



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS**

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Thesis Title:

Development of Smart Thickening Fluid based Ultra Resilient Adaptive Kinematic Soft Human Armour (SURAKSHA)

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SHORT ABSTRACT

With the progress of great development occurring in society, day by day a greater number of threats arises against humanity. The history of the conflicts between two parties is not new. In the present era, the form of war has been changing constantly, and it has taken various shapes such as guerilla warfare, insurgency, and similar. With the rapid development in technology, arms and ammunition have modernized. This increases the threat to the personnel who is directly participating in the conflict. The main objective during combat situation is survivability of the engaged personnel. Due to the rapid development in the lethality of bullets, there is an immense demand for the development of enhanced protective suit which can safeguard against these threats and are simultaneously flexible and light. This thesis presents the design and development of liquid ballistic body armour to counter extreme threats arising from the bullet (direct and indirect effect) from standard arms and ammunition (as per National Institute of Justice (NIJ) specifications). The effect of inter-yarn friction on the ballistic performance of the fabric is analyzed. The fabric consisting of varying yarn density (fabric sett) is considered to select optimum yarn density. From the numerical modelling, the ballistic performance of the fabric is optimized as a function of coefficient of friction and a critical coefficient of friction is obtained. The modelling of Shear Thickening Fluid (STF) treated Kevlar is presented and the ballistic performance of the STF treated fabric is evaluated. The numerical model of (STF) treated fabric utilizes the friction-based models and is implemented by adopting very high coefficients of inter-yarn friction. The present study shows that there is enhancement of ballistic performance due to increasing coefficient of friction up to a critical coefficient of friction for a specific fabric sett. Beyond critical level, no appreciable improvement in the ballistic performance of the fabric is observed. There is a decrease in the ballistic performance beyond critical friction level. After that, the Multi Material – Arbitrary Lagrangian Eulerian (MM-ALE) approach of modelling STF treated fabric is found to be an efficient option as compared to the friction-based model to evaluate the ballistic performance of the STF treated fabric. The different configurations of STF treated fabric are evaluated and optimum configuration is arrived to completely stop the projectile conforming to Ballistic Rating (BR) I, II A, II and III A as per NIJ standards. After that, the ballistic performance of STF encapsulated in bubble wrap configuration is analyzed and evaluated. The

STF encapsulated bubble wrap configuration consists of STF filled in bubbles and these bubbles are either uniformly or randomly placed to prepare a layer of bubbles. The numerical strategies for modelling of STF encapsulated bubble wrap configuration is proposed and presented in this thesis. In this study uniformly placed cylindrical bubbles of diameter 5 mm and height 5 mm is investigated and presented. This new configuration is found to be more efficient as compared to STF treated fabric in terms of ballistic performance against projectiles of different ballistic rating. The STF encapsulated bubble wrap is investigated under the impact of projectile of BR I, II A, II, and III A as per NIJ standards. The optimum configuration is arrived to completely stop the projectile conforming to BR I, II A, II and III A as per NIJ standards. Based on the outcome of the investigation a design guidelines and methodology are proposed in this thesis.

