles not only help protect armed forces from visual and IR detection but also-with regards to their heat and sweat management capabilities—ensure that the soldiers can perform to the best of their abilities even in extreme climatic conditions.

2. SALIENT FEATURES OF CAMOUFLAGE TEXTILES:
   - Physical lightweight and durability
   - Non glaring/shining
   - High tear and tensile strength
   - Comfort wear and antistatic
   - Shade stability
   - Wash and perspiration fastness
   - Windproof, water repellent or even water proof and breathable
   - Flame retardant
   - Antimicrobial, insect, mosquito repellent

3. TYPES OF CAMOUFLAGE
   1. Natural and artificial camouflage
   2. Thermal camouflage
   3. Visual camouflage
   4. IR camouflage
   5. Camouflages for multiple spectra
   6. Anti-radar camouflage

3.1 NATURAL CAMOUFLAGE:

There are mainly two types of camouflage under this category:

1. Mimetic camouflage
2. Disruptive camouflage

Mimetic Camouflage :

Mimicry Some animals and plants look like other things they mimic them. Mimicry is another type of deceptive coloration. It can protect the mimic from predators or hide the mimic from prey. If mimicry was a play, there would be three characters.
The Model - The species or object that is copied.

Mimic - looks and act like another species or object.

Dupe- the tricked predator or prey. The poisonous coral. Snake and the harmless king snake look a lot alike. Predators will avoid the king snake because they think it is poisonous. This type of mimicry is called Batesian mimicry.

Disruptive camouflage: Counter shading, which defeats a predator's ability to identify prey by shape. In countershading, the upper parts of an animal are dark and its lower parts are light. This reverses the normal distribution of luminance on objects, which are usually lit from above. Boundary disruption, Each zebra's stripes blend with the stripes of the other zebras around it. This kind of camouflage is called Boundary disruption, and it confuses predators, which tend to see only a large, striped mass instead of many individual animals.

Digital Camouflage: Digital camouflage is a type of camouflage pattern combining micro- and macro patterns, often though not necessarily with a pixellated look created with computer assistance. The function is to provide military camouflage over a range of distances. The "digital" refers to the coordinates of the pattern, which are digitally defined. The term is also used of computer generated patterns like the non-pixellated Multicam and the Italian fractal Vegetato pattern. According to the patent for MARPAT, pixellation does not in itself contribute to the camouflaging effect. The pixellated style, however, simplifies design and eases printing on fabric, compared to traditional patterns. While digital patterns are becoming widespread, critics maintain that the pixellated look is a question of fashion rather than function.

3.2 THERMAL CAMOUFLAGE: A thermal camouflage tarpaulin (heavy waterproof cloth for covering) for hiding heat sources against detection in a thermal image, comprising a base textile composed of a loop-formingly knitted or woven glass fabric is provided on the side which is remote from the heat source with
a compound whose reflectance values are in the region of a visual camouflage and/or in the infrared region. Said base textile is provided on that side which faces the heat source with a free-standing polyester film to which has been applied a vapor-deposited coating which reflects thermal radiation.

MATERIAL USED FOR CAMOUFLAGE TEXTILE:

In manufacturing of the camouflage materials that secure protective features in visible and NIR spectral ranges these coloration technologies are dominant:

- use of special selected dyes and pigments
- incorporating strongly IR absorbing pigments into printing paste
- incorporating strongly IR absorbing pigments into the polymer at a fiber forming process
- use of special and minimizing IR reflectance coatings (layers)

It is relatively easy to print a wide range of textile fibre types in the correct visual shades with the colour fast dyes. However it is more difficult to achieve NIR cover on the same fabric. Artificial fibres such as polyamide, polyester, aramids and their blends with natural fibres cause these particular problems. The camouflage should stay efficient during all the wearing time, so the colour fastness to various influences and treatments becomes an extremely important parameter, ensuring the concealment of the target both in the visual and NIR radiation spectral ranges.

In short, stealth comprises various means employed in offence to avoid detection by the other party. One typical example where stealth plays a very important role is the fighter aircraft. The aircraft in the air is seen conspicuously against a uniform background if it is not made stealthy. Similarly, a ship on a uniform background of sea and/or sky can be easily detected unless made stealthy. Of course, on land, there is a lot of heterogeneity for a military object such as a tank. Tanks of the
future may also have to be made stealthy. Stealth technology or low observable technology deals with the design of weapon platforms from the beginning stage itself to include low observable features as a major design goal, rather than as a retrofit capability. The various signatures that are to be considered in a stealth warship are: Radar, Infrared, Acoustic, Magnetic, Electric, Hydrodynamic wake, Extra low frequency, Miscellaneous such as contaminants etc.

3.3 VISUAL CAMOUFLAGE

BASIC PRINCIPLES OF CAMOUFLAGE IN THE VISIBLE REGION:

1. Hiding: In hiding, the objects are physically hidden by the use of natural materials such as vegetation natural and cut and artificial materials such as nets, screens etc. Screens: A variety of screens, such as horizontal, vertical and overhead types, are used for concealing stationary military objects. These screens act as physical barriers between the target and the sensor. Besides, there are smoke screens which provide temporary concealment in situations such as movement of troops.

Blending: In camouflaging by blending, the object is made to blend with the background. The object becomes an integral part of the background and is hence rendered invisible, and thereby unrecognizable. Camouflaging by blending involves optical principles which produce illusory effects. Principles which nature has applied to camouflage various animals

2. COLOUR MATCHING: The first requirement for an object to blend with its general background is that the colour of the object should be the same as that of the background.

3. DISRUPTIVE COLOURATION: Colour matching and simultaneous countershading is not possible under all conditions. One of the most important principles of camouflage is that produced by dazzle. It is an American term which came into popular use during war in
connection with camouflage painting of military objects. When an object is painted with irregular patches of colours of varying contrast and tones, the attention of the observer is diverted away from the actual shape of the object but drawn towards the dazzling patches. The patterns which attract attention do not bear any relationship with the shape of the object with which the observer is familiar.

3.4 INFRARED CAMOUFLAGE:
The term infrared camouflage denotes any device or equipment or technique employed to counter detection by an infrared system. Advances in infrared sensor technology have put great stress on infrared camouflage and demanded countermeasures.

PROPERTIES OF INFRARED RADIATION:
Propagation Characteristics Infrared radiation travels with the speed of light, like any other type of electromagnetic radiation, and, in its transit from the source undergoes reflection, scattering, absorption, transmission, diffraction and polarization. In most of the cases, the intervening medium between the source and the detector is the atmosphere. As the radiation passes through the atmosphere, it gets attenuated by its interaction with the various constituents of the atmosphere. This process is known as extinction. Visual vulnerability The detection probability, aided or unaided, is dependent on shape, size, hue, colour contrast, mobility.

MICROWAVE CAMOUFLAGE

These were synthesized in the laboratory and characterized by IR spectroscopy and elemental analysis. Absorber samples of finite thickness were prepared and tested for radar absorption at X-band frequencies.

3.5 MULTISPECTRAL CAMOUFLAGE MATERIALS
DMSRDE has initiated a programme for developing a multispectral camouflage system which should be able to cater for visible, NIR, thermal IR and centimeter and millimeter wave radar regions.

3.6 ANTI-RADAR CAMOUFLAGE
Camouflage material incorporates means for specifying and providing predetermined degree of reflection of incident radar waves which is optimum for particular use environments. The overall pattern is the resultant of control of reflection of longer radar wavelengths by a layer of electrically conductive fibrils of controlled density and reflection of shorter radar wavelengths by thin mosaic layer of metal. Metafil Mat is the ultimate material to provide effective shielding from electromagnetic interference. Our Metafil Mat is used in radar blocking equipment for the military and in shielding for satellite antennae. Metafil consists of aluminium coated glass fibres thermally bonded into a nonwoven mat of uniform density. The fibres are oriented to provide superior electrical and shielding performance. The structure of the material allows for conformability to irregular surfaces and compatibility with other base substrates or resin systems.

CAMOUFLAGE FOR MILITARY TEXTILES:

Through nanotechnology, new personnel camouflage systems can be developed that can change pattern and colors as environment changes. “Chameleonic” camouflage allows the soldier to become a mirror of his surroundings.

Military camouflage is the use of camouflage by a military force to protect personnel and equipment from visual observation by enemy forces. In practice, this means applying colour and materials to military equipment of all kinds, including vehicles, ships, aircraft, gun positions and batteldress, either to conceal it from visual observation, or to make it appear as something else.
The aim is to make sure that the surface of the soldiers and not form a contrasting shape against the background. The principles involved in camouflage materials are shape, shine, shadow, silhouette, surface, spacing and movement. The hues used in the camouflage are green, olive, khaki, brown and black.

4. PRINCIPLES

4.1 COMPROMISE: No single camouflage pattern is effective in all terrains. The effectiveness of a pattern depends on contrast as well as colour tones. Strong contrasts which disrupt outlines are better suited for environments such as forests where the play of light and shade is prominent. While civilian hunting clothing may have almost photo-realistic depictions of tree bark or leaves, military camouflage is designed to work in a range of environments. With the cost of uniforms in particular being substantial, most armies operating globally have two separate full uniforms, one for woodland/jungle and one for desert.

4.2 MOVEMENT: While patterns can provide more effective crypsis than solid colour when the camouflaged object is stationary, any pattern, particularly one with high contrast, stands out when the object is moving. Jungle camouflage uniforms were issued during the Second World War, but both the British and American forces found that a simple green uniform provided better camouflage when soldiers were moving. After the war, most nations returned to a unicoloured uniform for their troops. Some nations, notably Austria and Israel continue to use solid colour combat uniforms today. Similarly, while larger military aircraft traditionally had a disruptive pattern with a darker top over a lighter lower surface, modern fast fighter aircraft often wear gray overall.

4.3 DIGITAL CAMOUFLAGE: Digital camouflage provides a disruptive effect through the use of pixellated patterns at a range of scales, meaning that the camouflage helps to defeat observation at a range of distances.
4.4 NON-VISUAL Stealth technology by class corvette stealth. With the birth of radar and sonar and other means of detecting military hardware not depending on the human eye, came means of camouflaging against them. Collectively these are known as stealth technology. Aircraft and ships can be shaped to reflect radar impulses away from the sender, and covered with radar absorbing materials, to reduce their radar signature.

5. APPLICATIONS

UNIFORMS: The role of uniform is not only to hide each soldier, but also to identify friend from foe. Armies facing service in different theatres may need several different camouflage uniforms. Separate issues of temperate/jungle and desert camouflage uniforms are common. Patterns can to some extent be adapted to different terrains by adding means of fastening pieces of vegetation to the uniform. Helmets often have netting covers; some jackets have small loops for the same purpose.

LAND VEHICLE: The purpose of vehicle and equipment camouflage differs from personal camouflage in that the primary threat is aerial reconnaissance.

SHIPS, AIRCRAFT: Aircraft camouflage faces the challenge that an aircraft's background varies widely, according to whether the observer is above or below the aircraft, and with the background, e.g. farmland or desert. Aircraft camouflage schemes have often consisted of a light colour underneath and darker colours above.

IN FASHION AND ART: Fashion and the "Dazzle Ball" The scheme of decoration for the great fancy dress ball given by the Chelsea Arts Club at the Albert Hall, the other day, was based on the principles of 'Dazzle', the method of 'camouflage' used during the war in the painting of ships. The total effect was brilliant and fantastic.

CAMOUFLAGE IN ART WEAR: Protesters and fashionist as through nanotechnology, new personnel camouflage systems can be developed that can change pattern and colors as
environment changes. “Chameleonic” camouflage allows the soldier to become a mirror of his surroundings. Non-military use of camouflage includes making cell telephone towers less obtrusive and helping hunters to approach wary game animals. Patterns derived from military camouflage are frequently used in fashion clothing, exploiting their strong designs and sometimes their symbolism.

APPLICATION:
- Microwave antennas
- EMI/RFI shielding
- Lightning strike protection
- Electrostatic finishing
- Electrostatic dissipation
- Thermal dissipation
- Radar reflective composites
- Multi-resin compatibility
- Good drapeability, conforms to irregular surfaces

6. PRODUCTION OF CAMOUFLAGE TEXTILES

The concept of producing textiles that readily vary in colour has long been an anathema to the textile colourist for whom achieving permanency of colour has been a primary goal stretching back into antiquity. Consequently, colourant manufacturers have striven for many years to develop fast-coloured materials by hunting for dyes and pigments that are chemically inert and physically unresponsive once they have been applied to a substrate.

6.1 pH changes
Molecules can change colour dramatically in the presence of acids and bases, but these reagents and the solvents required to transport them make this method extremely difficult to implement in the applications.

6.2 Oxidation state changes
This method is also highly effective, but requires the migration of ions. The response time can be fast in solvents, but this
complicates the device. Gel-type devices might also be possible, though physical robustness, oxygen stability and response times represent serious engineering challenges. A device built on this principle would be similar to a polymer LED.

6.3 Bond breaking/making
There are a number of systems that undergo reversible bond-breaking, bond-forming processes that result in dramatic colour changes. Most commonly, these are light-initiated processes.

6.4 Mechanochromism
Certain compounds have been shown to undergo colour changes as a result of applied stress. A mechanochromic system is constructed by surface modification of conducting polymers.

6.5 Electric or magnetic field effects
Some highly polarizable systems have been observed to change colour in the presence of electric or magnetic fields.

7. Chromic materials
Chromic materials are also called camouflage fibres, because they can change their colour according to the external conditions. These materials have been used mostly in fashion, to create novel colour changing designs. Because of this, some people fear that the chromic materials will be a short boom, but the accuracy and endurance of the materials are being improved. Chromic materials refer to materials that radiate the colour, erase the colour or just change it because its induction is caused by the external stimuli (as ‘chromic’ is a suffix that means colour). So the chromic materials can be classified depending on the stimuli affecting them.

- Photochromic: external stimuli energy is light.
- Thermochromic: external stimuli energy is heat.
- Electrochromic: external stimuli energy is electricity.
- Piezochromic: external stimuli energy is pressure.
- Solvatochromic: external stimuli energy is liquid.
- Carsolchromic: external stimuli energy is electron beam.

8. CONCLUSION:
The development of several surveillance technology has rendered obsolete textile production techniques that provide camouflage solely in the visible region of the electromagnetic spectrum. Modern military forces require counter surveillance materials that afford protection against several surveillance technology, camouflage textiles must satisfy for all threats. The ease of fulfilling such requirements varies with the substrate of the camouflage material. Conventional methods for the coloration of other fibers have been found to be inadequate. Novel dyes and pigments, as well as new techniques, have had to be developed in future.

9. REFERENCES: