

Design and development of an instrument for measuring water vapor resistance of woven and knitted structures

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Introduction

Even in very cold weather, active people can overheat. The body sweats to balance heat loss with heat production at comfortable body temperature. Evaporative cooling is much less efficient, when wearing cold weather clothing. The cooler outer layers of clothing or the inner surface of the shell, whether the shell is highly permeable or not, sweating must be avoided, or at least minimized, because clothing with wet insulation is not very good protection from the cold.

Breathable fabrics prevent penetration of liquid water, but allow water vapor to diffuse through them to the atmosphere. An overview of breathable fabrics describes such fabrics as densely woven fabrics, membranes, polyurethane coated fabrics, and biometric material. The evaluation of these fabrics can be measured by resistance to penetration and absorption of liquid water, wind resistance and water vapor permeability performance characteristics. The first waterproof breathable fabric "Ventile" was developed from finest long staple cotton for military purpose. Gore-Tex microporous membrane was developed from polytetrafluoroethylene (PTFE) polyester with 1.4 billion tiny holes per square centimeter.

B.Farnworth and W.A.Lotens described for measuring the water vapor resistance of textile under variable conditions of relative humidity and effect of relative humidity on coated fabrics. G.N.Mathur et revealed the test methods for determining fabric breathability for protective clothing. O.Smith developed a water resistant breathable fabrics focused on Triplepoint Ceramic and performance test methods. Federal Laboratories of Materials Testing and Research developed new test methods and testing machines for water resistant breathable fabrics. Gretton J. C., Brook D. B., Dyson H. M., Harlock S. C. examined moisture vapor transport through waterproof breathable layers and apparel systems under a realistic temperature gradient and compared the results with those obtained from isothermal tests. Krishnan S. reported the requirements of breathable fabrics properties. HOLMES D.A studied the effects of atmospheric conditions on the water vapor permeability of breathable fabrics. C.A.Vanbeest and P.P.M.M.Wittgen is an apparatus has been constructed to measure the water vapor resistance of textile and other permeable fabrics.

This work is the fabrication of Instrument for measurement of water-vapor resistance for woven and knitted fabrics in cold condition by exposing the fabric to direct ice.

2. Principle of the instrument

The fabric was shaped as rounded one. The diameter of the rounded woven and knitted fabric was 9 cm. The cell consists of ice holding device and dessilator. The inner portion of ice holding device is used to hold the ice. The inner partition of ice container a door was set in the top fill the ice. In the bottom partition, prepared plate was set inclined with a tube to collect and removed melted water under this plate the sample was fixed. The upper part of cell contained approximately 150 ml of ice made from distilled water, the surface of ice was polished by rubbing in to a metal surface. And the outer portion is used to store glass wool or cooling mixtures to maintain the ice temperature.

The load cell contains RS 232 communication system. This is used to interconnect the computer system. The functions of this cell are to measure the weight change of salt accuracy of 0.01 grams and the change of weight per second is send to the WVTRS Ver 1.1 (Water vapor Resistance Testing Software). The final result of the tested fabric is given by this software. Which is automatically get the rate of mass changes in a sample every one hour and after ten hours it gives the water vapor resistance of the fabric in $M^2 Pa s/g$.

2.1. Principle

The Water vapor resistance (R) between the upper and lower part of the cell was calculated from

$$R = AP_{ice}/M,$$

Where, **A** is the area (M^2) of the sample through which diffusion occurs. P_{ice} is the vapor pressure (Pa) over ice at the temperature of the air environmental chamber. **M** is the measure of the rate of water vapor transfer between the parts of the cell (Kg/s).

3. Results and discussions

From the table 2. and fig 5. its clear that the water vapor resistance of single jersey knitted fabric was low, initially upto two hours and maintained constant upto eight hours.

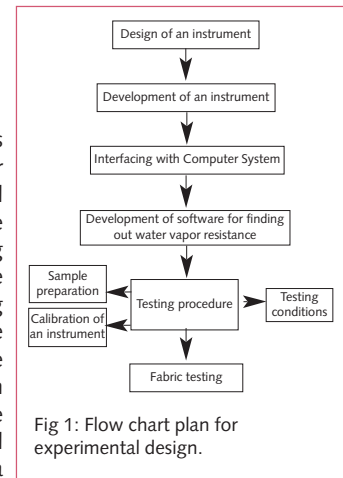


Fig 1: Flow chart plan for experimental design.

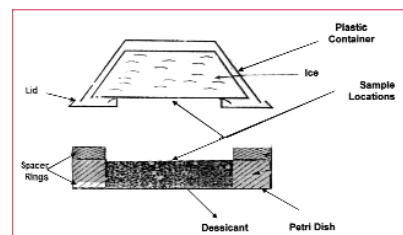


Fig 2. Principle of the instrument.

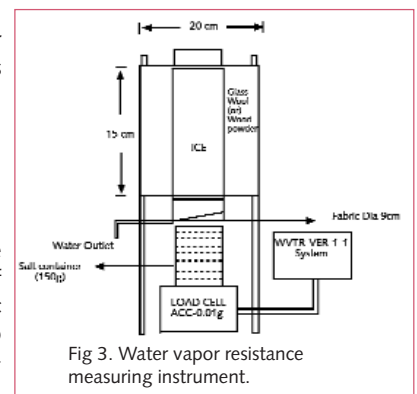


Fig 3. Water vapor resistance measuring instrument.

Table-1: Materials used for testing

Fabric particulars		
Structure	Knitted (Single Jersey)	Woven (Leno)
Thickness (mm)	0.2	0.0064
Weight (GSM)	95	110
Area of fabric (m^2)	0.0064	0.5
Instrument parameters		
Temperature of ICE ($^{\circ}C$)	$0^{\circ}C$	$0^{\circ}C$
ICE vapor resistance (Pa)	610.8	610.8
Time Interval (hour)	1	1
Initial weight of salt (gram)	148.12	147.80

1. Methodology and materials

Fabrication of an instrument for the measurement of water-vapor resistance of the woven and knitted fabrics in cold condition of the two structures is given in the flow chart (fig 1) and table 1 shows the materials used for testing.

Table 2: The Water vapor Resistance of Single Jersey Knitted Fabric

Time (hour)	Weight changes (grams)	Difference in weight (grams)	Water vapor Resistance ($m^2 \text{ pa s/g}$)
1	148.13	0.01	390.912
2	148.14	0.02	195.456
3	148.14	0.02	195.456
4	148.14	0.02	195.456
5	148.14	0.02	195.456
6	148.14	0.02	195.456
7	148.14	0.02	195.456
8	148.14	0.02	195.456
9	148.15	0.03	130.304
10	148.15	0.03	130.304



Fig 4. Water vapor resistance measuring Instrument with WVRTS Ver 1.1

instrument is with the close range of thermal diffusivity. It has been found that the fabric thickness and construction are the important parameter for water vapor resistance for both woven and knitted structures, tested in this experiment.

Table 3: The Water vapor Resistance of leno (woven) Fabric

Time (hour)	Weight changes (grams)	Difference in weight (grams)	Water vapor Resistance ($m^2 \text{ pa s/g}$)
1	147.80	0	0
2	147.80	0	0
3	147.80	0	0
4	147.81	0.01	390.912
5	147.81	0.01	390.912
6	147.81	0.01	390.912
7	147.81	0.01	390.912
8	147.81	0.01	390.912
9	147.82	0.02	195.456
10	147.82	0.02	195.456

After eight hours, the water vapor resistance is further

decreases, and it decreases as the time is increased. It was found that the fabric has good water vapor diffusion because of thickness of fabric is low.

In Leno (woven) fabric the results will not be transferred initially for upto three hours period. This is because of initial inertia developed and driving force

was developed after prolonged exposure of water vapor. From the table 3. and fig.6, it has been found that there is no water vapor transfer taken place initially upto three hours. After three hours a steep increase taken place and maintained the same upto eight hours. There is a fall in water resistance after eight hours.

Conclusion

A water vapor resistance measuring instrument for assessing the vapor resistance has been successfully designed and fabricated. The water vapor resistance measuring instrument permits rapid testing, for wide range of (light weight to heavier) textile materials. It has been observed that, the result, generated with the fabricated water vapor resistance measuring

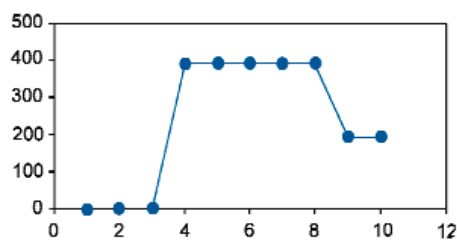
Water vapor resistance of Leno fabrics

Fig 6: Water vapor resistance of leno fabrics at various time intervals.

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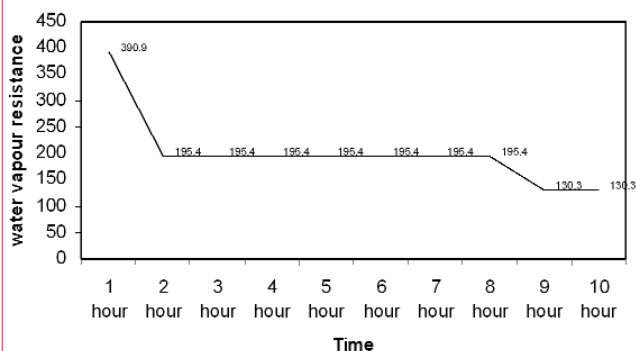
Water vapor resistance $m^2 \text{ Pa s/g}$ 

Fig 5: Water vapor resistance of single jersey knitted fabrics at various time intervals