Automotive Nonwoven Insulation Fabrics Produced from Virgin & Recycled Fibers and their Absorption Properties

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Abstract: Textiles in transportation are gaining more attention in the last few years as a result of high increase in the demands. In this research, 6 nonwoven fabrics have been produced from virgin and recycled fibers to be used for automotive insulation fabrics. In this paper, the results obtained for testing some produced insulation fabrics which have been presented. The tests included the strength properties, tear resistance, elongation, and air permeability of these fabrics in relation to their fabric structure and fiber composition. Additionally, the absorption properties of these fabrics have been investigated (i.e. absorption of kerosene, gas, car oil and water). The effect of time and liquid type has been explored.
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Key Words: Eco-friendly textiles, Automotive insulation fabrics, Needle-punching nonwovens, Recycling textiles, Nonwovens absorbency.

1. Introduction

In engineering, the term “insulation” refers to measures and equipment for restricting losses or the unwanted admission of energy or media such as fire/radiant heat, moisture, thermal energy, sound, electricity etc. Likewise, the term also refers to the insulation and barrier materials used for this [1].

Nonwoven fabrics have many applications in cars, and there are many reasons for the increased use of nonwoven fabrics in the car industry.

There are various definitions of nonwoven fabrics. For example, according to Textile Terms and Definitions[1], nonwoven fabrics can be defined as textile structures made directly from fibre rather than yarn. These fabrics are made from continuous filaments or from fibre webs or batts strengthened by bonding using various techniques [2] The main advantage of these fabrics is that they are very cheap fabrics.[2, 3 and 4]

Also, Nonwovens have a particular advantage as far as recycling is concerned, nonwovens used in motor vehicles can also be removed very easily [1].

1-1 Textiles in Transportation:

Transportation is the largest user of technical textiles. Textiles provide a means of decoration and a warm soft touch that are necessary features for human well being and comfort, but textiles are also essential components for the more functional parts of all road vehicles, trains, aircraft and sea vessels.

Probably the most important challenge facing the transportation industry is its effect on the environment. Yet the industry continues to grow and growth is inevitable for the foreseeable future as the economies of the developing nations and those of the third world progress [5] .

Nonwoven fabrics are likely to become more widely used in this important sector as the trend towards manufacturing lighter weight cars with lower fuel consumption continues. Examples of which are vinyl seat covers, sun visors, door padding and panelling, all of which can be made more cheaply from nonwoven bonded fabrics and have been used for some time now. Additions to the list of suitable uses are interior roof linings, and coverings, as heat insulation and sound proofing material, for the reinforcement of seat belt anchorage and roll-up systems, boot lining and padding, carburettor filters, battery separators, backing for tufted carpeting and needled floor coverings and upholstery materials. They can also be used as covering material for moulded seats and backing material for polyurethane coating [6].

Textiles in transportation are classed as technical because of the very high performance specifications and special properties required. Seat coverings, for example, are not easily removable for cleaning and indeed in automobiles they are fixed in place and must last the lifetime of the car without ever being put in a washing machine. Recycling has been and is the subject of much research [5, 7].

Early textile applications within the automotive industry took the form of car seat coverings. The traditional covering used in the vehicles in the early days of the industry was leather and the use of a textile fabric was rare and constituted a surcharge. In today’s modern vehicles the role of textile fabrics and leather coverings has been reversed. Leather was used for vehicle interiors because of its durability and strength regarding wear, despite the cost involved. The use of textile fabric was considered but the fabrics produced would have been basic and inadequate for the task of an interior covering for a vehicle. Today’s involvement of the textile industry in the automotive industry is considerable. During recent years, there has been an increasing amount of textile origin components being introduced to the automotive industry, such as seat belts, airbags, car seat covers and many other uses [8].

1-2 Fiber types and applications used in automotive textiles

Fibres intended for the automotive industry have to go through a thorough selection process in order to determine their suitability. This process takes into consideration such factors as safety, comfort and durability. Some organizations [such as ICI] carried out a series of tests for the automotive industry, which provided a list of five fibres that could be considered for use in automotive fabrics, these including acrylic, polyester, polyamide, polypropylene, and wool.

The application of textile products to the automotive industry is vast. Since the early days of the collaboration of the textile industry and the automotive industry, there have been many new initiatives creating more work transfer between the two [8].

1-2-1 Textiles and their role in sound insulation

The control of excess noise and vibration is an area that the automotive industry and the textile industry have investigated. Energy that is transmitted from a sound source such as the engine or tyres creates vibration and thus sounds. Car manufacturers solve this problem with the employment of a sound absorber. Felt is typically used for this application, as porous fabrics are adequate for the task. Reviews have shown that the circular cross-sections in felt were mitigating the sound absorbency of the material and that an alteration to the cross-section and possibly the fiber used would lead to a more efficient material for sound absorbency [8].

1-3 The car industry

Nonwoven fabrics have many applications in cars, and there are several reasons for the increased use of nonwoven fabrics:

1- Nonwoven fabrics offer a better price/performance ratio than textiles made out of yarns for many applications. A patent search would show that a great deal of work was carried out in the 1980s into developing nonwoven fabrics for the car industry.
2- By using specific types of fibres and optimized processing techniques, it is possible to produce nonwoven fabrics with a lower mass per unit area than substrates made out of yarns, but this is only relevant if all the performance requirements can be met. This may contribute to reducing fuel consumption, a factor that is of major importance in the car industry.
3- Nonwovens containing thermoplastic fibres exhibit favourable thermal deformation characteristics, yet still retain their three-dimensional deformation characteristics when cold.

Different types of nonwovens used in cars and the areas where they are used; it does not include woven, warp-knitted or weft-knitted fabrics. The latter are used in tire fabrics, airbags and seatbelts, and composite nonwovens made from glass fibres, for example, for use as load-bearing elements. Work is currently being carried out into replacing other substrates made from yarns with nonwoven fabrics [1].

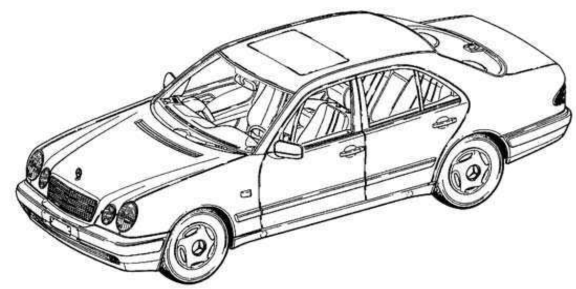

Fig. 1: Cars include several types of nonwoven fabrics [1]

1-3-1 Types of nonwovens used in cars:

1 Door lining: edge trim, door mirror, arm-rest, lower part (door pocket)
2 Sun visors
3 ABC-pillar covering (covering of seat belt)
4 Headliner (moulded roof): roof insulation, sun roof (cover), hood, hood padding
5 Parcel shelf: speaker covering
6 Boot lining: floor mat, sides (wheel casings), rear cover, back seat wall, spare wheel case
7 Filters: air filter, cabin filter, fuel filter, oil filter, during car manufacture, (lacquering) etc.
8 Engine housing: bumper felts, bonnet lining, rear side, (dashboard), battery separators, other insulation points
9 Instrument panel: (insulation), instrument panel (lower part)
10 Dashboard mat
11 Seats: lining for backs of seats, laminated padding for seat covers and bottom of seats, upholstered wadding, upholstery cover, reverse sides, head-rest cushioning, seat sub-padding, foam reinforcement, padding for centre arm-rest
12 Floor mats with tunnel: cladding, sub-upholstery (insulating material, stuffing)
13 Interior rear wall lining: floor of the car body, under the back seats (exterior wheel-case)
14 Estate cars and convertibles: side wall covering (lining for the wheel case), boot floor, lining for the hood-case, cover for the hood-case
15 General: Covering and transport tarpaulins, seat covers, tool pockets, pockets for holding vehicle

documentation, cleaning cloths, child seat, sleeping compartment in lorries, protective clothing worn during car manufacture/maintenance, backing substrates for imitation leather and microfiber nonwovens for seats and/or all types of covering components [1]

1-3-2 Required characteristics for nonwoven fabrics used as car insulations

The demands made of nonwoven fabrics for use in cars will depend on the loads and stresses to which they are subjected during use, and the effects of long-term usage.

Recycling legislation obliges the car industry to develop strategies for disposing of materials and to ensure that the components can be taken apart easily so that the materials can be reclaimed and recycled. This means that the various alternatives must be taken into account when designing and producing the components.

This also applies to nonwovens. It is becoming increasingly important for all the disposal strategies to be harmonized with each other. Ensuring that the covering components are all made from the same material has encouraged this development, and this strategy has won widespread acceptance in recent years [1].

1-4 Recycling:

One form of recycling which is environmentally friendly is practiced within the textile industry. This is the process by which surplus fibres or fibre assemblies are returned to the production train for reprocessing instead of merely being discarded; unfortunately, there may be a diminution of properties (such as fibres length, yarn evenness or fabric strength) and as a result, which can lower the quality of goods that can be produced from this recycled materials [9].

Recycling has been taking place now very strongly in the manufacturing of nonwovens used for interior car textiles including different insulation fabrics.

1-4-1 Recycling fibers:

Reclaimed fibers are from a secondary cycle of processing. To obtain them, fabric-type or thread-type textile waste is mechanically broken down as far as the fibers. Conventionally, the waste is pre-treated by means of cutting or picking and then transported through a take-in unit, acting as a clamp, of a drum rotating at high speed. The textile structure is broken down by steel pins which are on the drum surface, together with the clamping effect mentioned above. Structures will take several passages through the drum to become single fibers [10].

1-4-2 Recycling fibers in Nonwovens:

Reclaimed fibers are well suited to making nonwovens and yarns. As compared with primary fibers, reclaimed fibers show different characteristics. The damage they suffer during production entails a wide spectrum of fiber lengths with a high share in short fibers. Characteristics are influenced by the waste in question, its pre-treatment and the breaking-down processes as such. In most cases, reclaimed fibers are available as blends. Depending on product functions, reclaimed fibers can be looked upon as conventional in technical textiles, particularly in nonwovens (mobility textiles which mainly serve to cover up surfaces or to insulate materials, agrotextiles, and Geotextiles which are used to protect soil against erosion) In all these cases, reclaimed fibers are used because of low prices, or because they merely cover something up. However, reclaimed fibers are also applied in nonwovens to utilize highly valuable functional components [10].

1-4-3 Recycling fibers products and markets:

Reclaimed fibers can be manufactured from a variety of textile waste. Both quality and processability of such fibers depend on the kind of waste. Well-known are the pure sorted fibers of high quality which are achieved from spinning-fiber waste. In contrast, reclaimed fibers which are made of end-of-life textiles are of much poorer quality. They will rarely be found of homogenous fiber type.

There are many ways to using reclaimed fibers in both textiles and nonwoven textile products. The suitability of processes depends on waste characteristics and on how much they cost. To achieve easy processability, reclaimed fibers are frequently blended with primary fibers (15%).

As compared with the production of yarns, reclaimed fibers are even more often used today to make nonwovens. In Germany, about 95% of the reclaimed fibers are processed into nonwovens. The main fields of application are in technical textiles [10].

2- Experimental work:

2-1 Production of fabrics & Fabric structures:

In this research, 6 nonwoven fabrics have been produced from virgin and recycled fibers to be used in the production of automotive insulation fabrics

Both fabrics 11 and 12 have been produced using needlepunching machine using low needling on the needlepunching machine which will result in more fluffy structure compared with the other fabrics. Also, fabrics 11 and 12 have been produced with backs of woven polypropylene material to provide coherency to their structure.

For fabrics 10, 13, 14 and 15, the fabrics were produced using the Needlepunching machine using needling technique similar to fabrics 11 and 12. Fabrics

13 and 14 produced using high amount of needling, whereas, fabrics 10 and 15 have been produced using medium amount of needling. The high amount of needling results in providing more compact structures which will result in relatively lower and compressed fabric thickness.

Table 1: Specifications of fabrics used

Sample No.	Fibre composition	Fibre type	Weight	Application	Type of needling	Fabric Density
10	100% polyester	Virgin fibers	995.3 g/m^2	Car insulation fabrics	Medium amount of needling	0.29
11	100% recycled fibers	Recycled fibers with polypropylene back	565.35 g/m^2	Car insulation fabrics	Low amount of needling	0.144
12	100% recycled fibers	Recycled fibers with polypropylene back	752.6 g/m^2	Car insulation fabrics	Low amount of needling	0.126
13	100% polyester	Virgin fibers	427.6 g/m^2	Car insulation fabrics	High amount of needling	0.125
14	100% polyester	Virgin fibers	608 g/m^2	Car insulation fabrics	High amount of needling	0.187
15	50%, 50% blended wool, recycled fibers	blended wool, recycled fibers	1072.1 g/m^2	Car insulation fabrics	Medium amount of needling	0.339

2-2 Optical Pictures to Show the Surface Appearance of the Pictures:

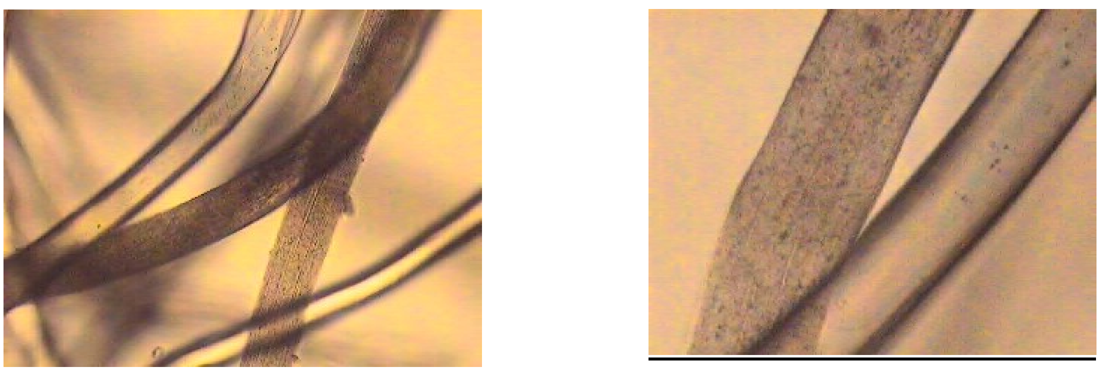

Figure 2: Optical pictures of fabric 10

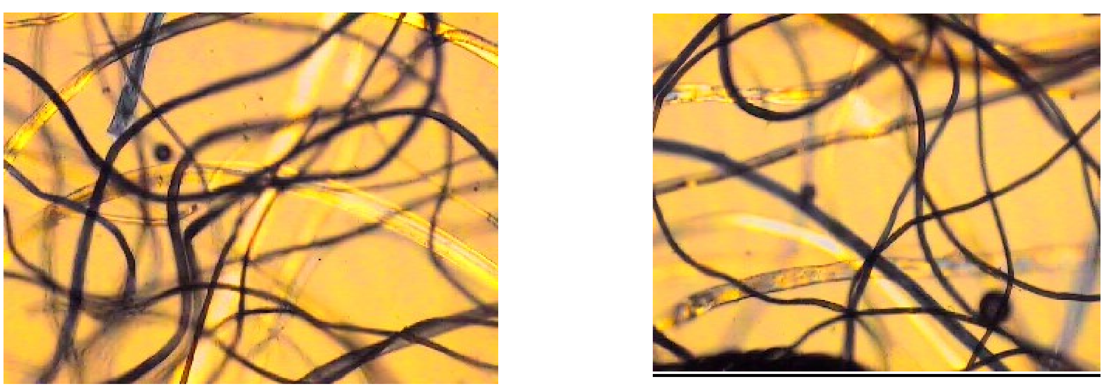

Figure 3: Optical pictures of fabric 11

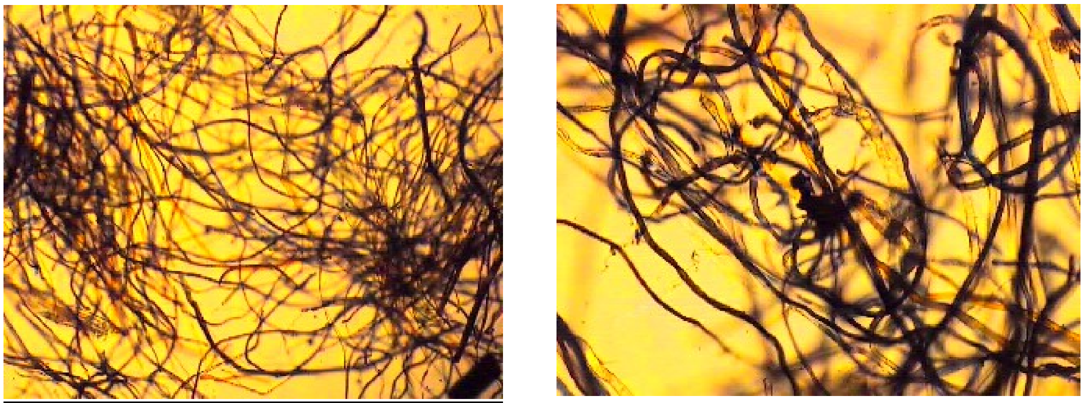

Figure 4: Optical pictures of fabric 12

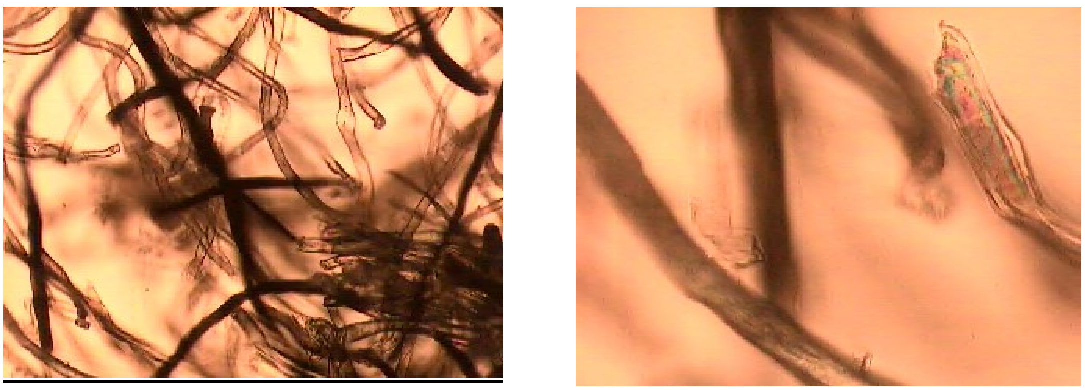

Figure 5: Optical pictures of fabric 13

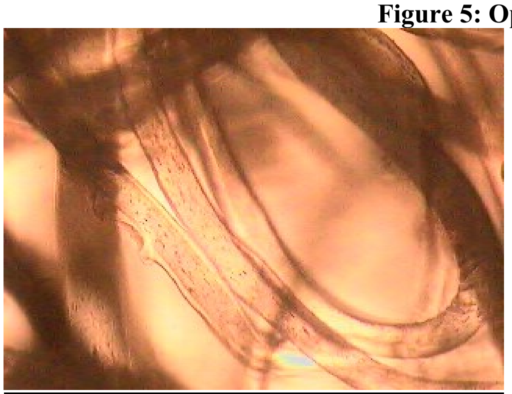

Figure 6: Optical pictures of fabric 14

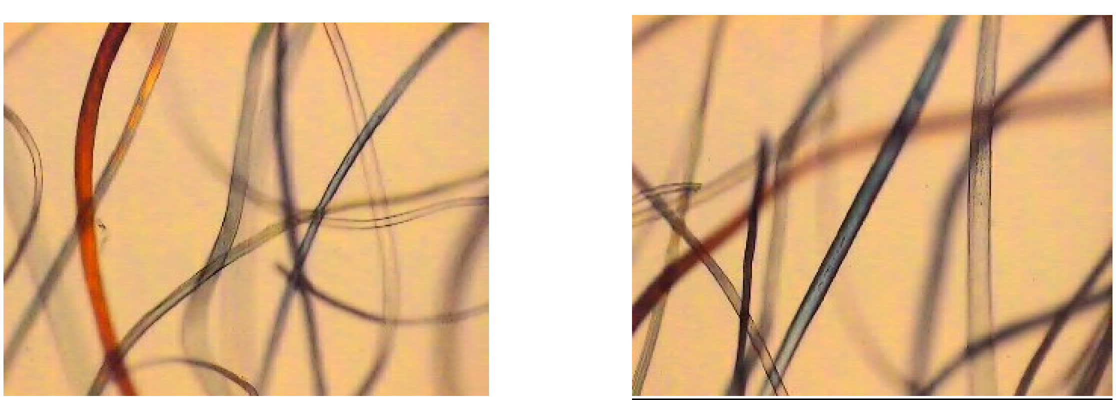

Figure 7: Optical pictures of fabric 15

3- Results and Discussion:

3-1 Physical and Mechanical Properties:

In this paper, the results obtained for testing some produced insulation fabrics are presented. The tests included the strength, tear resistance, elongation, and air permeability of these fabrics in relation to their fabric structure and fiber composition. Additionally, the absorption properties of these fabrics have been investigated (i.e. absorption of kerosene, gas, car oil and water). The effect of time and liquid type has been explored.

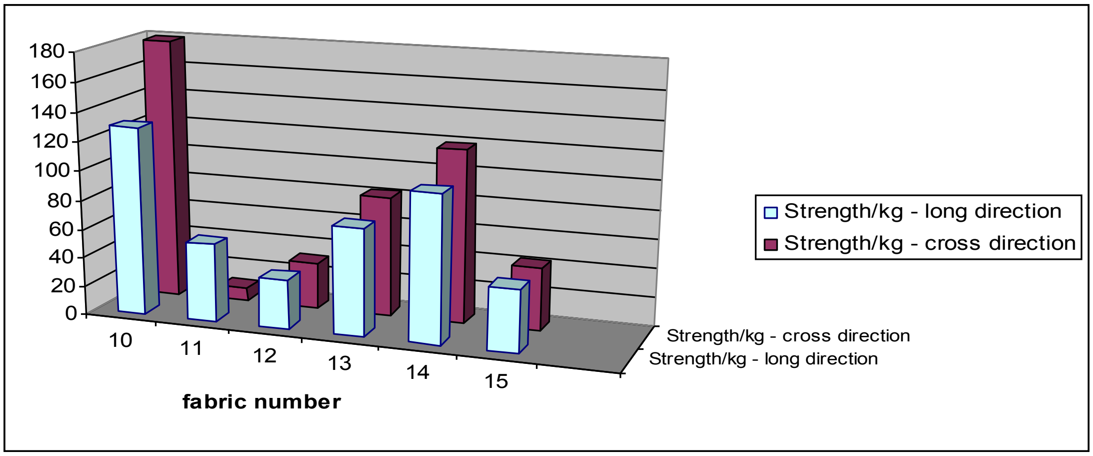

Figure 8. The results obtained for strength results for all the fabrics in both the long and cross directions.

Figure 8, show the results obtained for strength results for all the fabrics in both the long and cross directions. It can be noticed that the lower values are obtained for fabrics 11 and 12. This can be explained as a result of relatively loose fabric structures [3] It is important to mention here that these fabrics have a back structure made of woven polypropylene material which is used to provide more coherent fabric structures.

The highest values are obtained for fabric 10 in both directions, as a result of relatively compact fabric structure and higher weight per unit area.

Same explanation can be applied on fabric 14 and 13 where they follow fabrics 11 and 12 as they have relatively lower fabric weight per unit area. And as it can be seen, the weight per unit area plays an important role in nonwoven fabric strength.

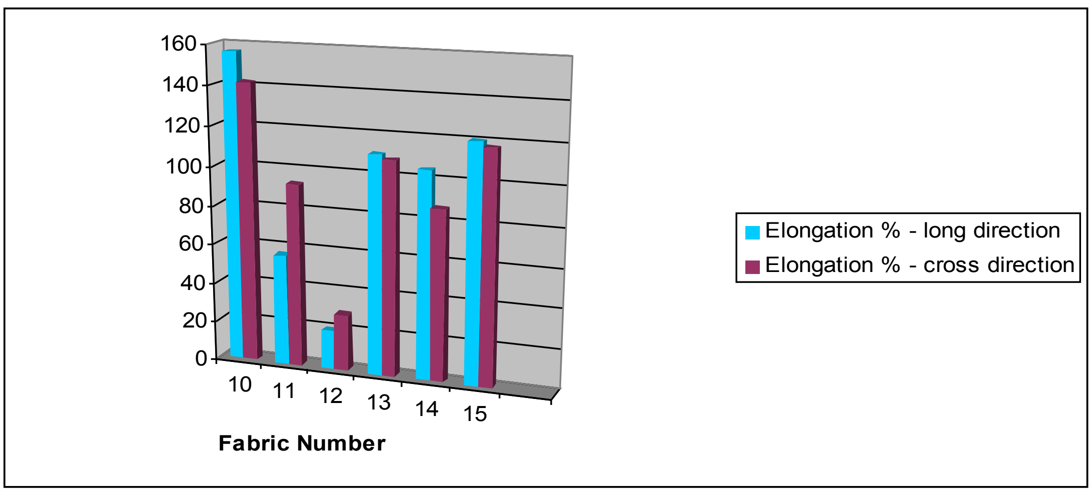

Figure 9. The elongation values obtained for all the fabrics in both long and cross directions.

Figure 9 presents the elongation values obtained for all the fabrics in both long and cross directions. It can be noticed that the highest amount of elongation obtained by fabric 10, which is one of the highest weight per unit area fabrics and has medium amount of needling during production.

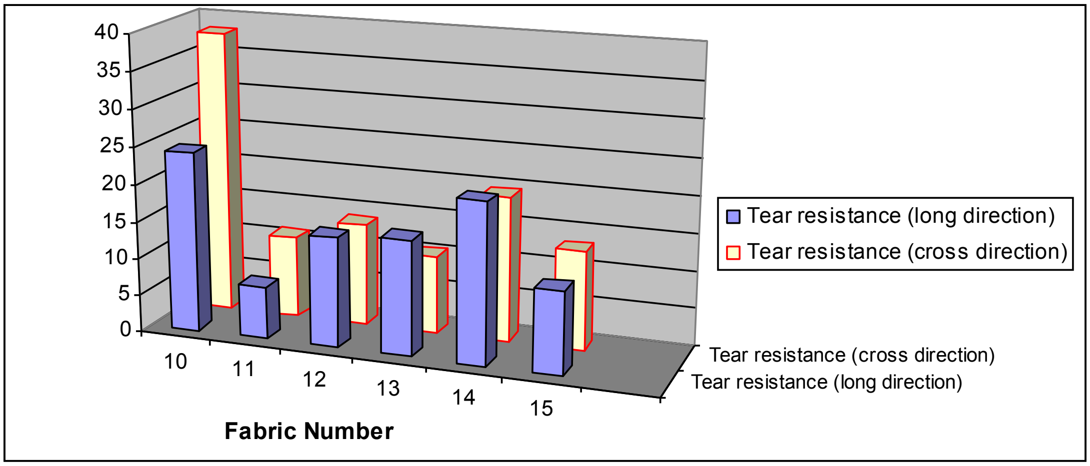

Figure 10: Fabric number Vs tear Resistance

Similar results obtained in figure 10 to that in figure 8. These results are similar to the results obtained in figure 8 and for the same reasons and same explanation can be applied.

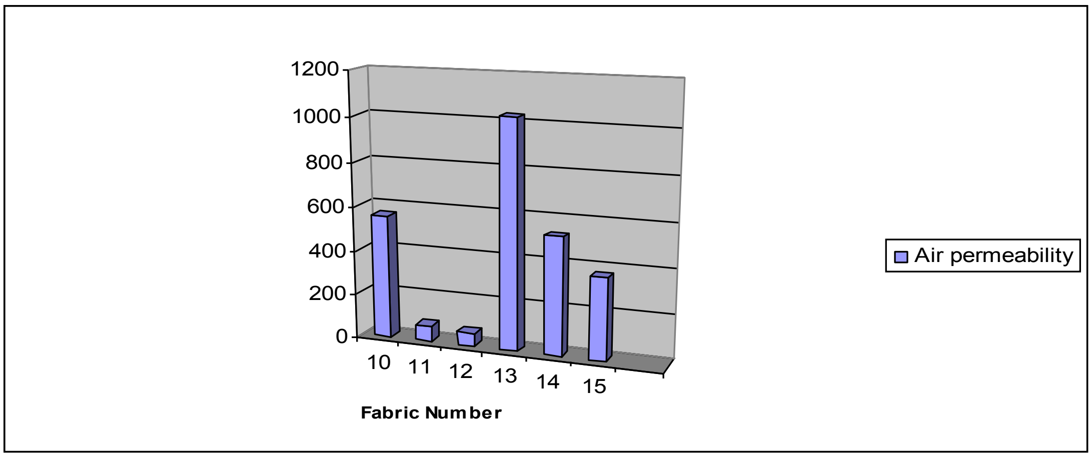

Figure 11: Fabric number Vs Air permeability

Figure 11 presents the air permeability values obtained for all the fabrics. It can be noticed that fabric 13 has obtained the highest air permeability value. This can be explained as a result of relatively lower thickness as it has the lowest weight per unit area compare with the other fabrics.

3-2 Absorption properties of insulation fabrics

The wicking properties have been investigated by testing the absorption of the fabrics in the long directions of the 6 fabrics. Wicking properties is represented by the wicking height along the fabric direction in cm. It is important to mention here that these nonwoven fabrics have random laid webs, so that, it is not expected to have a significant difference between long and cross directions regarding the absorption properties. Accordingly, only absorption in the long directions of the fabrics have been examined and calculated.

The absorption properties of the insulation fabrics have been tested using a simple instrument which has been designed by the researcher herself using three different liquids separately: kerosene, car oil, benzene and water.

Absorbency of fabrics is influenced by their wicking ability. Wicking occurs when a fabric is completely or partially immersed in a liquid or in contact with a limited amount of liquid, such as a drop placed on the fabric. Capillary penetration of a liquid can therefore occur from an infinite (unlimited) or (limited) finite reservoir [11, 12].

Wicking and wetting of fibrous is an important issue in a range of areas including nonwoven fabric industrial applications especially in specific areas, such as; automotive industry, where unsafe absorption amounts of liquids can lead to great risks.

3-2-1 Testing method (Wicking test method):

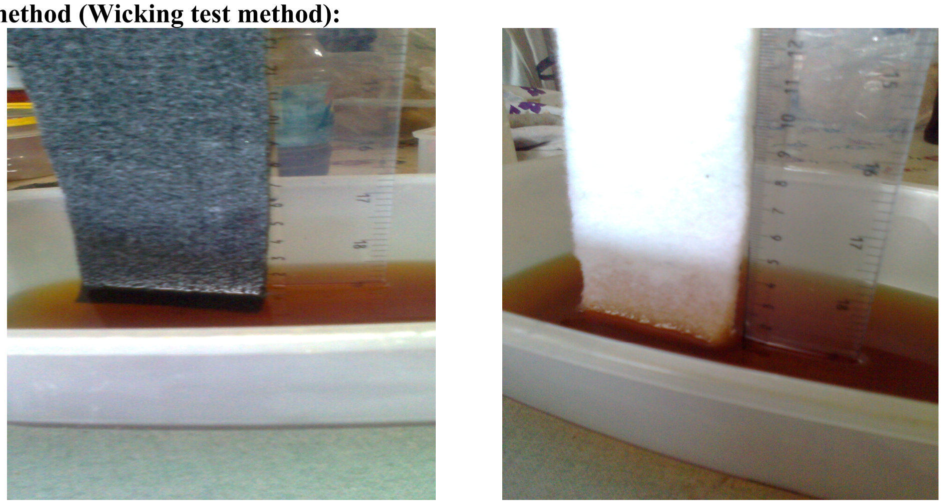

Figure 12: Wicking test designed by the researcher while carrying out the experiments

Figure 12 represents figures of the wicking tester designed by the researcher while carrying out the experiments on two different samples. The liquid transport rate was measured according to the vertical fabric strip wicking test by measuring the wicking height against gravity in the long direction of the fabric One end of strip (30cm X 5cm) was clamped vertically with the dangling end immersed to about 2 cm in kerosene, car oil, benzene and water respectively at an ambient temperature of 20±2ºc and relative humidity of 65±2%. The height to which the liquid was transported along the strip was continuously measured at 5 minute intervals for the first 20 minutes and then at 10 minutes intervals for another 20 minutes and then reported in centimeters(cm). The test has been conducted using a vertical wicking tester according to DIN 53924 method. These testing procedures have been carried out by the researcher herself.

3-2-2 Results and discussion of absorption:
Absorption of Kerosene:

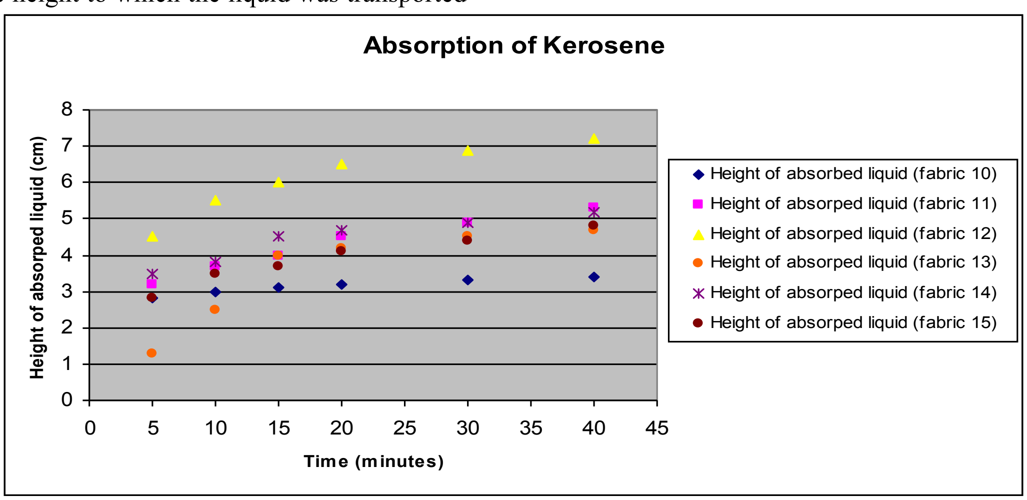

Figure 13: absorption of kerosene of the different samples

As it can be seen in Figure 13, wicking absorption of kerosene of the different fabrics has been examined for a period of time equals 40 minutes. The figure shows continuous increase in the amount of absorption with the increase of time. It also shows that fabric 12 has the highest amount of absorption compared with all the other fabrics, followed by fabric 11 and 14, and then followed by fabrics 13 and 15, and finally fabric 10.This can be explained as a result of the fluffy structure of fabrics 12 and 11 as they had low amount of needling.

It can be seen that fabric 10, which is composed of 100% polyester, has the least wicking ability compared with the other fabrics, and also fabric 15 as they have the highest weight per unit area. Nevertheless, fabric 15 composed of recycled wool fibers which has higher ability of absorption compared with polyester fibers in fabric 10.

It can be concluded that the amount of needling is the most important variable that affect kerosene absorption wicking followed by weight per unit area of the fabrics.

Absorption of gas (Benzene):

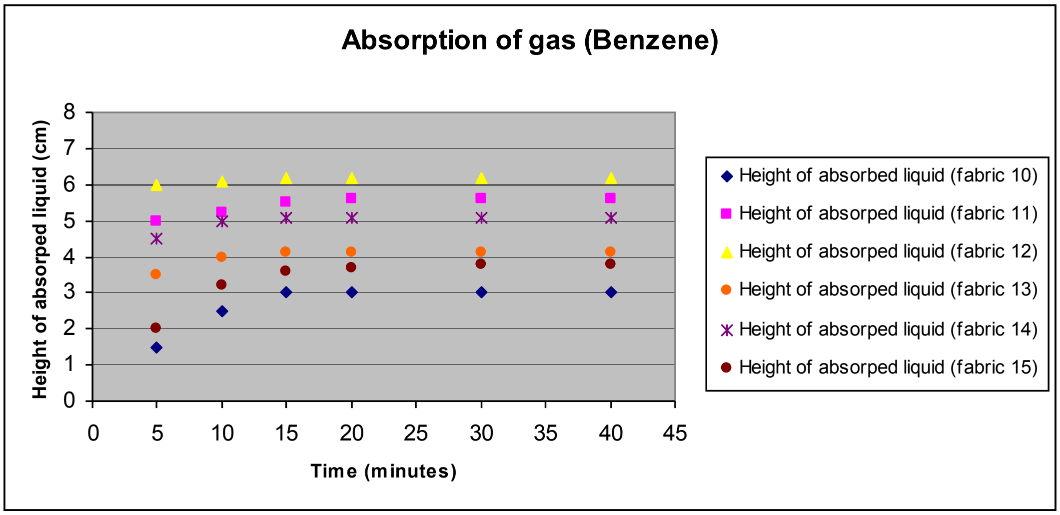

Figure 14: absorption of Gas (benzene) of the different samples

In figure 14, it can be seen the wicking absorption of gas (Benzene) of the different fabrics has been examined for a period of time equals 40 minutes. The figure shows increase in the amount of wicking absorption with the increase of time up to 15 minutes only. It can be seen that fabric 12 comes at the beginning of the fabrics that absorb gas, followed by fabric 11, and then fabric 14, then fabric 13, then 15 and finally fabric 10. Similar to the results in figure 13, fabric 12 has the highest ability of wicking ability for the same reasons mentioned and explained in figure 13**.** In this figure, it can be noticed that there is no continuous increase in the amount of gas wicking with the increase of time period. It can be noticed that the maximum increase of gas wicking has been reached after 15 minutes and after that, there no more increase has taken place. This means that the amount of absorption wicking became constant after the first 15 minutes, and this can be because of gas has the lowest density compared with the other gas products (e.g. Kerosene), and it is the fastest to evaporate, and as noticed through the experiment, the gas was getting higher but evaporates very quickly that the increase in the absorbed wicked gas did not take place in practical. And as a result, the amount of absorbed gas stayed constant and we had what we can call "Fixed rate of wicking absorption". These results obtained for all the fabrics (fabric 10- fabric 15) with different values for each.

Absorption of Car oil:

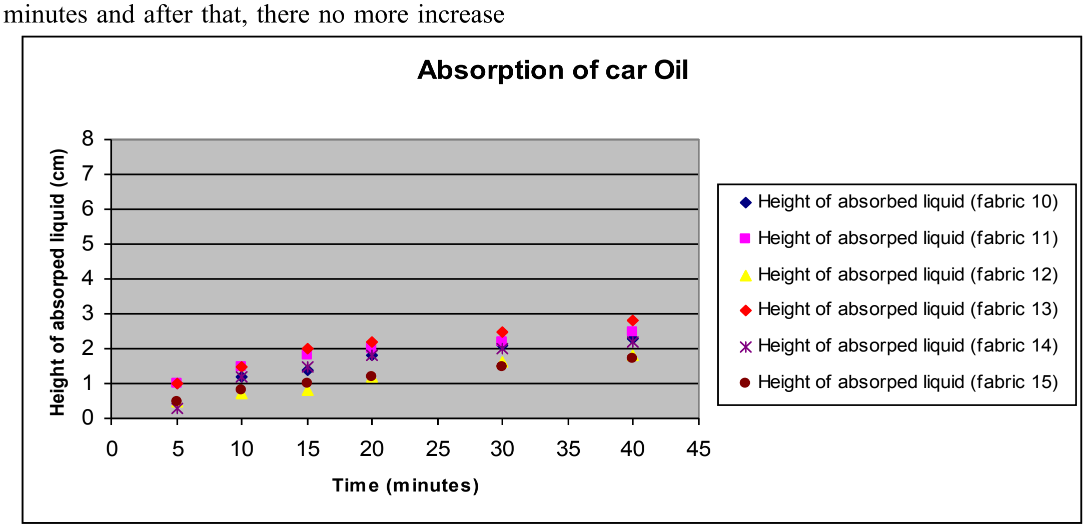

Figure 15: absorption of Car Oil of the different samples

In Figure 15, it can be noticed that there is a rapid increase of wicking absorption of car oil with the continuous increase in time for 40 minutes period of time. These results came similar to the results obtained in figure 14 (Kerosene), but different in the values obtained. The values of absorption wicking for car oil and water are much lower compared with kerosene or gas. In the figures 13-16, the scale of the Y axis is constant so that it is easy to compare between the results obtained for all the absorbed liquids. For example, the maximum value obtained for the kerosene absorption is 7.2, and for the gas is 6.2, and for the car oil is 2.8, and finally for the water is 2.5 cm. The lower amount of absorption wicking of oil can be as a result of high density of oil compared with kerosene and gas. Fabric 13 has the highest amount of absorption wicking compared with the rest of the fabrics, followed by fabric 11, then 10 and 14, then 12 and 15. These results can be explained as, fabric 13 has the lowest weight per unit area and also made of virgin fibers, which means that for oil absorption wicking properties, it is important to achieve low weight per unit area and fiber homogeneity to obtain high absorption wicking ability whatever the amount of needling applied. Also it can be noticed that fabric 11 followed fabric 13 in wicking ability, it is important to mention that fabric 11 followed fabric 13 in weight per unit area. And similarly, fabric 14 and 10 came after fabric 11 and 13, as they followed them in weight and also they are produced from virgin fibers.

So that it can be concluded that both weight per unit area and fiber composition are the main variables that affect absorption wicking properties of car oil. In other words, the less weight per unit area and more homogenous fibers obtained in the fabrics, the more wicking properties of oil can be obtained.

***Absorption of Water*:**

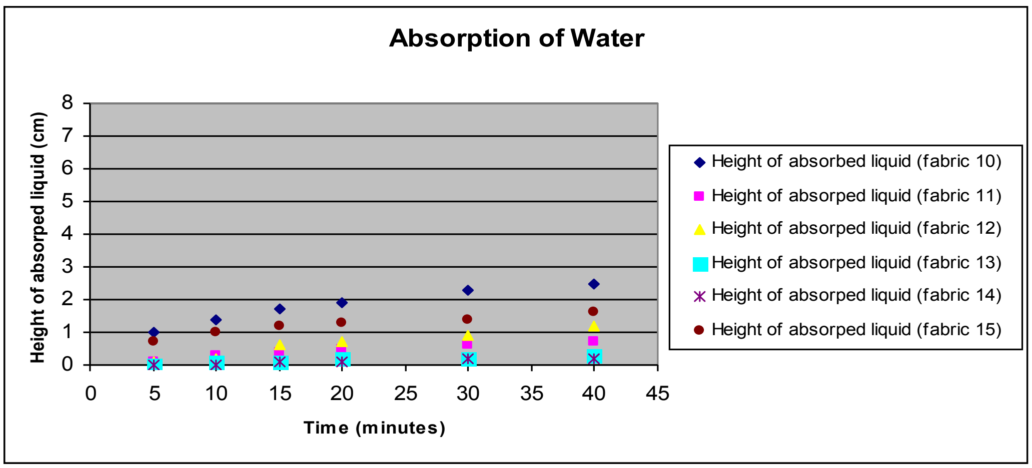

Figure 16: absorption of Water of the different samples

In figure 16, it can be seen that there is an increase in the amount of absorption wicking of water for all the samples with the increase of time. Generally, it can be noticed that the amount of absorbed water is much significantly lower than the other liquids (kerosene and Gas). This can be explained as a result of higher density and weight of water compared with the gas and kerosene. Dissimilar to all the results obtained in figures 13, 14 and 15, it can be seen that fabric 10 has the highest value in water. These results can be explained as fabric 10 is composed of 100% of virgin polyester fibers and also has a medium fluffy structure compared with fabric 13 and 14, and so that and despite that fabrics 13 and 14 have lower weight per unit area, fabric 10 has higher ability of wicking than fabrics 13 and 14 and also more than the other fabrics that are composed of recycled fibers.

Followed by fabric 10, we can find fabric 15 which is composed of wool recycled fibers which has high tendency to absorb water even though its weight per unit area is the highest compared with all the other fabrics. Followed by fabric 15, we can find fabric 12 and then fabric 11, which are composed of recycled fibers and have fluffy structures which allow more water wicking compared with fabrics 13 and 14 which have more compact structures.

As a result, it can be concluded that the more virgin fibers are available in the fabric structure, the higher the ability to absorb water. Also, the more hydrophilic fibers obtained in the fabrics less amount of needling, the more wicking ability of the fabric to wick the water.

3-2-3 Comparison of the absorption of different liquids for each fabric individually:

In this comparison, the results obtained for each fabric are analyzed separately, to identify the behaviour of each fabric individually regarding the wicking absorption of the different liquids (kerosene, gas, car oil and water).

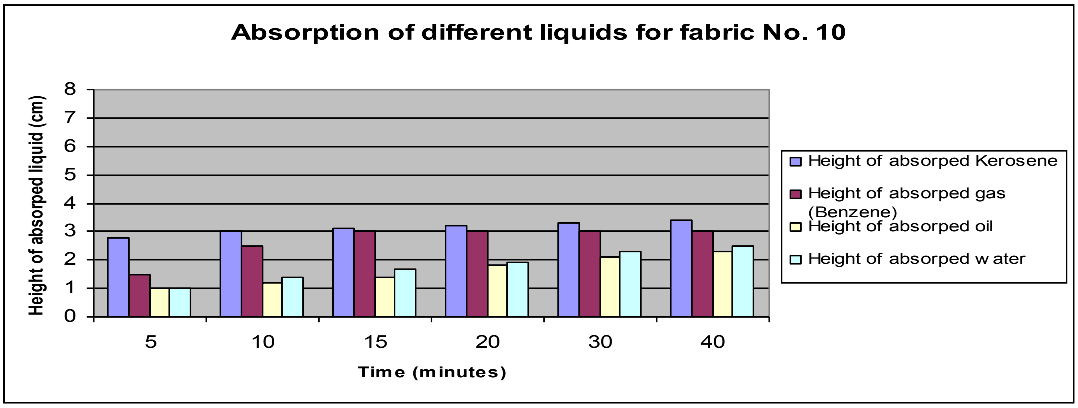

Figure 17: absorption of fabric 10 to the different liquids

In Figure 17, it can be seen that for fabric 10, generally the amount of wicking absorption of kerosene is the highest value and gas comes directly after kerosene and very closely to it, followed by water and finally the oil. And also, it can be seen that with the increase of time, there is an increase of wicking for all the absorbed liquids except of gas, there is an increase only for the first 15 minutes and then the rate of increase is constant.

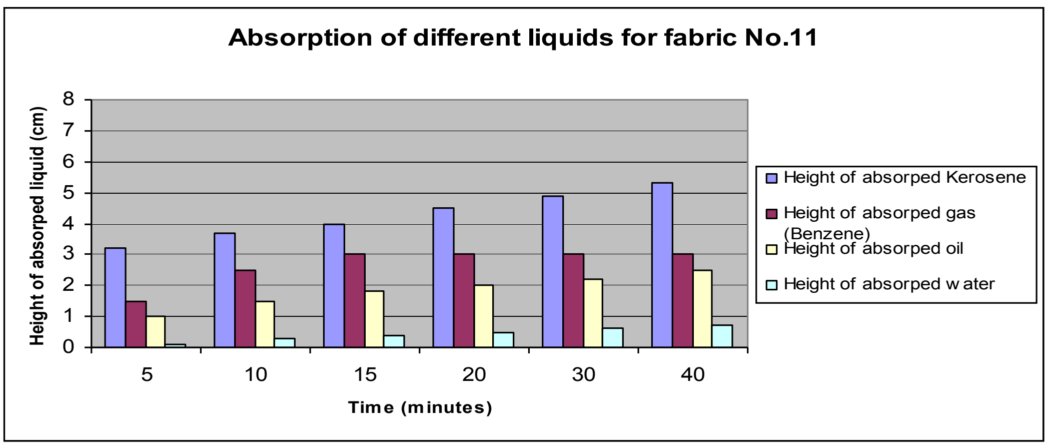

Figure18: absorption of fabric 11 to the different liquids

Similar to the results in Figure 17, in figure 18, it can be seen that for fabric 11, generally the amount of wicking absorption of kerosene is the highest value and gas comes directly after kerosene, followed by oil and finally the water. And also, it can be seen that with the rapid increase of time, there is an increase of wicking of all the absorbed liquids except of gas, where there is an increase only for the first 15 minutes and then the rate of increase is constant.

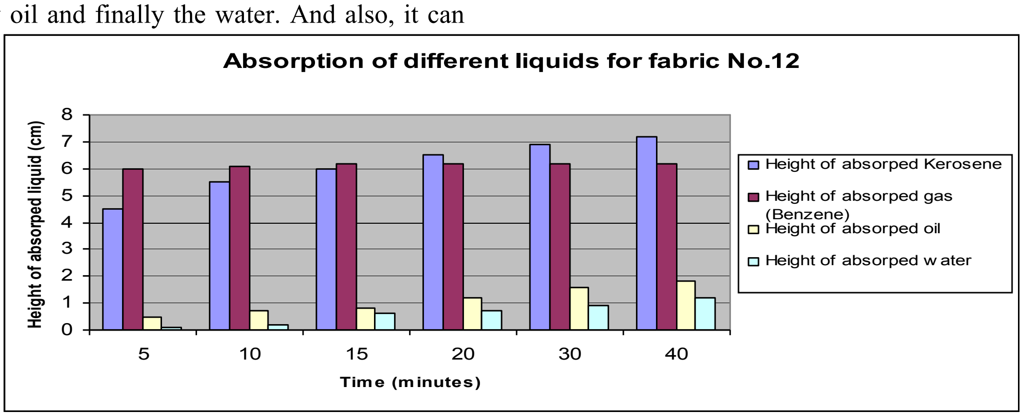

Figure 19: absorption of fabric 12 to the different liquids

The results are obtained in Figure 19 are similar to that in figure 18 except of generally the wicking amount of both kerosene and gas are much higher for fabric 12 compared with fabric 11. It is important to mention here that both of these fabrics have same composition (recycled fibers) and they have fluffy structure which provides more wicking ability.

Here, it is important to compare between fabric 10 and fabrics 11 and 12, as for fabric 10, the water wicking comes at the third place after kerosene and gas but the water liquid came at the fourth or at the last place for the fabrics 11 and 12. This can be explained as a result that fabric 10 is composed of virgin fibers which allow water absorption wicking much better than for fabrics that are composed of recycled fibers; 11 and 12.

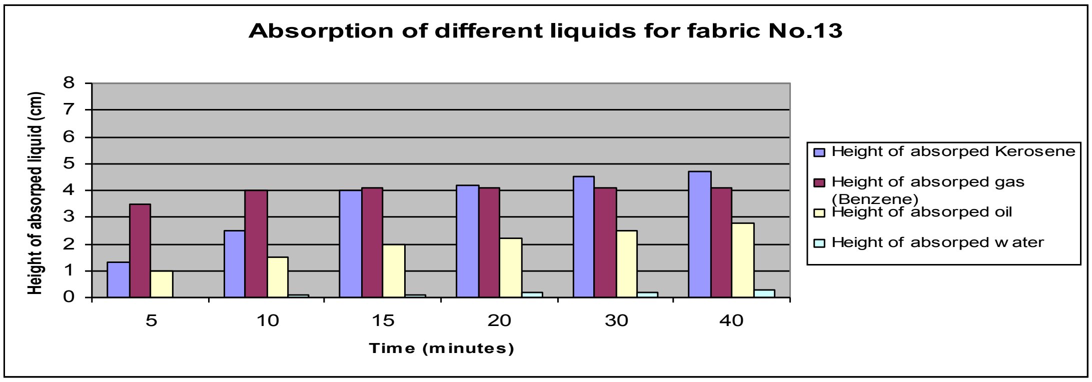

Figure 20: absorption of fabric 13 to the different liquids

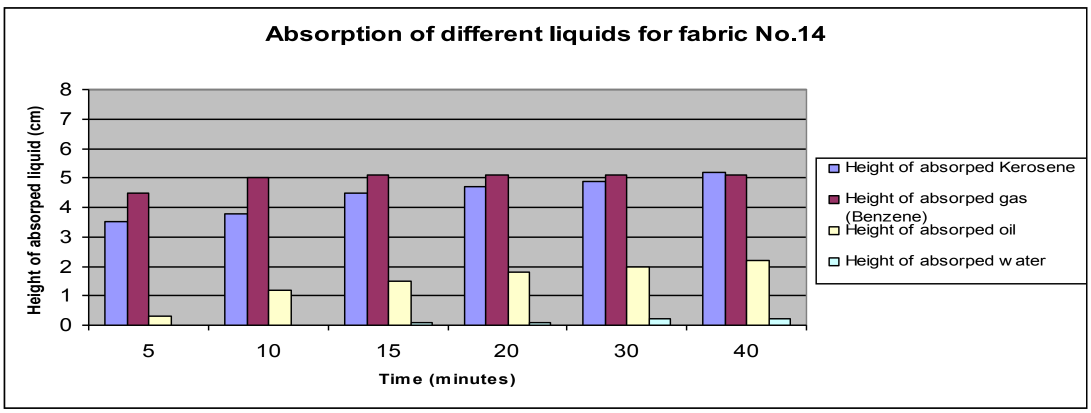

Figure 21: absorption of fabric 14 to the different liquids

In Figures 20 and 21, both fabrics 13 and 14 which have very close structures, it can be noticed that the wicking absorption of both kerosene and gas is exchanged between the fabrics during the periods of time. Following that, oil and finally the water.

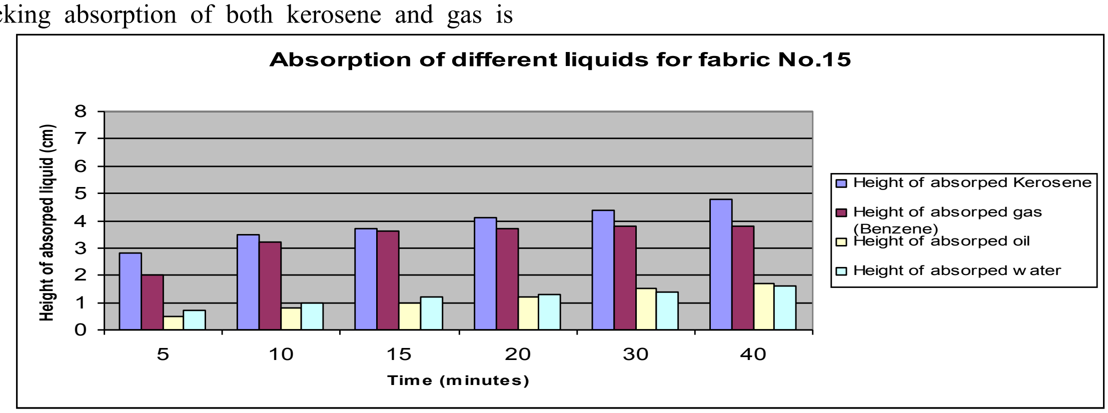

Figure 22: absorption of fabric 15 to the different liquids

In figure 22, it can be noticed that kerosene came at the beginning of the wicking liquids, followed by gas, then water and finally the oil. It is important to mention here that fabrics that have hydrophilic fibers in their structure have tendency to wick water more than oil (compare fabric 15 with fabrics 13 and 14 which are composed of 100% polyester fibers).

4- Conclusions:

1- Strength, tear resistance and elongation properties obtained for the insulated nonwoven fabrics depend to great deal on their weight per unit area and also on the amount of needling applied to the fabrics during production using needle punching machine. The higher the weight per unit area and the more amount of needling provided, the higher strength, higher tear resistance and lower elongation properties can be obtained.

2-Air permeability properties of needle punched nonwoven fabrics are affected by both weight per unit area and amount of needling of the fabrics. The higher the weight per unit area and the more amount of needling provided, the less air permeability properties can be obtained The type of fibers used in the production of the needle punched fabrics will also affect the air permeability of these fabrics. Using virgin fibers in the production of these fabrics result in higher air permeability properties of these fabrics compared with using recycled fibers.

3- Concerning kerosene and Oil absorption, it can be concluded that amount of needling comes as the most important variables that affect kerosene & oil absorption wicking followed by weight per unit area of the fabrics.

4- Concerning gas, it can be concluded that the gas wicking continued to a specific point and after that it started to stay constant whatever the composition of the fibers or the weight and that happened according to the lowest density of gas compared with the other gas products and its tendency to evaporate after specific amount of absorption wicking and time as a result of being the amount of absorbed liquid is equal to the amount of evaporated one. And at that time exactly, the phenomenon of "Fixed rate of wicking absorption" will take place.

5- Concerning water, it can be concluded that the more virgin and hydrophilic fibers obtained in the fabric structure, the higher the ability of the fabrics to absorb water. Also, the amount of needling has an affect on the wicking absorbency of the fabrics.

6- It is concluded that the nonwoven fabrics that composed of either hydrophilic or hydrophilic fibers have higher ability to absorb kerosene and gas much higher than water and oil as a result of lower density and weight of both gas and kerosene which enable their particles to easily absorbed..

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