The use of stratification to optimise the sound absorption of porous materials

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This paper presents a novel method for manufacturing porous acoustic absorbers with pore size stratification. These materials are made using automotive waste.Car tyres are granulated and separated into various grain sizes. Although the resultant rubber granular mix can be recycled, there is a considerable amount of waste left over during the granulation process. This waste is called tyre shred residue (rayon) and approximately 25 tonnes of this material is daily produced by a single tyre granulating company. The company has no use for this waste and it is sent to the landfill.

Three different methods for material manufacturing are studied.The first methodenables to achieve pore stratification using a low molecular weight polyol. The addition of polyol helped to create a top layer of relativelylarge open pores which improve the acoustic absorption coefficient via reducing impedance mismatch. The proportion of open pores, hence the porosity and acoustic absorption of the stratified materials, can be controlled here by the amount of polyol added. The pore sizes created within the porous structure are both wide ranging and complex.The addition of polyol results in the rate of reaction at the base of the material to be slower than that near the top. This produces larger pores at the container base whereas smaller pores are created near the container top. The surface of the material sample develops a membrane caused by the binder reacting with moisture in the air. This membrane traps carbon dioxide gas escaping through the surface, thus causing stratification throughout the material sample. Furthermore the higher porosity at the part of the sample with the larger pores results in high permeability (low flow resistivity) whereas the middle and end sections with the smaller pores exhibit lower air flow permeabilities.Because of a pore size gradient,the impedance changes gradually improving the overall acoustic absorption of the resultant material sample.

Stratification can also be created within the same material mixture by applying a temperature gradient. This method does not require the application of polyol. This mixture is also placed inside a container the base of which is heatedwith a hot plate for 15 minutes.Because of the application of heat, a faster polymerisation reaction occurs at the base of the container which is in contact with the hot plate. In this way, a larger proportion of smaller pores are produced near the base.The top of the container is vented to the cooler atmosphere, therefore a slower polymerisation reaction near the top results in a higher proportion of larger pores. This process enables to achieve a 4-6 fold difference in the permeability between the top and bottom layers of the sample and a gradual change of pore size distribution with the depth.

Finally, a vacuum can be used to produce stratification in a mixture of adhesive, tyre shred residue and water which is placed inside a container which is placed in a vacuum desiccator. When the vacuum pump is switched on for approximately 60 seconds, the mixture expands five timesits initial height. In this case porous material with a pore size gradient similar to that attained with the first two methods can be obtained.

The normal incidence absorption coefficient of 140mm thick materials specimens manufactured using the above methods has been measured in a 100mm impedance tube. The porosity and flow resistivity gradients of these samples have also been measured non-acoustically. The results show that a significant enhancement of the absorption properties can be obtained in the frequency band of 50 – 1600 Hz as compared with materials which pore size distribution is independent of the depth.

Keywords: stratified materials, recycling polymeric waste, pore size distribution, acoustic impedance, polyol, temperature, vacuum.

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Oral presentation preferred.