REVIEW OF LITERATURE

Soiling and soil removal has been extensively studied since last many years. The literature has been presented under the reviewed following heads

[2:1] SOILING

2.1.1 Nature of soil

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[2:2] DETERGENT

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2.2.3 Market detergent

2.2.4 Factors affecting detergency

[2:3] SOIL REMOVAL

2.3.1 Process of soil removal

2.3.2 Factors affecting soil removal

[2:1] SOILING
In this section studies on the nature of soil, the way soiling takes place, factors affecting soiling, types of soils is presented.

(2:1:1) Nature of soil

According to Nelson (1955) the accumulation of dirt resulting from the everyday use of clothing and household textiles is always a mixture, the component of which vary according to the factors of environment, fabric use and customs of the individual. For that he has considered soil as a complex mixture in two general categories.

a) A fluid component: oil and grease

b) A solid component: which is made up of small, more or less or inert particles

a) A fluid component

The dirt accumulated by clothing and household fabrics is usually a mixture of these two. It is obvious that these components of natural dirt, although in themselves complex mixture originate in large part from the common substances encountered in daily living.

To study the nature of these mixtures, dirt from several different sources has been examined. Ordinary street sweepings, rug dirt picked by vacuum cleaners, and the accumulation from air filters have been analysed with the idea that they are typical of the various soils.
encountered by textile materials and that they would, therefore, be useful in constructing a synthetic dirt for artificial soiling purposes.

Although a knowledge of the chemical composition of natural dirt should prove to be useful tool in helping to understand the nature of fabric soil, an important point to be noted is the fact that street sweepings or dirt packed up in Vacuum cleaners may not necessarily have the same composition as the non-removed soil remaining in a fabric after cleaning. With rugs, for instance, it is not the dirt that is removed that presents the problem, it is the material remaining after vacuum cleaning that causes the gradual change in appearance over a period of time. Because of the obvious technical difficulties involved, it is not surprising that only scattered information is available concerning the characteristics of this more tenaciously held soil.

Nelson (1955), has also shown that the most important soiling function of the fluid constituent is its tendency to pickup and retain solid particles. For instance a spot of butter or salad oil on a fabric, unless immediately removed, soon becomes dirtier and more discoloured. He remarks that this ability to bind solid particles has been termed "oil bonding" to which a large part of fabric soiling can be ascribed.

Nelson (1955), observes that the chemical nature of the oily materials, their degree of saturation and film-forming capacity is of considerable importance in respect to their case of removal after a period
of time. For instance, quick-drying vegetable oils, such as linseed or tung form solid films in a matter of hours, whereas more fully saturated oils may take days or weeks to effect a change. Thus, unsaturated oils or polymerizable substance and the solids bound by them become progressively more difficult, or even impossible to remove because of this chemical change in the soil itself.

(b) *The solid component*

The solid fraction of fabric dirt is at least as complex a mixture as the solvent extractable portion (only fabric soil). It is made up of an endless variety of organic and inorganic substances. Physical and chemical breakdown products of animal, vegetable and mineral origin. This is present in the form of very small often microscopic particles. these latter, together with certain food and body residues, are often associated with localised spotting.

The greatest source of trouble is from the finely divided particles and the oils that help to bind them. It is these which cause the overall dulling and discoloration that build up regardless of frequent mechanical cleaning operations.

According to Earl (1949), textile material contains several components: a) *Water-soluble substance:* Which offer no real cleaning problem, since they can be easily rinsed away. b) *Insoluble solid substance:* Such as lint, dust or soot and insoluble oily matter. These two
types of insoluble soils necessitate a cleaning treatment which will cause wetting, loosening, and removal of the soiling materials into the washing medium. The oily portion is naturally adherent and causes otherwise loosely adherent soiled soil to be bound to the fabric. Because of the frequent coexistence of oily and solid matter is natural soils, it has been generally assumed that synthetic soiled should contain these two types of material.

(A) Street dirt and vacuum dirt

Sanders and Lambert (1950), analysed natural soil, street dirt was selected for the study, since it represented the commonest type of soil encountered. As there exists no method for the analysis of free carbon an optical method which is used for observation of points was utilised to obtain semi quantitative estimates.

Soiling may take place in many ways. One example is street dirt consisting of particulate solids deposited on a current by an air current and held by electrostatic forces. Fabric may become soiled in use or even during laundering when soil may be removed from one fabric and deposited on other.

Soiling by particulate involve two steps: a) Transport of the fibre surface and b) Adsorption of the fibre. Transport of particulate soil can involve deposition by air current electrostatic attraction and contact transfer from a soiled surface to a cleaner surface Kissa (1984).
Berch and Peper (1963), studied unfinished cotton fabrics. Five differently finished cotton fabrics were taken for the study. Fabrics were soiled in aqueous dispersion of respectively (1) iron oxide with oleic acid, (2) carbon black with oleic acid and (3) vacuum cleaner dirt. They concluded that water repellent surface, like polyester fabric, soils heavily in an aqueous medium especially with hydrophobic soil. Vacuum dirt was removed by even simplest washing.

Bille (1966) has observed that soil on a textile fabrics comes mainly from two different sources. Namely, a) from the body of the wearer b) from the environment. Belle pointed out that another important source of soil is the wash liquor itself, soil re-deposition or "wet soiling", takes place during laundering due to pick up by the fabric of soil suspended in the was liquor. But thus is a secondary or indirect source of soil.

B) wet soil and dry soil

According to Setty (1955), The manner in which soil may enter into the interstices of a fabric is dependent, to a considerable extent, on whether the soil is wet or dry and if wet whether the liquid base is water or oil. Dry soil will not rapidly penetrate of its own accord.

In case of wet soil, the penetration of the liquid phase by capillary action will carry soil material into the interstitial spaces of the fabric. In that case, water is the natural wetting agent for both the fabric and the
soil on the other hand there are solid soils which are more readily wetted and dispersed by oil than by water. Therefore oil as a vehicle will effect greater penetration of solid material into the fabric (Utermohlen, 1947).

(C) Oily soil

Setty, (1955) have stated that soil can be of two types:

a) Solid soil  
b) Oily soil

In case of solid soil there is little or no orientation of the detergent molecule, but in the case of oily soil ionisation of the detergent molecule occurs. According to Nelson (1955), the possible sources of oily fabric soil are many incompletely burned liquid fuels from industrial plant, and home heating units, as well as the greasy vapours from cooking continually settle out of the air directly no to fabric or other exposed surface that may later come into contact with fabrics. It has been estimated that 401b of such oily liquids are volatilized in the average American home over a period of a year. Lubricating oils and greases from automobiles and machinery also provide a common source of fabric contamination, as do the excretion of the human skin and the oils and fats from food. Uttermohlen, (1974) showed that ageing effect was closely related to the degree and molecule Snell and Reich (1950) have helped him to report that with ageing soil becomes more difficult to remove with washing.
Soiling process

According to Niven, (1950) soiling is accumulation of dirt and oily particulate material on the surface or interiors of fibrous structural and result in discoloration, change in appearance and loss of fabric lustre. He also states that soil is generally heterogeneous mixture of many substances. Textile are soiled in different ways like by contract with another soiled surface or by contact with air-borne or liquid borne substances. liquid with which the fabric comes into contact may evaporate leaving behind the dissolved or suspended particles. Another important source of soiling is wash liquor itself. the fabric picks up the particles suspended in wash liquor. Soiling of fabrics may be due to interfacial attraction electrostatic attraction, mechanical forces and also hydrophobicity and oleophilicity of the substances.

Dave et al (1984), have emphasised that soiling of textile occurs in two steps:

(a) Transport of soil to the fabric surface
(b) Adhesion of soil to the fibre surface.

Soiling may be also influence by method of soiled application and environmental conditions. Kissa (1984), states that the most important soiling mechanism is transfer soiling which always involve mechanical work and is accomplished by pressure abrasion, impingement etc. he states that the main cause of soiling is adhesion of the soil particles to the
fibre surface and not mechanical entrapment of soil. Soil particles can even adhere to initially smooth surfaces, such as polyester. The strength of the adhesive bond depends on the forces of interaction interfacial area the area of contact, and whether a liquid is present on the fibre surface.

According to Cooke (1987), Soil particles are irregular in shape. The contact between soil particle and fibre increases when the particle is deformed on impact and more nearly conforms to the fibre surface. This means that pressure on the soil particle that causes deformation of soil particle as per the fibre surface will increase soiling. Rajkumar et.al (1983) have stated that soiling with particulate matter involves entrapment of particles in the inter and intra-yarn spacing. Soiling with fluids, however occurs by inter-yarn intra-yarn and intra fibre by wicking mechanisms.

Much work has been done to characterised the deposition of soil on laboratory soiled specimens.

Electron-microscopical techniques showed : used by Breen et. al.(1988)

(A) Particulate soil is found to be embedded in the oily layers held in crevices foamed between adjacent fibres.

(B) It also located on the surface of both synthetic and cotton fibres.

(C) It is found on secondary wall of cotton fibre.
In study of mechanism of soiling, Nelson (1955) states that the nature of complex are fundamental to an understanding of its formation and stability of soil. According to him fabric and dirt come together either by direct contact with a soiled surface or by contact with air-borne or liquid-borne substances. Though direct contact, simple mechanical forces act to transfer oily and/or solid material directly from a soiled surface to the surface and spaces available within a fabric. It is an everyday occurrence to soil clothing by contact with an object or to transfer oil and grease to a carpet from the soles of shoes. Fabric may also collect dust and dirt from the air or pick up dissolved or suspended substances from liquid with which they come into contact. The transportation of soil into fabric structures by fluids involves the principles of filtration, liquid-borne substances are frequently the cause of staining and spotting or splashing of muddy water on clothing. Dirt originally picked-up from the air or by direct contact with a soiled surface may be transported deeper into the fabric by later contact with liquid. Whenever fabrics are washed or dry cleaned, They are subject to the form of liquid soiling known as redeposition.

Snell (1960) states that dirt is retained in a fabric by mechanical and electrostatic forces and by 'oil bonding', A similar conclusion was
reached by the New York section AATCC, which mentions that particles may adhere to fibres by mechanical forces or occlusion in pits and crevices on fibre surface, by 'oil' bonding, and possibly by electrical forces.

* Mechanical Entrapment

Mechanical entrapment is undoubtedly responsible for the largest weight of dirt accumulated by most textile materials; it may also be the cause of some of the most tenaciously held soil. To appreciate fully its importance, an understanding of fabric, yarn and fibre structure is necessary. Weave and yarn constructions of cotton fabrics is very widely. At one extreme is the open porous condition of a pile fabric and at the other, the dense compact surface of ducks or broadcloth. The tightly woven structure of the latter prevents the entrance of all but the smaller particles, while the open surface of a rug pile offers little hindrance to the penetration of large quantities of coarse grained dirt.

* Natural soiling Vs Laboratory soiling

Obendorff's (1987) work was carried out on seven cotton/polyester shirt-collars that had been soiled by repeated wearings. Although greater variability in soil type and soiling level's existed on naturally soiled fibres, the distribution of residual sales on naturally soiled woven shirt collars was similar to the distribution of residual soils found on laboratory soiled fabrics. Oily soil was located in the
continues secondary wall and lumen of the cotton fibre and in the interior of damaged polyester fibre, which were not changed. Soil particles were concentrated in aggregates on fibre surface and were entrapped in the crevices of the inter yarn spaces. They were also observed to have been moulded around individual fibre or adhered to oily surfaces. Oily and clay soil were detected in the some locations on many yarn surfaces, providing evidence that they were in fact, residual as a composite soil.

In another study by Obendorff (1987), fabrics were soiled by trained panellists, who prepared the soiled specimens by wiping the fabric over the face and neck, while it was held taut on a smooth spherical surface some of this facial wipes had a less uniform distinction of oily soil within the inter fibre spaces than laboratory soiled woven shirt collars. The oily soil on the facial wipes tended to be more heavily concentrated on the upper scale of the yarn than the lower one. This may have resulted from the application method or different ageing conditions that limited the diffusion of oil under the treatment conditions and time frame. A wide range of soil levels was observed among facial wipes prepared by panellists on both the laundered and unlaundered samples. The range of variation in soil level between facial wipes prepared by different panellists had an effect on the concentration of the oil within the fibrous structure.
It was concluded that while facial wipes provide a method for soiling fabrics with natural soil, the differences in soil levels and possibly in oil distribution must be accounted for in the experiment design of the research. Sanders and Lambert (1950) have compared the artificial soil with a natural soil using a Targo-to-meter is to clear the artificially soiled samples. The naturally soiled samples were washroom towels. These was washed in an ordinary washing machine. In both cases, there was gradual build-up of soil on the fabric and the build up was more rapid with some detergents then with others.

In case of wet soil the penetration of the liquid phase by capillary action will carry soil material into the interstitial spaces of the fabric. In that water is natural wetting agent for both the fabric and soil. On the other hand there are solid soils which are more readily wetted and dispersed by oil’s than by water in which oil as a vehicle will effect the greater penetration of solid material into the fabric (Utermohlen.1947).

One of the aspects of the oily component of soil namely, the ageing effect, was studied by Utermohlen and Wallace, (1947). It revealed that prolonged ageing makes the soil more difficult to remove. They showed that ageing was closely related to the degree and nature of the unsaturation of the oil molecule.

In the same study Utermohlen and Wallace (1947), discussed that soiling may take place in some indirect ways. Working with street dirt,
they found that a fabric may become soiled not only while in use but also even during laundering, in which case soil may be removed from one fabric and gets deposited on another. It may even get redeposited on the same fabric.

Durham, (1961), is of the opinion that solid dirt is extremely difficult to classify. At one extreme are carbon molecules as soot (charcoal), these are inert in the inter-fibre which is very difficult to remove. Other extreme was vacuum dust particles which completely remove by even simplest laundering.

Compton and Hart (1957) made an attempt to determine the bonding mechanisms of the permanent soil substrate complexes of carbon black and to evaluate the factor affecting them by studying various systems. They concluded that the reflectance coefficient were large. In this test there was less than 0.100 units of reflectance differences.

Utermohlen, (1947) has discussed the effect of washing cotton fabrics. The investigator found that cloth containing 5% or more starch was more darkly soiled that unstarched cloth was darkly soiled than unstarched cloth from carbon-tetra chloride dispersion of lamp-black. The soil was more readily removed from starched than from unstarched clothes.
FACTORS AFFECTING ON SOILING

(a) *Fibre morphology*

Soiling in general has been compared by many workers to the dyeing process and, since the morphological state of a fibre plays a great part in dyeing, the effect of crystalinity and orientation on soiling was examined. In a study by Bowers and Chantry, (1969), continuous filament polyester yarns of varying draw ratio’s were prepared, and the amount of sebum absorbed was measured gravimetrically. Since these fibre’s were of varying denier, this study also provide the opportunity to study the effect of denier on soiling.

The results showed that as draw ratio increases, the amount of body sebum absorbed and retained after washing also increases. The compactness degree of order and total crystallinity of polyester fibre increases on drawing and, if this type of soiling were diffusion-controlled, one would expect a decrease in absorption as the draw ratio increases. The exact opposite is observed, indicating that crystallinity has no effect, or that the effect of denier. As these data show, there is good correlation between denier and the amount of sebum absorbed. This type of behaviour would be expected only if soiling was surface-controlled, rather that diffusion-controlled, since as denier decreases surface area per weight increases.
Over all fibre morphology, does not directly contribute to soiling. Dry heat changes both orientation and crystalline structure of polyester fibre. Even though fibre morphology does not directly control soiling phenomenon in polyester, it is at least partially responsible, because it controls the fibre hydrophobic-hydrophilic characteristic.

This important fibre parameter relates to soiling across several chemical types of man-made and natural fibres. In polyester, small changes in moisture in the atmosphere affects the degree of soiling.

(b) **Fabric Construction**

Bowers and Chantry (1969), have quoted the effect of fabric construction on absorption and soil retention. According to them mechanism by which soiling occurs, on single filament of textile fibres may be completely eliminated as these fibres are constructed into wearable garments. This important variable was investigated first by soiling and washing four times, four unfinished 100% cotton fabrics having different constructions; Oxford, broad-cloth, poplin and twill. Percent soiled after wash was determined. The result shows a gradual deterioration in fabric appearance weights of fabric increase. They have also observed that weights of fabric only partially controls retention of soil. The softer, more loosely woven oxford containing large Law-twist yarns is considerably easier to clean than the board-cloth which has small highly twisted yarns, woven closely together.
According to Nelson (1955), when cotton fibre becomes soiled with extremely small particles, their removal by any means short of the fibre is virtually impossible. This indicates that carbon particles in this low size range do not make up a large part of the natural dirt encountered in ordinary use. Since, if they did, soil removal even by severe laundering would be a more serious problem than it actually is.

According to Nelson (1955), two main factors affect the way soil gets deposited on fabric. These are:

(a) Geometry of fabric construction

Soil gets deposited in relatively large spaces between the yarns and in the smaller systems of pores between the fibres of yarn.

(b) Morphology of fibre soil
gets deposited in the fine angles formed by single fibres and in/on the microscopic fibre surface itself.

(C) Fabric finish

Berch & Peper (1964), recognised the tremendous effect that resin finishes can have on surface properties of cotton. It is apparent that these chemical finishes change the bulk fabric properties, and therefore are one of major importance in the gradual whiteness deterioration of polyester/cotton garment's. The hydrophobic/hydrophilic nature of the substrate is one parameter that is drastically affected by these treatments.

When a fabric is hydrophobic, it is generally oleophilic and can absorb
and retain larger quantities of body sebum which leads to increased retention of carbonaceous soils.

A series of polyester, polyester/cotton and cotton twill fabrics were treated with a commercial glyoxal type resin and the moisture regain of each of the treated fabric was determined by weighing boundary samples. (even dried 3 hours at 105 °F) allowing them to condition for 16 hours at 65% relative humidity and 73 °F (23 °C) and weighing again. Fabric were then soiled by using spangler’s soiling procedure. The results, showed a linear decrease in soiling as regain of moisture increases. It should be noted that resins are only one of many additives present in commercial finishing formulations. While these chemicals have shown to increase, soiling, the variety of softness, hard builders, wetting agents, etc. can also have a deleterious effect on maintaining the fabric’s original appearance.

(e) Synergism between oily and particulate soil

Particulate soil found on clothing is often covered with body sebum. The particles can become embedded in a fatty matrix, or the oil can encapsulate the particle and/or the fibre. The retention of soil particles has been observed to increase when sebum was present to investigate this synergism, laboratory soils of oil and clay where applied in different orders and individually.
Table 1. Soil removed and whiteness indices after laundering for oily and clay soil treatments.

<table>
<thead>
<tr>
<th>Soil treatment</th>
<th>Soil removal(%)</th>
<th>Whiteness</th>
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<tbody>
<tr>
<td></td>
<td>Clay</td>
<td>Oil</td>
</tr>
<tr>
<td>Oil only</td>
<td>--</td>
<td>42</td>
</tr>
<tr>
<td>Clay only</td>
<td>83</td>
<td>--</td>
</tr>
<tr>
<td>Oil/Clay</td>
<td>66</td>
<td>36</td>
</tr>
<tr>
<td>Clay/Oil</td>
<td>54</td>
<td>23</td>
</tr>
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As shown in Table 1 the multi component soils-oil/clay and clay/oil-where removed less effectively from the fabric when either clay or oil alone. The unwashed specimens soiled with oil followed by an application of clay exhibited higher level of clay on fibre surfaces than the other two clay treatments (clay only and clay/oil). Soil entrapped within sheaths of oil, resulting in tenaciously bounds oil. The multi component soil of clay and oil was located in the crevices between the closely spaced fibre, which is the region where residual oil was observed, samples soiled only with oil. Thus it appears that clay is attracted to oil.

When the oil was applied before the clay, the yarns were coated with a smooth layer of oil which served as a fatty matrix to entrap the clay platelets.

When the oil was applied after the clay, the fluids soil encapsulated the soil particles, tenaciously cementing the clay to the fibre surfaces. These suggests that the clay absorbs oil and/or the oil binds clay, forming a composite soil as observed on the shirt collars.
The soiling properties of different fabrics will also be influenced by the physical characteristics of the fibre, yarn and fabric (Bensiek 1971).

Cotton fabrics absorb about 7 to 10 times more oil during wear than fabrics containing synthetic fibre, while retaining about 3 to 4 times more soil after laundering (Obendroff, 1983).

Weatherburn, (1955) is of the opinion that fibre morphology in polyester is only partially responsible for soiling because it control's the fibre hydrophobic hydrophilic characteristics.

[2] DETERGENT

2:2:1 History of detergent

2:2:2 Types of Detergent

2:2:3 Market detergent

2:2:4 Factors affecting on detergency

(2:2:1) History Of Detergent

During world war I, there was an acute shortage of fats and attempts were made in Germany and other countries to produced another substance having the following two properties ;

(a) It's power to lower the surface tension of water, (b) It's property of emulsifying oil and fats.
These substance termed as "detergent". The first detergent was developed in 1860 and known as Turkey-red-oil. This synthetic compound was developed to compete with washing soda. It is used for dyeing purposes. The next detergent prepared was Lauryl sulphate, prepared from coconut oil. Another important detergent prepared commercially is dodocyl benzene sulphate.

While first synthetic detergents were produced in the thirties and early forties, due to the second world war, they were not manufactured on a large scale. It was only after the end of world war II that synthetic detergents examine to be used on a large scale. There was a rapid growth of detergent industry during 1945 and 1955, in U.S.A. Detergents were introduced in the Indian market by Hindustan Lever and other multinational companies. Tata oil mills, Godrej, Nirma and some other Indian companies started manufacturing detergents in the late sixties.

Extensive marketing and advertising on both audio and visual media have made detergents very popular for daily washing and cleaning operation.

The synthetic detergent industry with annual

2:2:2 Types of detergents

(a) Anionic

(b) Cationic
(c) Non ionic

(a) Anionic detergent

Anionic detergent are those which dissolved in water, and divide into components having positive and negative charges. These phenomenon is known as ionisation. The heavy part or the long chain part of the anionic detergents carries a negative charge on, electrolytes of thus solution migrate towards the anode and hence detergent of this type are called anionic detergent. Anionic detergent exists depending upon their chemical constitutions. Anionic detergents are used in greater quantity for formulation. Alkyl Aryl sulphonates is one type of this detergent which is made by the chlorination or cracking of straight-chain Hydro carbons of $C_{12-18}$ chain. Material is usually designated by the following formula

Fig:

\[ R \]

\[ \text{SO}_3\text{Me} \]

Anionic detergents are used for producing law sudsing. Heavy duty powders and liquids.

(b) Cationic Detergent

In cationic detergents the case is reverse than anionic detergent. On ionisation in water, the heavy component of the molecule of cationic detergents carries a positive charges. However, cationic detergent are
rarely used in textile for detergency problems and are widely used as softeners. Cationic detergent can be determined either by reversing the filtration of cationic detergent. This class of detergents has the positive ion functional while the negative ion, which is either CH or HSO₄ etc., is the solubilizing ion. Thus cationic are some kind of bases whose hydrochloride or chloride or bisulphate etc. slats are soluble. However, cationic are not used as wetting agent or detergents but their use are more dependent on their positive charges. They are used as a dye fixing agent for soluble anionic type of dyes like the direct dyes. The big cat ion combines with the bigger in soluble complex, which is not easily wasted out. They are also used as a softening agent, as anti-static agent, as dyeing assistants as water.

Cationic detergents are characterised by the fact that, in aqueous solutions, the oleophilic moiety is positively charged. Cationic detergent are seldom used, exception foam controllers in laundry detergents, because of there incompatibility with anionic detergent. They are employed in combination with non ionic in speciality formulations.

(c) Non-ionic detergent

These are neither acid nor base. In fact they do not ionise at all. Their solubility in water is due to the multiplicity of OH groups. Non-ionic are very versatile products. They have been used as a wetting, dispersing agents, detergents, softeners and anti static agents. Since they
are neutral, they have a special advantage where alkalinity of anionic is a disadvantage as in the case of scouring of wool.

In cotton textile by David Sobolev (1970), the advantages which non-ionic surfactants have over their counterparts are good detergency, liquid form, no subsequently good wetting and dispersing power, stability, good compatibility and easy removability on washing.

Non-ionic substances include compounds obtained by the condensation of alkyl phenol, fatty acids in alcohols, amides, amines and merceptance with ethylene oxide.

According foster (1971), non-ionic detergents have shown a remarkable increase in economic importance in recent years. This expansion has been caused by steadily decreasing manufacturing costs, a wider range of availability and increased acceptance for use in a greater variety of formulations.

(2:2:3) Market Detergent

According to Durham (1961) very first detergent sold in large quantities for house-hold were merely simple solutions of anionic detergent in water of active concentrations varying from 5 to 20%. They rapidly become standard house-hold washing powder. Recent years these light duty detergent have become more sophisticated and liquids
have now appeared with builders for many heavy duty washing. More particularly in house-hold washing machine.

In today's society, the choice of a commercial detergent product for laundering of garment necessitates consideration of the efficient washing and reasonable cost.

Karl et al. (1975), emphases said that synthetic detergent for house-hold used are heavy duty for the washing machine and light duty for hand washing especially of delicate fabrics. These product have been powders or spray-dried particles, but recently there has been a shift to heavy duty liquid from light duty liquid detergents, a tend which will probably continue.

DIFFERENT MARKET AVAILABLE DETERGENT

(a) High sudsing heavy-duty laundry powder and liquid.

(b) Low sudsing heavy duty laundry powder and liquid.

(c) Detergent powder with enzymes.

(a) High sudsing heavy-duty laundry powder and liquid.

These product for general house hold laundry operations are normally formulated with 10-20% detergent based. Usually alkyl-aryl sulphonate or fatty alcohol sulphate, or combination of these materials
up to 10% sodium silicate is usually, added to inhibit corrosion of washing machine parts. The major builders added at a 35-50% level, are sodium try-pole-phosphate \((Na_3P_3O_{10})\), sodium pyro phosphate \((Na_4P_2O_7)\), or combination of these two. The liquid product contains essentially the same ingredients as the powders. Small amount of thickeners, such as methyl cellulose, are invariably present in these liquid product.

(b) *Low sudsing heavy duty laundry powder and liquid.*

Anionic detergents are used to formulate this type of product, in addition small amount of non-ionic detergents are added to in part controls suds. Liquid and powder types differs mainly in their water contents, however, the powders may contain increased quantities of fillers, such as sodium carbonate or sodium sulphate. Both types use the same phosphate and silicate builders as described in the high sudsing variety.

* Liquid Detergent

Sandoz (1974), has studied and introduced highly efficient virtually non-foaming detergents under the trade name of "sandonpan Lf liquid", which is especially suitable for cleaning surface preparations from textured polyester fibres. It has a high degreasing capacity. This
liquid detergent also permits large amounts of spooling oil, causing undesired foam formulation to cleared from the fibre surface, and it is thus cleaned to ensured perfect prints and dyeing on the pre-washed goods. The viscosity of liquid detergent is an important consideration from the processing point of view.

(c) Detergent with enzymes

The newest entries in the detergent market are the stain removing enzyme detergents. Two types are currently sold:

1. The pre soak varieties, which are used prior to washing and relay on the stain removal via enzymes action during lengthy soaking, and,

2. The regular type, used in normal washing operation and relaying on enzymatic stain removal during the normal wash cycle. Up to 1% enzyme is present in such products.

(2:2:4) FACTERS EFFECTING DETREGENCY Chawala (1943), had listed factors;


4. Emulsifying and dispersing power 5. Age of bath prior to washing

According to Sesly (1943), listed factors effecting detergency:
A. (a) Wetting power (b) Foam power (c) Emulsifying power (d) Dispersing and de-flocculating power (e) Protective action against redeposition

B. (a) Nature of detergent bath (b) Nature of the substrate surface (c) Nature of soil (d) composition (hardness) of the water used and its effect on the substance to be cleaned.

C. (a) Chemical nature of the detergent (b) Concentration of detergent (c) Temperature (d) Degree of mechanical action (e) Duration of treatment

Vastava et al (1984), Sanders and Lambent, (1984) have described the steps involved in the removal of a soil particle adhering to a fibre surface.

(A) Penetration of a thin liquid between the particle and the fibre surface of the particle and fibre with adsorption of substances in the wash liquor such as that of the detergent.

(B) Transport of the discharged soil particle into the bulk of the wash liquor.

Durham (1981), Although detergency is diverse a unifying element exists in the structure of detergent molecules. Every detergent molecule consists of a polar group attached to a long non-polar
hydrocarbon chain. For example; detergent sodium lauryl sulphate has this structure:

\[
\begin{align*}
O-\text{Na}^+ \\
\text{C}_{12}H_{25} \quad \text{OS}=\text{O} \\
\text{O}
\end{align*}
\]

The shaded structure is the non-polar hydrocarbon chain.

It is because of this peculiar molecule structure that, detergent solutions passes good wetting and emulsifying power, so that they foam and are capable of cleaning soiled surfaces.

Kissa, (1981) has described detergency as a process involving three consecutive steps:

[1] *An introduction period* equivalent soaking during which water and detergent diffuse into the soils substrate, but soil removal as such is slow or insignificant. The length of introduction period depends upon the rate of agitation, the nature of the soil, the detergency and the substrate.

[2] *The soil removal period*

(a) Most of soil particles adhering to non-polar end of the detergent molecule and is pulled away from the surface of the fabric and into the liquor due to hydrophilic nature of the polar end of the detergent molecule.

(b) Some of the soil particles, especially those consisting of oily substances, however, may get emulsified (i.e. form small droplets of oil and disperse in water).
(c) A very small portion (like salt from perspiration of soil gets dissolved in water).

This is how soil is removed from fabric.

[3] *In the final period* the soil removal is very slow or negligible.

(2:2:4) **FACTOR AFFECTING IN DETERGENCY**

(a) *Quality of water* (Sesly, 1943)

Water used for laundering purpose must be soft. When hard water is treated with soap, the latter is removed from water as an insoluble precipitate and is not available for detergination until all the calcium and magnesium salts are removed, that is until the hard water is softened. Chemicals dissolved in hard water make part of detergent used in effective by reacting with its molecules.

*Temperature of water*

Water temperature has been partially affecting on the fabric during washing, because some enzymes has been greater effective during washing, after water temperature is above 45 °C, its act as a good cleansing agent.

Temperature of which washing takes place also determines the efficiency of a detergent optimum temperature has been found to be 53 °C.

(b) *Detergent concentration*
To determine the optimum concentration of detergent for cleaning a given fabric, different concentrations were used with polyester fabric. Optimum concentration of detergent for cleansing polyester fabric thoroughly was found to be 3 gm/litre. Whereas in an identical situation optimum concentration of detergent for cleansing cotton fabric thoroughly was found to be 1 gm/litre.

Most of the washing conditions now recommended by detergent manufacturers used by house by come from years of experience in washing. Soil fabric of unfinished 100% polyester and 100% of cotton were washed together at various detergent concentrations for 10 min. at 50 °C, in tar-go-to-meter. Both anionic and non-ionic commercial household detergent was used. The amount of soil (sebum) retained were determined gravimetrically on carefully weighed and conditioned samples. Results, were that cotton fabric/fibre is easily cleaned at practically every detergent concentration, where as polyester requires about three times the normal recommended amount of 1.0 gm./lit. which (corresponds to about 1 cup/wash load) to give adequate.

In fact at the recommended concentration of anionic detergent, the sebum, removed from the cotton, re-deposition the polyester fabrics, making them more soiled then they were before washing. In an associated experiment it was found that the non-ionic detergent was considerably more effective in cleansing polyester then the anionic
detergent (Bowers and Chantry, 1969). Therefore it was advisable to wash cotton and polyester garments/linen in separate.

(c) Mechanical Action

Mechanical Action is well recognised as one of the most important factors in practical detergency. Many practical cleaning operation, particularly those used on hard surfaces, depends on the mechanical action of the liquid bath to loosen and remove the soil from the substrate. The mechanical action was varied by varying the speed of the machine and the number of steel balls in the jars.

[2:3] SOIL REMOVAL

2:3:1 Process of soil removal

2:3:2 Factors affecting soil removal

[2:3] SOIL REMOVAL

Textile fibre differ in size and contour, as well as their chemical constitution. (Durham 1961). The type of fibre and its surface structure, as well as the final forms of woven or knitted textile, all affect soiling and their washing. (Compton and Hart).

The oil contain a proportion of dirt embedded within itself and also holds some of it to the fibre by adherence. Foreign particles may also be embedded in the structure of the fabric. Vigorous agitation in water alone will remove some of the dirt but the presence of a
detergent brings about detachment with much less violent effort. The cleaning efficiency depends very much upon the nature of the detergent.

In soil removal process, by treating the soiled cloth with optimum strength of detergent solution, the soil can be removed from the cloth.

Narris (1967), studied that when soiled articles placed in laundry machine with water detergent, theoretically the soil is removal from the fabric dependent on many factors. including water, temperature, type and amount of detergent and chemical composition of textile fibre being laundered. If there is not enough detergent present in wash water all the soil will not be held in dispersion.


Marcel (1984), stated that soiling and the soil removal of soils form fabric has been common problem. One of the most important criteria for determining the clothing value of the textile material is the accumulation of foreign matter or the fabric surface during its used and its removal so, as to clean it.

Smith and Sherman (1984), reported the efficiency of a given laundering process in effecting soil release from textiles as a complex function of the nature of soil, the manner in which the soil was originally distributed in the fabric. The surface energy of the textile fibre, the fibre surface topography and the overall fabric construction. The problem of
removal soil from textile by laundering has received much by skilled investigators over the course of many years.

Vaugh (1975), Mechanisms of detergency are discussed from the kinetic point of view. In general, soil removal involves
(a) An induction period during which soil removal is slow.
(b) A rapid soil removal period during which the amount of soil in the substrate decreases linearly with the increasing logarithm of the washing time.
(c) A final period during which the amount of soil retained does not decrease significantly. They have suggested that the rate of soil removal is proportional to the amount of removable soil. They conducted that the soil removal process follows first order of the kinetic.

The type of surfactant systems has a marked effect on soil removal from fibrous substrate. These surface active agent used in laundry detergents belong to a chemical class of highly polar, high molecular weight molecules that form micelles in solution. These molecules can be anionic, cationic, or non ionic in aqueous solution. On cellulosic fibres, the anionic surfactant are most effective in, soil removal, with non ionic surfactants being next in effectiveness.
Because of the small number of sites for ionic reactivity on polyester, Bowers and Chantry (1949) hypothesized that non ionic surfactant should be more effective than anionic or cationic surfactants.

They and Fort et. al (1966), demonstrated that the non ionic surfactants are most effective in cleaning polyester.

Soil removal involves roll-up mechanisms. It is well known phenomenon that occurs at the fibre/water oil three-phase boundary line. Therefore oily soil removal is intimately related to the wettability of fibres and fabric.

*Removal of solid soil

Whom, snell et.al.(1949) have investigated that the effort to stimulate natural soils in laboratory testing has influenced theories of the mechanisms of removal of mixed oil-solid soils, since it has led to the assumption that the same oil which binds the solid to the fabric plays an important part in the effective removal of the solid soil during washing. It is generally considered that the oil-forms a film on the solid or pigmenting component and binds them to the fibre surface. The problem of removal then are those chiefly with the water oil interface, and removal of the composite soil is accomplished byemmelsification.

It appears, however that this concept of soil removal is inadequate. Soiling of fabric occurs with material containing inappreciable quantities of oily matter. Moreover, the removal of the oily and of the solid
components in the fibre from which oil can be readily removed by washing while most of the carbonaceous soil is left on the fibres.

In the case of detergent solution use to remove soiling matter from the fabric, Hill (1976), divided the process removing soil roughly in to three categories.

(1) The solution must come in to intimate contact with the fabric and penetrate within the fabric.

(2) The oil which is usually present in the soil must be removed, when the soiling matter will usually come away fairly.

(3) The soiling, after removal must remain suspended in the solution and not be redeposited on the fabric.

Material Provided by Godrej Soap Ltd. (1997), the washing process involves two stages the removal of soil from the substrate and it disposal in the wash liquor without redeposition.

When a surfactant is dissolved in water the surface tension of the solution is progressively lowered until the concentration reaches a value dependent upon the particular surfactant used and then remains constant.

At the land surface, the surfactant ions are oriented, so, that the hydrophilic ends are in the water and the hydrophobic ends point out the outer end. Some what similar consideration apply to the removal of fatty soil from a substance by what is known as 'roll-up' mechanism. A solution which has sufficiently strong wetting properties in relation to the
substrate can penetrate under the soil and gradually ease it away as a droplet.

*Removal of oily soil.

Study conducted by Wellace & Utermohlen (1949), detergency experiments above indicate by Earl et. al. (1949), that the presence of oils in the artificial soiling mixtures caused little or no increase in the case with which the pigment soil could be removed.

They also find that drastic changes between the formulation of the applied soil use of an oil binder, of a non-oil binder, or of no binder liquid at all. Conclusion justified that removal of oily soil and of pigment soil from cotton cloth are largely independent process for artificial soils, and that the pigment does not depend for removal upon the presence of an oil. The authors consider it possible that the importance of an oil in aiding the removal of natural soils from cotton fabric is also slight or negligible, and believe that the previously postulated theories of the mechanisms of removal of solid soil from textile materials are in need of reconsideration.

In the presence of an oil component in artificial soiling mixture has no value in aiding in the removal of the solid pigment soil by washing. It might as well be omitted from the soiling dispersion. This omission would automatically eliminate the changes in the ease of cleaning of artificially soil fabric upon ageing. Which are due to
polymerisation of the unsaturated components of the oil. Tukuzo et al. (1992), stated that oily soil removal is intimately related to the wettability of the fibre and fabrics.

The relationship between the detergency of non polar oily soil and the wettability of fabrics determined by capillary spreading measurement Kawase (1990), The result are discussed in terms of the work of adhesion of the oil for the fibre immersed in a surfactant solution.

**FACTORS AFFECTING SOIL REMOVAL**

1) Nature of fabric

2) Effect of pH on washing

3) Fabric finish

1) *Nature of fabric*

Bowers and Chantry (1949), Polyester fibre requires more detergent and longer washing comparatively cotton fibre requires less detergent and shorter washing. They have also recognised the important role that fabric can have on absorption and retention. It is obvious however, that fabric weights do not entirely control retention of soil.

2) *Effect of pH on washing*

Durham, (1961) studying the behaviour of metal oxide soiling on cotton has noted that optimum cleansing takes place at a pH value of 9.5., David son and Mil widsky (1967), explain the effect of pH value on
cleansing cotton goods, which are still the bulk of household wash, require a moderately high alkalinity. On contact with such a solution the cellulose fibre swells slightly, allowing the water to penetrate into the fibre thus loosen adhering dirt.

So, it self is decomposed by acid and hydrolyses to a certain extent even in pure water this hydrolysis lower the concentration of effective detergent by converting it in to the foam of free fatty acid, devoid of detergent powder.

(3) Fabric finish

Berch and Peper (1964), recognised the tremendous effect that resin finishes can have on surface properties of cotton. It is apparent that this chemical finishes change that bulk fabric properties, and therefore are of major importance in the gradual whiteness deterioration polyester/cotton garment's. The hydrophobic/hydrophilic nature of the substrate is one parameter that is drastically affected by this treatments. When a fabric is hydrophobic, it is generally oleophilic and can absorb and retain larger quantities of body sebum which leads to increased retention of carbonaceous soils.

A series of polyester, polyester/cotton and cotton twill fabrics were treated with a commercial glyoxal types resin and the mixture regain of each of the treated fabric was determined by weighing bone dry samples (Oven-dried 3 hours at 105 °F), allowing them to condition for 16 hours
at 65% relative humidity and 73 °F (23 °C) and weighing again. Fabric were then soiled by using Spangler's soiling procedure. The results showed a linear decrease in soiling as regain of moisture increases. It should be noted that resins are only one of many additives present commercial finishing formulations. While these chemical have shown to increase soiling, the variety of softeners, hand builders, wetting agent etc. can also have a deleterious effect on maintaining the fabric's original appearance.