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Measurement and Interpretation of Liquid Transport in the Porous Fiber Assemblies

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INTRODUCTION

The transport of liquid in a fibrous network is largely governed by the structure of the fabrics. Since most of nonwoven fabrics are structurally anistropic materials, flow properties depend on the direction of fluid flow[1-3]. Recently, the movement of fluids into and through nonwoven fabrics can be critically important in many end uses such as baby diapers, sanitary napkins, catamenial tampons, surgical sponges, dressings and gauzes[4,5]

Accordingly, knowledge of flow properties is essential in the design and application of engineering fabrics and it is important to characterize a fluid flow behavior of nonwoven fabrics. So, we have established the fluid transport behavior of multi-layered needle punched nonwoven fabrics with a newly designed apparatus.

THEORETICAL ANALYSIS

The permeability of a fabric(k) has usually calculated using Darcy's law

$$v = \frac{-\omega k \frac{\partial P}{\partial r}}{\eta} \qquad (1)$$

where, v is the fluid velocity, ω is the fabric porosity, η is the liquid viscosity and $\partial P/\partial r$ is the pressure gradient. For a growing circular front, the equation (2) can be useful to understand the liquid transport of nonwoven fabrics,

$$G(A) = (A^2(2\ln A - 1) + 1)/4 = k\,\Delta P t/\omega\,\eta\,r_0^2 \qquad (2)$$

where, $A = r_f/r_0$ is radial transport rate, t is time, r_0 is initial radius and ΔP is pressure difference.

EXPERIMENTAL

An experimental apparatus for this study is designed and manufactured. A 15cm square fabric specimen is placed between two acryl square plates. A 1cm diameter inlet hole is centered in the upper plate and a Teflon® shutter valve is set to separate the flow region from a fluid reservoir containing water.

The experiment is initiated by opening the shutter valve in the top plate and allowing liquid to spread radially in the plane of porous media and then the shape of the advancing front are monitored video camera as a funtion of time.

RESULTS AND DISCUSSION

Fig. 1 shows temporal fluid flow behavior of porous fiber assemblies. The permeability value is calculated using equation (1) and the relationship local permeability and time on the multi-layered fabrics is shown in Fig. 2. The local permeability of fabris is decreased up to 10s and nearly keep constant over 10s. It is considered that liquid transport in the porous fiber assemblies is affected on the entangled fiber structure. Fig. 3 shows the effect of punching density on the radial variation of nonwoven fabrics with transport time. The radial variation for the different punching density of nonwovens is generally increased in processing time.

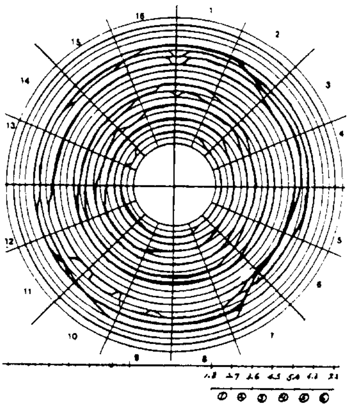

Fig. 1. Temporal flow front sequences for porous fiber assemblies.

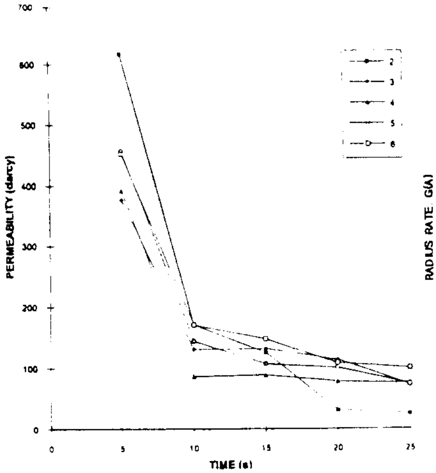

Fig. 2. The relationship local permeability and time on the multi-layered fabrics.

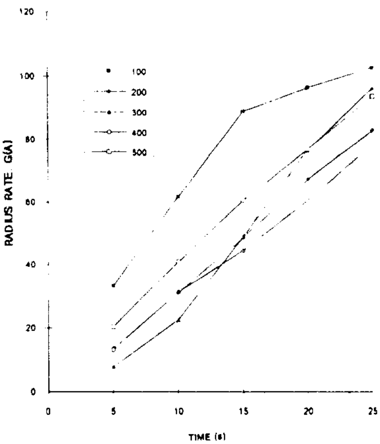

Fig. 3. The effect of punching density on the radius variation in process of time.

CONCLUSION

We have investigated with repect to a liquid flow behavior of multi-layered needle punched nonwoven fabrics. The results obtained in this study are as follows:

(1) The local permeability of fabris is decreased up to 10s and nearly keep constant over 10s and (2) The radial variation for the different punching density has generally increasing trend with the processing time.

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