II REVIEW OF LITERATURE

The review of literature in the present study is discussed in the following sections.

2.1 Effect of dry and wet abrasion on fabrics.

2.2 Effect of acrylic finishes on abrasion in fabrics.

2.3 Effect of finishes in general on other properties.

2.1 Effect of dry and wet abrasion on fabrics

The wear life of a fabric is an important element in determining consumer satisfaction with a textile product and one of the factors influencing the wear life in the fabric is abrasion resistance. Fabric abrasion can be studied using several approaches. Humberger (37) pointed out the importance of fabric geometry in the translation of inherent fibre properties to the final structure. A major form of damage to yarn structure is plucking and tearing producing a cyclical pattern of increasing and a decreasing amount of fibre disarray within the yarn. These types of the yarn damage have been observed after Accelerator abrasion and after actual wear and laundering. Galbraith (31) suggested sequences of changes in fibre yarn and fabric structure as a result of abrasion. These changes involved a cyclical pattern of fibre dislocation followed by fibre breakage. Clegg (15) reported the following type of fibre damage in worn garments - transverse marking and cracking of cotton liners/..

liners, silk and wool brusing, and critical damage to cotton and wool and fibrillation of cotton and liners.

Rollins et al (59) reported that dry abrasion of cotton caused surface smoothing followed by surface lumpiness with crushing and smashing.

Resin treated cotton fabrics and their controls were subject to accelerated laboratory abrasion on the Accelerotor, the Stoll Flex Quartermaster Universal Wear Tester and the wash wheel. Dry and wet abrasion were tested. Similar fabrics from actual garments put through normal wear trials were also investigated in order to compare abrasion damage occurring in normal wear life with that resulting from acceleratory laboratory abrasion. Abraded samples were examined with the aid of scanning electron microscope. The type of damage depends upon the abrasion test method adopted. Damage resulting from actual wear conditions is different from that resulting from any of the Accelerated test methods employed and can not really be simulated by any single laboratory test available at present. Therefore it is not surprising that very poor correlation has been observed in the past between actual wear life of fabrics and accelerated laboratory abrasion tests.

The Work by Galbraith et al (30) on blend fabrics indicated that a laboratory test method which involved a stress-to rupture the cotton fibres in polyester/cotton blend followed by a tumbling-abrasive action to remove the cotton fibres fragments. This made it possible to rank several jean-fabrics in/..

in the order of a tensile stress or multidirectional stress used to rupture the cotton fibre.

Abrasion caused little change in the length distribution of polyester fibres of fabrics at final levels. Abrasion caused less strength loss for the resin finished cotton fibres of the crease resistant and durable press fabric than for the fibres of the pure finished fabrics.

Work done by Dweltz (22) showed that cotton fabrics at different stages of chemical processing, were abraded to different extents. The work was on a WIRA abrasion tester with three different abradants, namely, a smooth paper, a similar paper with rough unfinished surface and a standard worsted fabric. Three different plain weave cotton fabrics selected were (a) desized and scoured (b) bleached and mercerized and (c) dye and resin treated. Scanning electron microscopy revealed that progressive chemicals, especially resin finishing reduced the abrasion resistance of these fabrics. The rate of attrition of the cellulosic material at the surface of the fabric was much faster for the rough paper than for a smooth type of paper abradant. The cross-bred worsted abradant was less severe than paper in its abrasive action. It also produced in general a more fuzzy fabric surface. Resin treated fabrics had fewer of these loose surface fibres than the other two samples, particularly the scoured fabric, which had the most. In the resin treated fabrics, the abraded single fibre/..

fibre-ends did not exhibit any twisting, whereas this characteristic feature was rather extensive in the non-resin finished samples. The lack of twisting and rolling of fibres probably arose from the constraints imposed by the resin crosslinks which made the fibres more rigid and caused them to tend to fracture or rupture sharply rather than fibrillate over a somewhat extended length.

Microscopic studies of the abrasion of durable press cotton fabrics have been mainly limited to abrasion produced on laboratory instruments and laundry treatment rather than that produced by actual wear. Comparison was done between the shirts which were not worn but abraded in both ways, dry while wearing and wet while washing, and the shirts which were worn and abraded in both ways dry and wet conditions. The type of damage was the same for both as the fabric was resin treated. The outer layers had been smoothed off from the less severely damaged fibres and deep cracks at a wide angle to the fibre axis were frequently observed. In the case of polyester shirt damage was less, perhaps the polyester fibre acted as a shield and protector for the cotton fibre present. This was reported by Margret (46).

Test methods in the study done by Dweltz (22) included:

(a) dry abrasion for 100 cycles on warp strip employing the Soil Flex Quarter Master universal wear tester with standard carbide steelbar.

(b) dry abrasion of a 4" x 4" test sample in an Accelerotor using a 250 fine grit emery abrasive liner at 2000rpm for/..

for five minutes.

(c) wet abrasion of a 4" x 4" in test sample in an Accelerotor using a corrugated (ribbed) abrasive liners for ten minutes at 3000rpm and

(d) repeated wash cycles in standard garments wash and wear (each washing at 95°C for 30 minutes followed by linedrying) until major damage occurred at one place on the fabric. Samples were examined after 15 cycles of wearing of the garment followed by the laundering after each wearing operation.

In general the number of abrasion or wash and wear cycles withstood by the resin treated fabrics to the experience of the first home were very much less than that of the control. Therefore abrasion wear was restricted to low levels and the damage to individual unbroken fibres at the fabric surface was determined in regions where abrasion was apparent but no hole yet formed. Hence the number of wear trials employed in the study was not a measure of the size of the garment but was only to determine the nature of damage imparted during the course of actual wear and laundering operations.

Rollins (59) published a transmission electron microscopic survey of replicas of abrasion pattern of various modified cottons including a limited number of samples abraded by laundering. In using the replica technique, only restricted areas of fabrics are visible, but differences in character of wet and dry abrasion were noted. No specific comparison of/..

of washer and drier action was attempted. Since wet and dry abrasion are known to produce different types of damage in cotton fibre, it was of interest to determine wheter a correlation exists between washer damage with dry abrasion. The scanning electron microscope presented an effective means for pursuing such a study.

Elder and Ferguson (23) studied the abrasion resistance of some woven fabrics with plain wear as determined by the accelerotor abrasion tester. The materials were ranked in order of decreasing resistance to abrasion with carborandum, rubber, metal and plastics abradants. Polyamide fibres have outstanding resistance to abrasion and cellulose ester and regenerated protein fibres have poor resistance to abrasion. Microscopical examination of detritus confirmed that this consisted of small segments of complete fibres which indicated that abrasion occurs on fibre breakage. A useful correlation is established between the specific strength and initial modulus of a fibre or the energy of rupture of mechanically conditioned fibres and the abrasion resistance of a fabric.

2.1.1. Effect of abrasion on surface characteristics of fabrics

In the abrasion study carried out by Soni (65) to get some useful information on the nature of abrasion caused by coir under conditions of dry, wet and alternate dry and wet abrasion and its effect on physical properties of cotton/..

cotton, polyester and their blends. In general, the results from abrasion had some relationship with performance in use as conditions used for the test were of slow wear. The conclusions were as follows:

(a) The raised surface initially increased and then decreased in dry, wet and alternate dry and wet abrasions, due to teasing out of the fibres from the yarns resulting in fuzzy surface. With subsequent abrasion, fibres became detached and flattened.

(b) Bending resistance decreased with increasing dry abrasion.

(c) Dry abrasion had little effect on air permeability in cotton fabrics, in others dry abrasion decreased air permeability.

(d) The tensile strength decreased with increasing abrasions (all types).

(e) The percentage elongation decreased initially and then increased after dry abrasion. Elongation was the highest/the most in wet abrasion and intermediate in alternate dry and wet.

Coir was found to be simulating slow wear like that in actual use of different fabrics including polyester cotton blends.

Vyas (68) concluded in her abrasion study that coir-cum-rubber abradant allowed formation of pills as a result of/..

of flat abrasion. Pill formation also depended on fibre content of the blended fabric. Greater polyester fibre content led to more pill formation.

Masih (47) concluded in flat abrasion study that there was decrease in tensile strength, elongation and elastic recovery with the increase in abrasion. But air permeability increased with the increased abrasion. Pilling tendency of fabrics increased with increased abrasion.

Parkhani(56) and Shah (62) concluded that percentage tensile strength decreased gradually after dry and wet abrasions. Percentage elongation after dry abrasion first decreased and then increased. Percentage tearing strength after dry and wet abrasions also decreased with increase in abrasion. No relationship could be established between dry and wet abrasions. The formation of theory of abrasive wear was thus noted as complex. It was suggested that the useful life was possible before the elongation tends to decrease from the plateau.

The pilling tendency in cotton fabrics as a result of repeated laundering has been reported by Chanchal (10). This was due to the extensive deterioration of the cellulosic content leading to finer and softer yarn, after repeated laundering. The structure of grain and construction of the fabric had been observed to be more open that ultimately led to an increased number of protruding fibres resulting in/..

in greater pilling tendency. Similar findings were reported by Grant (33).

Good after-wash performance in a fabric is achieved by the fabric-resistance to external and internal distortional forces. A good crease recovery property in wet and conditioned state is essential to have a good washing appearance.

Chanhal (10) stated that with the increased abrasion cover factor was decreased and crimp was increased. laundering had affected fabric thickness and fabric weight. There was an increase in picks/on and in thickness but fabric weight decreased as a result of increased laundering.

2.1.2. Effect of abrasion, in general.

Abrasion resistance is one of the important properties of fabrics and has a bearing over several other properties like durability, serviceability and pilling. It is well known that life of a ring spindle tape depends upon its resistance to abrasion also. Any abraded fabric will be discarded as unserviceable because of its ugly appearance as a result of loss of mechanical properties, wear pilling and colour patch.

The term "wear" as applied to fabrics is believed to be more closely associated with the conditions surrounding everyday use and service, the combined effects of several factors/..

factors such as stressing, staining, laundering, drycleaning, creasing etc. including abrasion. It follows that simulating these conditions in the laboratory to assess the wear life expectancy of a fabric is a formidable task. However abrasion resistance of a fabric could serve as an indicator and can be readily determined in laboratory, albeit the result being qualitative in nature for comparative assessment only. Abrasion may be generally classified as:

a. Plane or flat abrasion wherein a flat area of the material is abraded.

b. Edge abrasion wherein the kind of abrasion which occurs on folds (eg. collars, cuffs, trousers, bottoms etc) is simulated.

c. Flex abrasion wherein rubbing is accompanied by bending.

In actual service a fabric encounters some or all types of abrasion with objects covered by or with surface in contact with it. These can be of all shapes and sizes as well as with varying degrees of hardness or softness. Thus the serviceability of a fabric as determined by one of the many causative factors viz its wear life can be partially assessed by estimating its abrasion resistance. The reduction in the serviceable life of apparels due to wear caused by flat abrasion is a slower process than that caused by either flex or edge abrasion. Hence the choice for flex abrasion resistance determination, also the variation in the/..

the abrasive quality of the extremely hard carbide tipped foexing bar can be considered negligible.

Abrasion resistance properties of fabrics play an important role in the selection of apparel and industrial fabrics. The author (10) describes an experiment to study the effect of weave and set on resistance to abrasion and threaded slippage properties of woven fabrics. The rub properties such as resistance to abrasion and thread slippage force are highly correlated. A linear relation exists between them. Thread slippage force in fabric therefore has been considered as a laboratory method for evaluation of abrasion resistance.

In a study, Neelakantan and Mehta (3) have tried to identify the physical properties of an easy-care 100% cotton fabric that can correlate with the end use performance of garments made out of this fabric. They analysed two sets of data. From the first set of data the performance of the twelve plain weave fabrics of different counts and construction but resin finished and cured under similar conditions has been obtained in terms of the number of wear wash cycles which shirts made out of these fabrics could withstand before showing the first sign of damage. In the second data fabrics of different weaves and construction, the performance has been obtained in terms of the number of laundry cycles that cuffed trouser legs could withstand before showing the first sign/..

sign of damage.

Preliminary studies on these data indicated the complexity of the phenomenon of wear performance of a fabric from knowledge of its initial strength and elongation. Further there is no need to conclude if the laboratory assessment of abrasion resistance between the value of the regression co-efficient do not exhibit any trend with the wears or weight/unit area of the fabrics. This suggests the need to identify other treatment parameters that are related to the fabric wear life.

Among the various physical properties, resistance to abrasion has been considered as a major factor in determining wear life. This has led not only to the development of more than sixty abrasion machines but also to extensive studies to understand the influence of fabric construction, yarn count, weave and chemical finishing treatments and abrasion resistance. However available evidence indicates that it is difficult to draw conclusions on the end use performance of a fabric based on studies on abrasion alone.

2.1.3 Studies on different abrasion machines

Galbraith et al (30) studied the fabric break down mechanisms which occurred during the laboratory abrasion of matched 100% nylon and 100% cotton fabrics. They found that the abrasive wear damage caused by Accelerotor and Schiefer/..

Schiefer and Stoil Inflated Diaphragm abraders occurred primarily at the yarn surface. As the fibres on the yarn surface were worn through, the abrasion damage proceeded inwards by peeling off the successive layers of the fibres.

2.2. Effect of acrylic finishes on abrasion resistance properties of fabrics:

2.2.1. Effect of finishes in general

Finishing of textiles is important to enhance the saleability of fabrics, so also their suitability for end uses. The finishing modifies the properties of textiles and influences the wear rating. The finishes alter the feel, the appearance, the soil resistance, the tear strength or the wear resistance of fabrics, so also affect the abrasion resistance.

The improvement in the appearance involves shine, whiteness, and fullness in feel (that is softness, smoothness and stiffness). Depending on the end use, some properties are desirable in the fabrics, such as dimensional stability, wrinkle recovery, pilling resistance, some level of flame retardance, soil release property etc. The properties of the unfinished material are governed by the fibre composition, construction of the fabric as well as conditions of the precautions taken during pretreatment. The finishing techniques and chemicals will differ for fabrics made from different fibres. The blends like those containing/..

containing lower percentage of polyester, require different type of finishing. This is similar to that of cotton. Finishes improve some properties such as hand, wrinkle resistance and stain or soil resistance in addition to abrasion resistance (6, 11).

However it has been investigated (32) that when abrasion conditions are mild (low abradant pressure and predominantly frictional abrasion) the resin finishes may increase rather than decrease abrasion resistance. Reeves (58) reported that resin finishing of cotton lessened the tendency of its fibre ends to be teased to the fabric surface. In both studies the resin finished fabrics had greater weight loss than the non-resin or pure finished fabrics but retained a greater percentage of their original breaking strength after abrasion. This fact was confirmed by both Haycook (35) and Warfield (71). These authors concluded that the better retention of fibres within the yarn struture of the resin finished fabrics contributed to greater inter-fibre friction and therefore higher fabric breaking strength, even though the fibre fracture and loss of fibre fragments was greater for these fabrics than for their pure finished counterparts.

Rollins et al (59) found that the type of abrasive damage altered when cotton fibres were reacted with cross-linking resins. Untreated cotton fibres abraded dry showed/..

showed surface smoothing and brushing. As abrasion damage became severe, transverse cracks appeared and triangular wedges were pinched out of the fibre sides. When fibre broke, fibre ends were mangled and frayed, fibrillated and brushed.

According to Fortess (24) and Marsh (48) the objectives of finishing are:

a. to improve aesthetic qualities.
b. to impact specific functional properties not inherent in fibre or fabric.
c. to improve easy care characteristics.
d. to improve durability by improving certain service qualities.

As stated by Nanavati (54) there are mainly three types of finishing treatments with resin, namely anti-crease finishing, wash and wear finishing and durable press finishing. Though the method of imparting anti-crease finish or wash and wear finish is essentially the same, the difference is only in the type and level of the crease recovery. In wash and wear fabrics, along with dry crease recovery, wet crease recovery is also important, because dry crease recovery is responsible to a large extent for the wrinkle resistance during wearing, whereas wet crease recovery is most important in smooth drying property after washing. In durable press finishing fabrics are treated with high concentration of resin i.e. about 8 to 10 percent. The losses to mechanical properties/..

properties are higher with durable press finishing than those with easy-care finishing.

Thermoplastic Finishes

Thermoplastic finishes are those polymers which consist of long linear moleculas accompanied by some branching but not inter-connected (i.e. cross-linked from molecule to molecule). These plastics rapidly soften and melt with heat and re-harden to rigid materials upon cooling. Generally there is no appreciable change in the physical properties of the thermoplastics through repeated heating and cooling cycles. They may be re-melted and re-shaped until they do not introduce charring or degradation to the re-worked material according to Harper (34).

Thermosetting Finishes

Thermosetting resins generally are liquids or low melting solids, which under the influence of heat, pressure, ultra-violet light, radio frequency excitation, catalysts and accelerators, are transformed into rigid products that are relatively infusible and insoluble. They can not be re-shaped or re-melted after they have been cured to their final state. Thermosets are cured set or hardened into a permanent shape. This curing is an irreversible chemical reaction also known as cross-linking, which usually occurs under heat. For some thermosetting material however, curing is initiated at room temperature.

The cross-linking that occurs in the curing reaction is/..

is brought about by the linking of atoms, between or across two linear polymers, making a three dimensional rigid chemical structure.

2.2.2 Effect of A) Lubricating finish, b) coating finish and c) wrinkle resistance finish.

a. Some finishes cause slippage of fibres and thus are of lubricating type lubricants.

a) Lubricants such as silicones or polyethylene compounds may improve flex abrasion resistance by increasing fibre and yarn mobility within the fabric structure. They have less effect on the flat abrasion resistance of a fabric, since this property is more dependent on fibre binding than fibre and yarn mobility. Murry (53) reported that these softeners increased the tear strength and elongation of resin treated viscose fabrics. These however reduced the flat abrasion resistance slightly and had little effect on the flex abrasion resistance. The mid-west (AATCC) scientists have reported that the cationic softeners lowered the tumbling abrasion resistance of cotton print cloth and corduroy, acetate-tricot and nylon tricot fabrics but improved the abrasion resistance of polyester cotton shirting, acrylic double knit and polyester double knit fabrics.

b) Coating finishes (62) often increase the flat abrasion resistance of the fabrics by increasing the fibre binding and by covering the fabric surface with some type of sizing or/..

or polymeric material but in the past have been less successful in improving flex abrasion resistance.

c) Wrinkle resistance finishes are applied to cellulosic fibres because of the poor elastic property of these fabrics. A large proportion of the apparel, bed linen and drapery fabrics containing these fibres are treated with cross-linking resins to improve fabric wrinkle-resistance. Such finishes increase elastic recovery but both the tenacity and elongation of the cellulosic fibre (especially for cotton) are reduced and thus drastically lower the ability of these fibres to absorb energy and their abrasion resistance. The lowering of resistance to flex, tumble or edge abrasion is particularly severe. This usually results in a short total wear life for all cotton fabric unless the loss is compensated for by using heavier and stronger fabric construction.

The distribution and migration of synthetic resin in normal ped-dry-bake sequence can be influenced by allowing time for these processes of resin in the peripheral regions of the fibre may improve the abrasion resistance without seriously reducing the crease recovery.

Acrylates, silicones, urethanes and polyesters applied with water soluble material for internal reaction improve the abrasion resistance of durable press finish particularly by laundering. The internal deposition of polymers followed by back coating only with cross-linking agent also improves the/..

the abrasion resistance as reported by Whitely (72).

2.2.3 Cross-linking Finishes

It was investigated by Cooper et al (17) that preferentially cross-linking cotton cellulose, in selected regions of the fabric structure, resulted in improvement of abrasion resistance as compared with conventionally cross-linked cotton fabrics. The application of polymer forming cross-linking agents to the wearing surface of fabrics causes a small improvement in wrinkle recovery and a significant reduction in apparent dye fading and surface fuzzing. The abrasive wear caused by washing under severely abrasive conditions can mask the abrasive wear under mild conditions of tumble drying so that the combined effects are not materially more abrasive than washing alone. They also found out that adequate curing is required for better performance.

A typical backcoating formulation consists of :

The cross-linking resin in concentration 12% to 30% (solution basis).

The catalyst 20% of the resin concentration.

A thermoplastic softener or combination of softness 2-5% of the solution and

A thickening agent (such as hydroxyethyl cellulose about 0.9%) to increase the viscosity sufficiently to prevent the solution from penetrating to the face sides of the fabrics.

It/..

It was reported by Carl Hamalainen et al (9) that the polyset process for durable press involved two pad-dry-cure treatments. In the first step N-methylol cross-linking agents were deposited on and within the cotton fibres primarily by polymer formation using weak acid polymerisation catalysts. Step two used a strong latent acid catalyst to cause more extensive cross-linking to obtain the desired smooth drying performances. The process is suitable for pre- and post-curing operations by essentially eliminating the release of formaldehyde after step one; this permits the use of most types of N-methylol cross-linking agents in delayed curing process. The efficiency of polymer deposition of the type of methylol cross-linking agents are noticed on the properties of the products. The process is particularly responsive to lubricant and softener additives in both step one and step two. Comparison of fabrics treated by the polyset process and those treated by the conventional process are made in respect to breaking and tearing strength, accelerators and flex abrasion resistance and resistance to chlorine bleaching.

Cotton fabrics were oxidises with nitrogen dioxide and sodium periodate and cross-linked with Dimethyleurea and with dimethylol dihydroxy ethylene urea by dry-pad-cure process. The effect of pre- and post-oxidation to resin treatment on the crease resistance and tensile strength properties of cotton fabric have been investigated. The results/..

results show that crease recovéry angle increases with degree of oxidation and further periodate oxidation causes the release of strain in cellulose structure, thereby lowering the loss in textiles strengths. Resin treatment on the other hand improves alkaline sensitivity of periodate oxycellulose. Periodate oxidation and resin treatment therefore seems to complement each other.

2.2.4 Polyacrylic finishes - their preparation and properties

Polyacrylamide (PAAM) is a synthetic polymer soluble in water, formaldehyde, glycerine, popylene alcohol, it is insoluble in alcohol ethers and ester hydrocarbons-dimethyl-formaldehyde and acetone. PAAM is features by high adhesiveness and stability up to 130-150°C. At higher temperature a water insoluble space network polymer is formed. The preparation is available as percent gel and dry granulate of polyacrylamide sulphate.

Dry granulated polyacrylamide sulphate is obtained by radical polymerisation of acrylamide in an aqueous medium in the presence of a redox catalyser system with subsequent salting - out by ammonium sulphate and drying of the polymer. Its molecular weight is approximated between 500 to 600 thousands.

It dissolves in water on heating, the duration depends on the temperature and initial concentration of the poly-acrylamide.

It/..

It is advisable to prepare the size at a temperature of 80-85°C with a polymer content of 5-6%. The polyacrylamide gel is obtained by saponification of acrylic acid nitrile in technical sulphuric acid with subsequent neutralisation and polymerisation of the acrylamide solution in an alkaline medium in the presence of redox catalysers.

The chemical nature of this polymer determines the possibility of inter molecular cyclisation and inter molecular bonds. These features of the polymer determine its viscosity and the rubber-like properties of the polyacrylamide gel. When treated with alkali and peroxides the viscosity and ductility of polyacrylamide are reduced but its solubility in water increases. For obtaining a size with good adhesiveness it is recommended to add 30% hydrogen peroxide in the amount of 0.06% from the PAAM gel mass.

Polyacrylonitrile and its copolymers are insoluble in water. They dissolve in dimethyl formamide, dimethyl sulphoxide rhodante salts. Raw materials used for making size are fibrous forming polyacrylonitrile and its copolymers containing not less than 85% of acrylonitrile and 15% of comonomer acids.

Polyacrylic acid (PAA) and polymethacrylic acid (PMAA) are obtained by radical polymerisation of methacrylic acid in aqueous medium at a temperature of 40-60°C in the presence of redox medium of potassium persulphate and sodium bisulphite or in a medium of organic solvents, at temperature of

75/..

75-100°C in presence of benzoyl peroxide.

The recommended temperature of a sizing bath using acrylate substances is 70-75°C. Destruction and cyclisation of polymethacrylate acid starts at temperature above 110-120°C.

To reduce the corrosive capacity of the size it is recommended to add into it different corrosion inhibitors such as sodium nitrite, boric acid and phosphoric acid ester as suggested by Onikov (55).

2.2.5 Use of acrylics as finishes

A mixture of acrylamide and dially dimethylammonium chloride was copolymerised on the surface of polyester fabric in presence of a catalyst system comprising ammonium persulphate and sodium dithionite. According to Maity (45) the finish was found to impart durable antistatic and hydrophillic properties to the fabric without any deterioration of its basic properties such as breaking strength, tearing strength and handle.

In a study done by Frick (26), reaction products from acrylamide and glyoxal or gluteraldehyde have been used as finishing agents to give cotton wrinkle resistance and durable press properties. These reaction products serve as example of adducts from aldehyde and amide with electron-withdrawing acryl group. The effectiveness of these products was less than that of conventional amide-formaldehyde agents but about equal to that of presently available formaldehyde-free/..

free agents. The finish from acrylamide and glyoxal had greater resistance to acid than the most common formaldehyde free finish. At its present stage of development the experimental finish caused some discolouration and chloride resistance. In preliminary work of this research use of hydrogen peroxide in addition to ammonium persulphate reduced the discolouration.

An aldehyde that has been investigated extensively is glyoxal with urea. Glyoxal forms water soluble, cyclic adducts that have been used as cross-linking agents for cotton (27).

2.2.6 Some researches on polymerisation - cross-linking of N-methylolacrylamide in cotton fabric are reviewed below:

Several variations of polymerisation of N-methylolacrylamide (NMA) in cotton were explored (60) to clarify factors critical to the achievement of resistance with superior retention of strength and abrasion resistance in the fabric. Persulphate catalyst simultaneously initiated, both polymerisation and cross-linking reaction of N-methylolacrylamide (NMA) in cotton fabric. The result from dry-cure reaction fell in the conventional range of textile performance properties achieved by treatment of cotton fabric with agents such as Dimethyldihydroxyethylene urea.

A simultaneous treatment of cotton fabric with 4.5- dihydroxy-1,3,-dimethylethyleneurea and an acrylate copolymer was/..

was studied by Kazuhida Yamamoto (44), when acrylate copolymers with low glass transition temperatures (below -22°C) and high molecular weight (above 10^5) were used with the cross-linking agent. The treated fabrics had an excellent level of crease resistance, tensile strength and flex abrasion resistance. Good durability to repeated laundering, resistance to hydrolysis, wash-wear rating, resistance to shrinkage and colour fastness were also obtained on the resin finished cotton fabrics.

Mastura Raheel and Maureen Deverlien (50) studied the modified effects of liquid ammonia as a final finishing treatment and as a pre-treatment for durable press finish on the wear performance of all cotton broad cloth. Abrasion resistance and appearance retention were taken as indicators of wear life. Abrasion was monitored by Stoll Flex Abraser in dry and wet conditions and repeated laundering. Abrasion resistance was assessed from residual breaking and elongation at break behaviour of fabrics, whereas wrinkle recovery, dimensional stability and whiteness retention gave a measure of appearance retention qualities.

Liquid ammonia improved the tensile strength and Stoll Flex-abrasion in dry condition as well as dimensional stability of cotton broad cloth. As a pre-treatment for durable press finish, liquid ammonia significantly improved abrasion resistance, tensile strength retention, wrinkle recovery and dimensional stability in cotton broad cloth relative/..

relative to durable press treatment by itself.

2.2.7 Acrylic finishing in grafting/irradiation, its effect

It was studied (39) that grafing of the cotton fabric with polyacrylamide decreased the resistance of the fabric to aqueous soiling, but after cross-linking with DMDHEU, this resistance to soiling was somewhat restored. An Egyptian team (39) studied the effect of such grafting by the use of both chemical and physical means of graft initiation on the soiling and soil release properties of cotton, before and after the fabric was given durable press cross-linking treatment with DMDHEU. The presence of polyacrylamide increased the resistance to oily soil. Copolymers prepared by redox grafting and irradiation grafting performed differently. Non-aqueous oily soil-release was impaired by grafting but could be improved by cross-linking without softeners.

It was also reported (39) that incorporation of conventional soil-release finishes in the cross-linking formulation enhanced the aqueous soil release properties of cross-linked polyester-cotton blend fabric. The opposite holds true for non-aqueous oily soil-release properties replacing the conventional soil release properties. Replacing the conventional soil release finishes with laboratory prepared polyacrylic acid in the formulation considerably improves the aqueous and non-aqueous oily soil resistance properties of the blend (39).

Sharma/..

Sharma and Daruwala (61) studied cross-linking of cotton through graft copolymerisation. Fabric samples were grafted with binary and tertiary mixture of selected vinyl monomers along with acrylamide on to cotton fabric using ammonium nitrate as catalyst from aqueous solution or emulsion and subsequently polyacrylamide grafts were methylolated _in situ_ and cross-linked. Except in the case of acrylamide-acrylonitrile treatment, finished fabrics showed good wrinkle recovery properties accompanied by satisfactory retention of breaking and tear strength and also very much improved resistance to abrasion. The finish was suitable for the differed-cure process with minimum evolution of formaldehyde. When the above mentioned uncrossed grafted samples were cross-linked through N-methylol cross-linking agents, improvements in wrinkle recovery properties were accompanied by usual losses in strength and abrasion resistance. However, when tertiary mixtures containing ethyl acrylate, acrylamide and acrylonitrile were grafted at higher polymer add ons and fabric was cross-linked through the conventional cross-linking agents, very good abrasion resistance properties along with good strength retention were achieved.

Polyacrylate and polyurethan additives to cross-linking treatments of circular knitted cotton fabrics are discussed by Kottes (43). The effect on textile properties of varying glass transition temperature in these polymers from 30-40°C is examined. Dimensional stability and strength of the finished/..

finished fabrics are independent of polymer glass transition. Fabric stiffness and resistance to flat abrasion increases and recovery from tensile strength decreases with increasing glass transition temperature of polymer additives.

Some additional effects of cross-linking treatments such as DMDHEU (3% and 6%), Polyacrylate (3%), Polyurethane (4%) on knitted cotton fabrics were found by Cooke (16) in the course of work and these may be useful in divising improved finishes. These effects include changes in extension, tensile recovery properties produced by cross-linking treatments on cotton jersey. These changes are comparable with those produced in cotton woven fabrics.

It was investigated by Danial and Vincent (18) that acrylic emulsions can be cured at room temperature. They cross-link and give extremely durable bonds. Another advantage of this emulsion is adhesive; adhesives based on them can be cured without destroying the properties of delicate substrates. Recently polymer emulsions and low temperature catalysts have come into the market and are receiving attention.

Modi and Mehta (52) investigated formaldehyde cross-linking in a swollen state in aqueous hydrochloric acid at room temperature, this improves wet crease recovery. Both dry and wet crease recovery properties are improved in fibres in the collapsed state when reacted by the nominal pad-dry-cure techniques. Formaldehyde fixes with cellulose as the concentration of the acid is increased.

Acrylamide/..

Acrylamide reacts with cellulose under alkaline conditions to give an additional product. The amide group subsequently methylolated and cross-linked with cellulose under acid catalyst. This has been reported by Mehta and Mehta (51).

Shenai (64) studied alkaline catalysed reaction of vinyl group of acrylamide with cellulose by reacting cotton fabric with acrylamide. The results show that a slight increase in the crease resistance of the fabric (20-30°) and little increase in abrasion resistance. It was concluded that in the presence of an alkaline catalyst, acrylamide can be polymerised to form water soluble polymer in cellulose substrate and to react with cellulose to some extent.

2.2.8 Effect of finishes on swelling vs cleaning

Extensive work has been done on the important problem of soiling of cotton textiles. John Beninate's (42) investigation extends these studies to include fabrics whose fibres have been chemically cross-linked in partially or heavily swollen state. The degree of swelling of fibre, in dimensionally stabilised fabric, contributes much to the physical and chemical properties of the fabric surfaces, and hence to some degree must affect soiling and ease of the soil removal of the fabric. Further it is shown that variations in the degree of soiling and ease of soil removal of the fabric exist, when unmodified 80 x 80 print cloth and formaldehyde/..

and formaldehyde treated print cloth cross-linked in partially swollen and in highly swollen state are soiled with aqueous and oily carbon black and iron oxide dispersions. Cationic, anionic and non-ionic functional groups attached to these fabrics through chemical modifications also influenced wet soiling.

The degree of fibre swelling of the fabrics studied influenced the ease of soil removal of carbon black and iron oxide soils applied from aqueous media. These soils were removed more readily from highly swollen fabrics. In the removal of non-aqueous oily soils, these fibre swelling effects were noted only in the anionic fabrics. The presence of ionising and non-ionising functional groups on the fabric surface in general do not improve ease of soil removal.