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SHOCK WAVE PROPAGATION IN THE GAP BETWEEN THE COMBAT HELMET-HEAD ASSEMBLY

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ABSTRACT

Military personnel frequently encounter blast in battlefields. In a far-field regime, shock waves alone can cause an invisible wound in the brain by causing hemorrhage or concussion, which is termed as blast-induced Traumatic Brain Injuries (bTBI). It is essential to identify the location of pressure peaking points due to shock reflections that are essential in designing better quality combat helmets to mitigate bTBI. So this study mainly focuses on understanding the pressure peaking due to shock waves in the gap between helmet and head for front and bottom blast loading directions.

Keywords: combat helmet, bTBI, Blast waves, shock waves.

INTRODUCTION

Recently, due to advancements in the explosives, blast-related injuries increased relative to ballistic wounds. The precise mechanism for the occurrence of bTBI is still unclear, and the rarity of this trauma has contributed to the relative lack of established treatments for bTBI. Recent researches suggest that mild blast waves traveling in the gap between helmet-head might be a contributing factor for bTBI due to pressure peaking [1,2].

EXPERIMENTAL SETUP

In the current study, the shock tube is used for generating blast waves. Idealized helmet-head assembly is held rigidly inside the shock tube. The dynamic pressure sensors are mounted at three locations (front T1, middle T2, and rear T3) on the surface of the head for quantifying the pressure. Front direction (fd) and bottom direction (bd) loading is considered. Furthermore, for each loading configuration, two cases namely, the head alone (ha) and the head with helmet (hwh) are considered. Three trials are conducted in each case for ensuring consistency in results.

RESULTS AND CONCLUSIONS

In experiments due to variation in the magnitude of the incident pressure due to various factors of the shock tube, a simple data normalization strategy is used to find the peaking factor which is used for comparison between two cases, Figure 1.

The peaking factor is higher at T_1 for the fd-ha case compared to the fd-hwh case. The percentage of decrease in peaking factor value in fd-hwh case at T_1 is 17.50%. But in the contrary, at T_2 and T_3 the peaking factor is relatively high in fd-hwh case compared with fd-ha case and also the percentage of increase in peaking factor value at T_2 *and* T_3 are 28.69 and 51.69 % respectively.

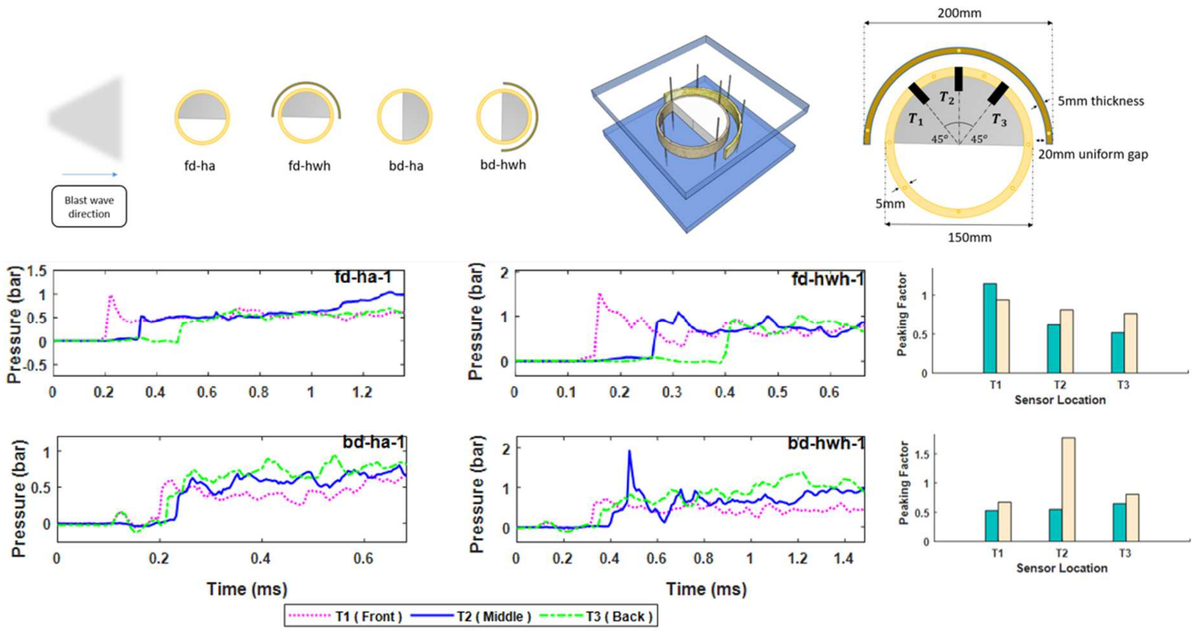

Fig. 1 - Experimental setup and surface pressure plot

The peak pressure values at T_1, T_2 and T_3 are almost the same for the bd-ha case. But in the case of bd-hwh at T_2, there is a significant peaking due to the constructive interference of waves from both directions. The percentage of increase in peaking factor values at T_1, $T_2$and T_3 are 34, 223.10 and 23.66 % respectively.

The critical factor in the design of a combat helmet for protection against mild blast is to mitigate traumatic brain injury by reducing the pressure peaking effects. Hence in this study, the pressure peaking in the region between the helmet and head assembly is examined by subjecting it to blast loading in front and bottom direction. The pressure is measured from the sensors placed at three locations on the surface of the head for two cases involving the head alone (ha) and head with helmet (hwh). Of the different cases considered in this study, the peaking factor is high at T_2 when the blast loading direction is from the bottom of the head with helmet case. This information plays a key role in mitigating the effect of mild blast impact by optimizing the shape of the helmet in the design process.

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