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UNCONSTRAINED SHAPE OPTIMISATION OF A LIGHTWEIGHT SIDE DOOR REINFORCING CROSSBAR FOR PASSENGER VEHICLES USING A COMPARATIVE EVALUATION METHOD

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ABSTRACT−This paper presents an efficient and extensive exploratory search for lightweight side-door intrusion-bar assembly design concepts using the approach previously developed by the author. The study aimed to discover latent dependence or other relationships between the geometry based design input parameters and the performance objectives (strength and lightweight) to identify the best engineering concept designs. The utilisation of the adopted approach and the extended substructures in particular, allowed for more than 2.6 times more design alternatives to be explored in the same time frame, which significantly increased necessary confidence in the acquired discoveries since a priori hypothesis about factors or patterns of input parameters was absent. The Pearson product-moment correlation coefficient and the Spearman's rank correlation coefficient were used to discover any potential and latent relationships, and the effects significance plots were utilised to deduce the best settings for each parameter and construct a generalised preferred shape.

KEY WORDS : Impact beams, Finite element analysis, Substructuring, Conceptual design

NOMENCLATURE

CR : crash resistance
F(x) : force-displacement function
x : displacement, mm

1. INTRODUCTION

The traffic accidents are one of the leading causes of mortality in modern society. Although technologies such as safety belts and frontal airbags proved to be effective in preventing fatalities in rollovers and frontals, their effectiveness was partial in side impacts. While absolute numbers of fatalities are decreasing, deaths in lateral impacts now account for a larger share of the fatalities. Side impacts account for close to 9,000 occupant fatalities per year in the US, which ranks it second only to frontal impacts as a cause of occupant fatalities in passenger cars. During a side impact by another vehicle, the car's side structure has limited capacity to absorb energy. The structure is deflected into the passenger compartment nearly at the impact speed of the oncoming vehicle and soon makes contact with the occupant, especially the occupant's torso, as it tends to be on the same level as the oncoming vehicle's front. The torso injuries account for about 60 % of life-threatening lesions. In a study conducted by NHTSA, it was observed that older occupants are over-represented in the side impacts primarily because older drivers have more difficulty recognising when it is safe to turn across oncoming traffic or enter an intersection. It is also conceivable that older occupants are especially susceptible to injury in this type of impact. This becomes very alarming given that in most developed countries population is ageing as a result of sustained low fertility and increasing life expectancy.

Injuries due to such accidents are a problem that can be controlled considerably if adequate attention is given to accident and injury prevention strategies. In order to minimise injuries due to the side impact, compulsory reinforcements as solid energy-absorbing barriers, also known as side-door intrusion bars or impact beams, are usually placed in the passenger car doors for additional protection against large external forces that are applied upon vehicle collisions. Due to these reinforcements, according to the study by NHTSA, fatality risk was reduced by 14 % for occupants in single-vehicle side impacts and by 23 % when impacts involve a single fixed object. In those cases, in addition to absorbing energy, the impact beams have an internal guard-rail-like role which enables a car to glide past the fixed object with a longer and shallower crush pattern on the car. Furthermore, the structural integrity of a side door was better preserved when the impact beams are present which also reduced the risk of nonfatal injuries in lower-speed crashes.

As these impact beams add a sufficient degree of rigidity to a passenger car door to resist external forces during an

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