foaming within the mold. The disadvantages of such a process were discussed above. As a third variant, a process is disclosed wherein the material is subjected to elastic compression while compression molding a preheated foam material. Preheating is done in an oven. However, this process is disadvantageous in that many foam materials require very high temperatures for thermo-elastic forming. PMI foams for instance require temperatures of 185°C at least. It is further necessary for the core material to have been appropriately heated up throughout its entire corpus to avoid material failures. However, at such temperatures, particularly since these are only possible with prolonged heating for several minutes if they are to be uniformly distributed, many outer materials such as PP for example would be so severely damaged that the process cannot be carried out.

In U. Breuer, Polymer Composites, 1998, 19(3), pp. 275-9 a slightly modified process of the third variant from Pip, discussed above, is disclosed for PMI foam cores. The PMI foam core and the fiber-reinforced outer materials are heated up using an IR heat lamp. Such IR heat radiators, which emit light at wavelengths in the range between 3 and 50 µm (IR-C or MIR radiation) in particular, are particularly useful for heating the substrate quickly. However, the energy input, which is desired, is very high and so at the same time causes damage to many outer materials, such as PP for example. Accordingly, only polyamide 12 (PA12) is disclosed in Breuer et al. as possible matrix material for the outer layers. PA12 is readily heatable to above 200°C without the plastic being damaged. Simultaneous forming of the foam core is not possible in this method of operation, since the thermal radiation of this IR spectrum does not penetrate into the foam matrix and hence no thermoplastically formable state is obtained.

Problem

Against the background of the prior art discussed, the present ~~invention~~ disclosure accordingly has for its object to provide a novel process whereby rigid foamed materials can be rapidly and simply shaped without structural damage and/or be processed together with outer layers, especially with thermoplastic materials, into composites.

The present disclosure~~invention~~ has more particularly for its object to provide a process wherein these composite materials are produced in a forming operation and at the same time the choice of surface material is relatively free without this surface material being damaged during processing.

The process shall further be useful for partially consolidating foamed materials with or without outer material. The process shall also be useful for producing hollow articles from two or more foamed materials with or without outer layers. The process shall further be modifiable such that it can be combined with a vacuum-forming operation.

Furthermore, irrespective of the individual embodiments posed as objects, the novel process shall allow fast cycle times of distinctly below 10 min.

Further objects not explicitly discussed here may become apparent hereinbelow from the prior art, the description, the claims or exemplary embodiments.

Solution

The objects are achieved by a novel process for forming foamed materials. This novel process is particularly useful for forming rigid foams as of highly crosslinked polyurethane (PU), polypropylene (PP) or of poly(meth)acrylimide, especially of polymethacrylimide (PMI). The process comprises the steps of:

a) optional composite ply layup with outer materials and a foam core thereinbetween,

b) heating the foamed material by irradiation with near infrared radiation (NIR radiation) having a wavelength between 0.78 and 1.40 µm,

c) forming with a forming tool,

d) cooling and demolding the final workpiece.

in a first aspect, there is provided a process for forming foamed materials, wherein the foamed material comprises PMI, PP or highly crosslinked PU, said process comprising the steps of:

a) optional composite ply construction with outer materials and a foam core thereinbetween,

b) heating the foamed material by irradiation with near infrared radiation (NIR radiation) having a wavelength between 0.78 and 1.40 µm,

c) forming with a forming tool,

d) cooling and demolding the final workpiece.

Two different embodiments are possible here. In the first, the tool for heating with the NIR radiation and the forming tool are separate from each other. The process in this case comprises the steps of:

a) optional composite ply layup with outer materials and a foam core thereinbetween,

b1) introduction into the machine-side active region of the heating fields