World Academy of Science, Engineering and Technology
International Journal of Materials and Textile Engineering
Vol:12, No:07, 2018

Sequential Padding: A Method to Improve the Impact Resistance in Body Armor Materials

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Abstract : Application of shear thickening fluid (STF) has been proved to increase the impact resistance performance of the textile structures to further use it as a body armor material. In the present research, STF was applied on Kevlar woven fabric to make the structure lightweight and flexible while improving its impact resistance performance. It was observed that getting a fair amount of add-on of STF on Kevlar fabric is difficult as Kevlar fabric comes with a pre-coating of PTFE which hinders its absorbency. Hence, a method termed as sequential padding is developed in the present study to improve the add-on of STF on Kevlar fabric. Contrary to the conventional process, where Kevlar fabric is treated with STF once using any one pressure, in sequential padding method, the Kevlar fabrics were treated twice in a sequential manner using combination of two pressures together in a sample. 200 GSM Kevlar fabrics were used in the present study. STF was prepared by adding PEG with 70% (w/w) nano-silica concentration. Ethanol was added with the STF at a fixed ratio to reduce viscosity. A high-speed homogenizer was used to make the dispersion. Total nine STF treated Kevlar fabric samples were prepared by using varying combinations and sequences of three levels of padding pressure {0.5, 1.0 and 2.0 bar). The fabrics were dried at 80°C for 40 minutes in a hot air oven to evaporate ethanol. Untreated and STF treated fabrics were tested for add-on%. Impact resistance performance of samples was also tested on dynamic impact tester at a fixed velocity of 6 m/s. Further, to observe the impact resistance performance in actual condition, low velocity ballistic test with 165 m/s velocity was also performed to confirm the results of impact resistance test. It was observed that both add-on% and impact energy absorption of Kevlar fabrics increases significantly with sequential padding process as compared to untreated as well as single stage padding process. It was also determined that impact energy absorption is significantly better in STF treated Kevlar fabrics when 1st padding pressure is higher, and 2nd padding pressure is lower. It is also observed that impact energy absorption of sequentially padded Kevlar fabric shows almost 125% increase in ballistic impact energy absorption (40.62 J) as compared to untreated fabric (18.07 J).The results are owing to the fact that the treatment of fabrics at high pressure during the first padding is responsible for uniform distribution of STF within the fabric structures. While padding with second lower pressure ensures the high add-on of STF for over-all improvement in the impact resistance performance of the fabric. Therefore, it is concluded that sequential padding process may help to improve the impact performance of body armor materials based on STF treated Kevlar fabrics.

Keywords : body armor, impact resistance, Kevlar, shear thickening fluid
Conference Title : ICTF 2018 : International Conference on Textiles and Fashion
Conference Location : Paris, France
Conference Dates : July 19-20, 2018