Scientific Bulletin of the „Petru Maior" University of Tîrgu Mureş
Vol. 7 (XXIV), no. 2, 2010, ISSN 1841-9267

RESEARCH AND APPLICATION OF VISCO-ELASTIC MEMORY FOAM, IN THE FIELD OF FOOTWEAR MANUFACTURING

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ABSTRACT

The paper study and tests the use of Visco-Elastic Memory Foam in ergonomic shoe insoles application. To maximize comfort needs, Memory Foam responds to the unique curves and pressures points of the person's soles. This application is not necessarily meant for people with disabilities, but for normal everyday use of a high comfort shoe.

Keywords: Visco-Elastic Memory Foam, Shoe insoles or permanent inserts, ergonomic

1. Introduction

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like honey, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain instantaneously when stretched and just as quickly return to their original state once the stress is removed. Visco-elastic materials have elements of both of these properties and, as such, exhibit time dependent strain. Whereas elasticity is usually the result of stretching along crystallographic planes in an ordered solid, viscosity is the result of the diffusion of molecules inside an amorphous material [1].

Viscoelasticity value can vary in function of temperature or other given value. The viscosity of a viscoelastic substance gives the substance a strain rate dependent on time [1].

Purely elastic materials do not dissipate energy (heat) when a load is applied; however, a viscoelastic substance loses energy when a load is applied, then removed [1]. Since viscosity is the resistance to thermally activated plastic deformation, a viscous material will lose energy through a loading cycle. Plastic deformation results in lost energy, which is uncharacteristic of a purely elastic material's reaction to a loading cycle [1].

Maxwell model (Fig. 1. a.) and Kelvin–Voigt model (Fig. 1. b.) are examples of constitutive models for linear viscoelasticity, were E: elastic constant and η: the viscosity of the material [1].

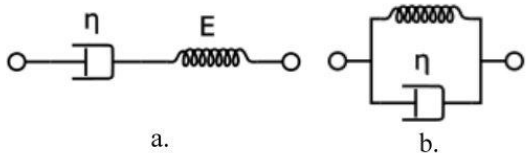

Fig. 1. *Examples models for linear viscoelasticity*

2. Material used

Visco-Elastic Memory Foam dates since 1971. NASA in an effort to relieve astronauts of the G-force experienced during lift-off, it developed visco-elastic pressure-relieving foam like material that was temperature-sensitive and it evenly distributed body weight [2]. NASA released this material to the public in the 1980s. Originally proved unstable for commercial use however, after several years of research and development by NASA, they succeeded in developing a proprietary formulation and proprietary process to manufacture a stable, durable and commercially viable product [2]. It was further developed by Tempur World's Dan-Foam factory in Denmark and released for commercial sale in 1991

Today main producers and developers of these material sale products under bards like Tempur-Pedic® and Isotonic®. The material's properties are from the unusual properties of its cell structure.

The used Tempur type polyurethane memory foam is presented in a colored scanning electron micrograph, magnification x264. (Fig. 2.)

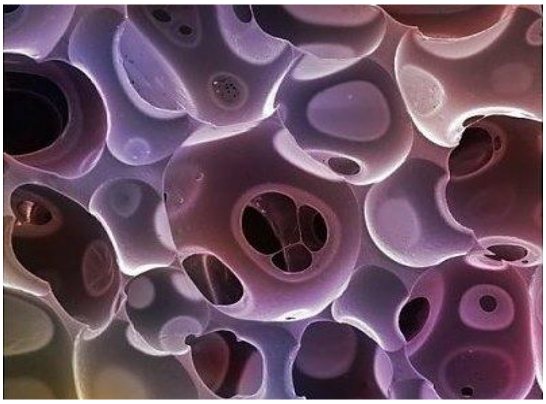

Fig.2. *Tempur memory foam polyurethane colored scanning electron micrograph magnification x264*

Unlike standard foams that only partially compress when under pressure, Tempur memory foam cells compress fully when pressed upon by another force, then they spring back to their original shape very slowly, (hence the name memory foam – The foam appears to remember the shape of the last object placed upon its surface) (Fig.3.).This slow recovery plays a major role in the materials therapeutic properties.

Fig.3. *The effect of memory foam on the used material*

Memory Foam will mold itself to any surface, and hold that shape (without sticking) as long as the object remains pressed to it; thus reducing pressure points on a users back, neck, legs and souls. No other material has this custom shaping properties that memory foam does. In addition, memory foam is temperature sensitive. This means that at lower temperatures it is harder (more viscous), and at higher temperatures it is softer (more elastic). The temperature sensitive quality accounts for the "melting" feeling and also accentuates the custom molding affect of the foam itself.

The behavior of Memory Foam is determined by its density. The denser the material the heavier and firmer it is to the touch. Also, the denser products usually take a lot longer to recover from a compressed state and are therefore thought to be more supportive than less dense memory foam. Because of this slower recovery, and increased support, denser foams are more expensive than less dense materials.

Density of this material can vary between 13-80 kg/m^3. The Tempur type material used are different thickness slices from a block of material with density of 60 kg/m^3

3. Application

An interesting and useful application of this material is for Memory Foam Shoe Insoles or permanent inserts. This derives from the fact that shoes are a common used item, and it doesn't need a big amount of this special and expensive material.

This application is possible due the fact that recent research and developments made memory foam hypo-allergenic, anti-bacterial, and anti-microbial. Also cost efficient is an important factor. As result, these insoles won't breed foot fungi.

Other methods used are common shoe insoles (Fig.4.) that bring unprecedented relief without creating extra bulk; rigid non universal EVA foam support; new and expensive gel insoles- whose rigid volumes actually resist foot contours.[3]

Fig. 4. *Common shoe insoles*

Memory Foam insoles respond to the unique curves and pressures of persons feet, like cradling in a soft pillow all day long.

4. Experimental results and discussions

Experimental results observed material behavior and applicability; tries finding an optimal thickness of the 60 kg/m^3 used material that gives the effect of increased support area and equalization of pressure points for maximization of comfort.

The measure method is orthopedically foot scanning technique. (Fig. 5.)

Fig. 5. *Measuring method: Orthopedic foot scanner*

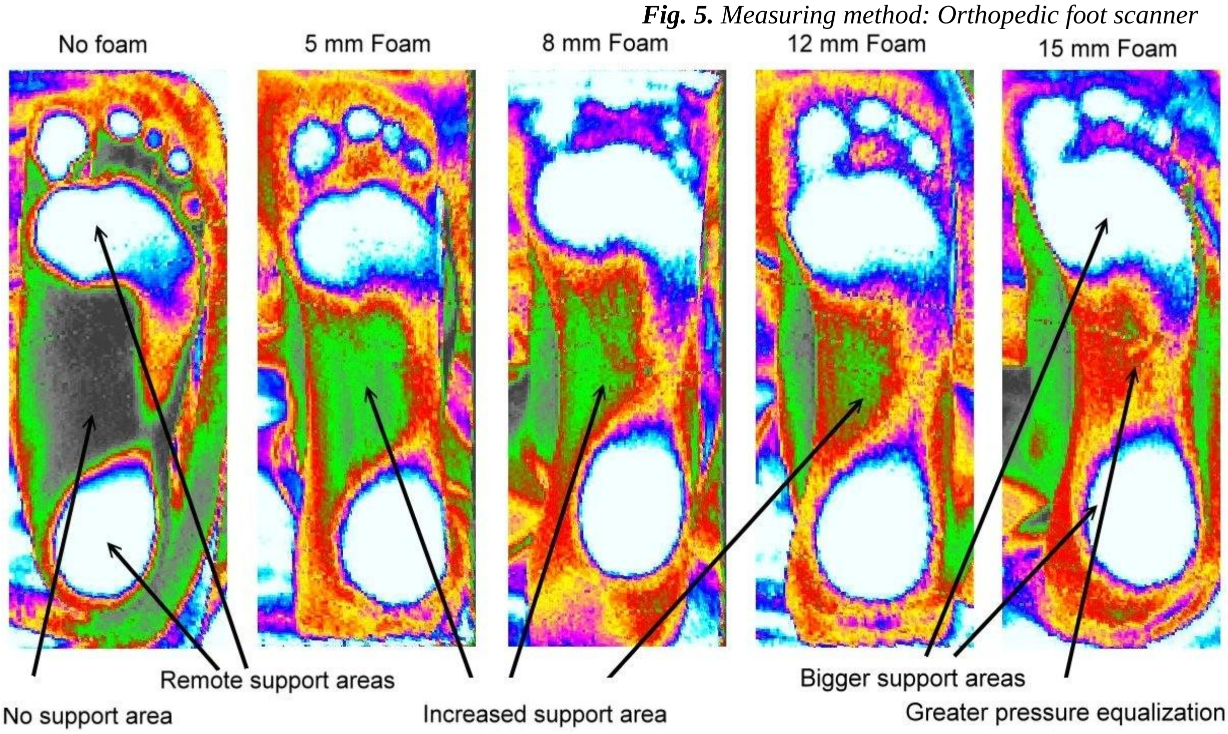

Fig. 6. *Orthopedic tests under different conditions*

Provided by a medical cabinet, the subject was placed on an orthopedic foot scanner with different thickness of material 5, 8, 12, 15 mm placed under the same conditions. The measurements were done by qualified medical staff.

This computerized method outputs thru specialized software, a colored image (Fig.6.). Image shows a visual representation of the loads across subject feet. The load is according to a percentage load chart. (Fig.7.)

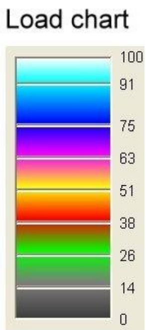

Fig.7. *The load chart*

In these results is visible that with the increasing of thickness, the support area becomes bigger, and the unsupported areas became supportive. Theoretically a better result can be obtained with thicker foam; this needs more space inside the shoe.

This result can be beat only with custom shoe insoles by taking a plaster or foam impression of the foot in a neutral position. The impression is then sent to a lab where the misalignments of your feet are corrected with compensation and stabilization techniques. The lab can incorporate special wedges to adjust arches that are too high or too low using a variety of soft, semi-rigid, or hard materials. The finished orthotic is then placed in the patient's shoe to keep the foot and body in proper alignment. This method is an Orthotics method and addresses to patients' with disabilities.

5. Conclusions

Memory Foam Shoe insoles or permanent inserts (Fig.8.) can replace current shoe insoles to bring unprecedented relief without creating extra bulk. Can be applied into any shoe and can be dimensioned for specific needs. Increased support area and equalization of pressure points maximize comfort needs for every foot shape and size. Heel, arch and toes support is achieved every time every time the user takes a step.

Fig. 8. *Applied Visco-Elastic material*

Greater thickness giver a better result, but cost is greater and space is required. An optimal thickness of 12 mm uncompressed Visco-elastic memory foam is considered useful in footwear manufacturing industry. To verify an additional different type of test was made under the same conditions with similar results. (Fig.9.)

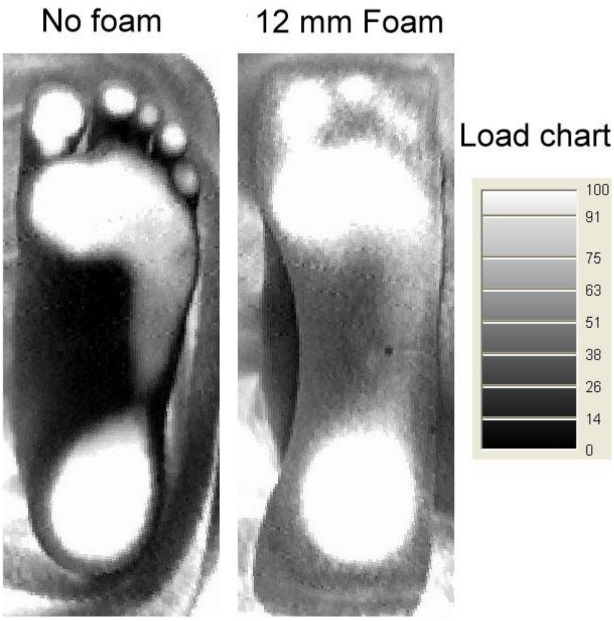

Fig.9. *Additional different type of test for 12mm*

Higher density memory foam tends to have more of the unique memory feel that makes the foam more supportive.

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