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Advanced aerodynamic system for airbag inflation

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Abstract. A supersonic pulse aspirated inflator (ejector) is developed for a driver air bag with a potential to be used in airbags of any bigger sizes. It should initiate air aspiration from a car compartment into the 50-60 L airbag to inflate it within 30-50 ms with the aspiration ratio above 4. The ejector model is designed on the basis of Prandtl-Mayer flow analysis, in particular, using generation of simple suction waves at a sharp edge of an expansion area.
Investigations were carried out as the combined numerical and experimental modeling including aspirator engineering design, fabrication, and further testing. Experiments were fulfilled using a specified facility with high-pressure tanks built in the Laboratory for Advanced Aerodynamics & Interdisciplinary Research (Advanced AIR). Multi-stage multivariate studies of measured pressure fields and airbag inflation process embraced a number of various configurations, shapes and dimensions of aspirator elements.
As a result of analyzed design modifications, an optimized one was found to meet the engineering requirements. Parallel experiments using a small gas generator to initiate air entrainment are held in the Shanghai East Joy Long Motor Company.

Keywords: Airbag; aspirated inflator; experimental modeling; air entrainment; pressure measurements.

1. Introduction

Modern trends in automotive industry including boost of interest to autonomous cars requires new approaches to provide safety on the roads. Besides, there are known imperfections of conventional airbag (Pack et al. 1993) operation like gas generators occasionally killing people. Gas generator issues are analyzed in numerous works (Kyoung-Su Im et al. 2016, Korobov and Golovastov 2015, Young-Duk Seo at al. 2011, Agusti-Mejias et al. 2010, Charlery et al. 2015, Kistler 2017) and the results are partly used here to project them to operation and characteristics of an airbag pyrotechnic system with a smaller amount of a propellant. Together with explosively growing needs in cheap cars and lowered cost of passive restraint systems, these circumstances

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require development of more reliable and safe inflation systems. Airbags controlled by aspirated inflators will not harm an occupant, they require small gas generators of 1/3 size of conventional gas generators, eliminate satellite crash sensors and occupant sensors (Breed 2014). These two approaches are shown schematically in Figs. 1 (a) and 1 (b).

Thus the goal of this work is to develop a supersonic pulse aspiration system and to optimize it for a driver's airbag providing inflation of the 50-60 L airbag within ~30 ms with the aspiration ratio ≥ 4.

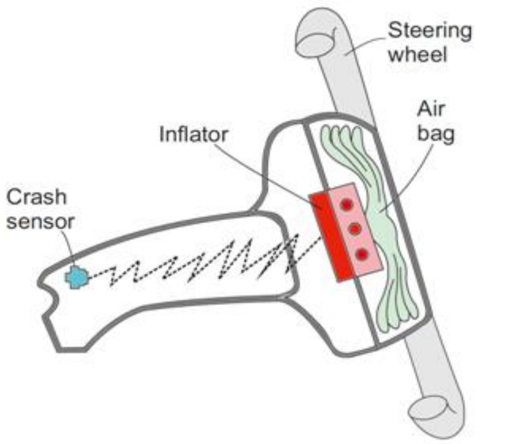

Fig. 1 (a) Operation of a conventional inflation system based on a production of a necessary amount of gas by a pyrotechnic element

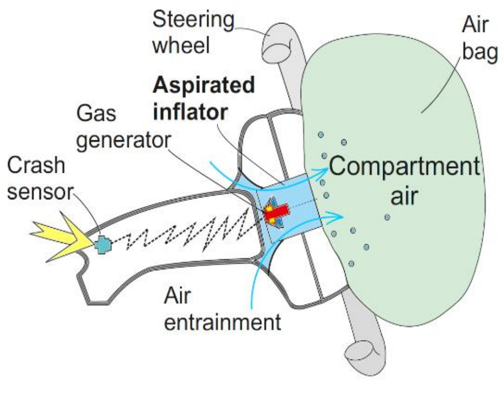

Fig. 1 (b) Aspirated inflator operation based on the entrainment of ambient air due to the supersonic pulse ejector

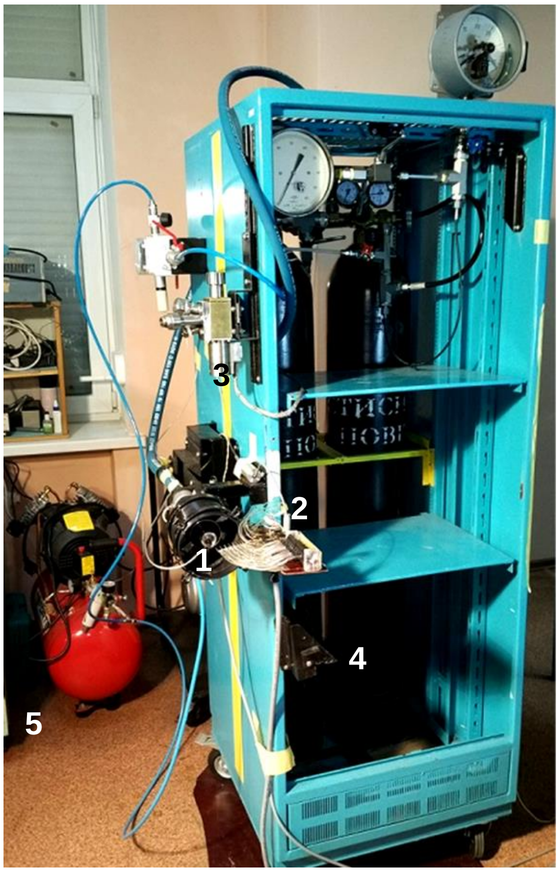

Fig. 2 Experimental facility: 1 – aspirated inflator model; 2 – pressure probe rake; 3 – high-speed valves; 4 – compressed air tanks, 0-100 bar; 5 – high- and low pressure compressors

Unlike Coanda effect (Stewart 1975), the Prandtl-Meyer expansion fan effect can provide higher pumping pressure and higher aspiration ratios. That is why the latter was taken as a basis for driver's airbag aspirator development using combined numerical & experimental research.