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THEORETICAL AND EXPERIMENTAL ANALYSIS OF A CNG CYLINDER RACK CONNECTION TO A BUS ROOF

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ABSTRACT−From our perspective, a global technology development should be focused on resolving the issues of environmental impact and conservation of available natural energy resources. New technological solutions and alternative fuels, such as Compressed Natural Gas (CNG), have increasingly more application for modern engines and vehicles. If we take into account the situation in city transport, where primarily vehicles with diesel engines are used, a strategic proposal is to begin by retrofitting these into bi-fuel or dedicated Natural Gas Vehicles (NGVs). This paper analyzes the retrofit of a diesel bus into dedicated NGV. To confirm the safety of the vehicle in city transport, we addressed the problem of mounting a gas rack with CNG cylinders on the roof of a retrofitted city bus, according to UN ECE Regulation No. 110. This assembly is the most critical part of the retrofitted bus because of the concentration of stress due to increased mass and the application of a specific installation for supply of CNG from the cylinders to the engine. These regulations must be met in all parts of the vehicle, but we only focused on those areas affected by the retrofit to NGV.

KEY WORDS : Natural gas vehicle, Finite element method analysis, UN ECE Regulation No. 110

1. INTRODUCTION

The global energy and environmental situations have intensified the use of alternative and environmentally clean fuels (Cho and He, 2008). This is true for city buses, taxis, delivery vehicles and personal cars (Stocchetti and Volpato, 2011).

As a contribution to the global strategy to address these issues, this paper analyzed the retrofit of a low-floor city bus powered by a diesel engine into a dedicated NGV using an original CNG engine. The bus roof has been additionally loaded with CNG cylinders and with new equipment and specific parts for the CNG fuel line. The main goal of this research, from the design to the retrofit and use of the bus, was to provide theoretical and experimental verification of the joint assembly used to connect the gas cylinder rack to the body grids of the bus roof (Milojevic and Pesic, 2011; Ale *et al*., 2008).

The position of the gas cylinder rack on the bus roof and joint assembly solution was evaluated using Finite Element Method analysis (FEM below) (Kojic *et al*., 1994).

By making experimental measurements on the bus, we determined the deformation and tension at critical points in the roof structure. In this way, we compared the results and verified the calculating model.

The new prototype of low-floor CNG-powered bus was homologated and used in city transport.

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2. CNG TANK INSTALLATION

The retrofit of the diesel bus into a dedicated NGV begins with the joining of the CNG cylinders with the original rack (Figure 1) to the bus roof. We selected a CNG storage system that includes type 3 cylinders composed of an aluminum 6061 liner reinforced by carbon fiber in epoxy resin (brand Dynecell®), with a favorable ratio between weight and volume (0.3 kg/L to 0.4 kg/L) (Rasche, 2009).

The position of the new center of gravity is calculated, taking into account the added weight of the CNG cylinders with the rack on the bus roof. During the retrofit, we have considered the existing regulations regarding the dimensions and gross vehicle weight. Specifically, we took into account the requirements relating to the correct joining of the main parts of the CNG fuel line and gas cylinders, all legislated by regulation ECE R 110 (Milojevic *et al.*, 2009; Ebrahim *et al.*, 2005).

To avoid damage to the existing roof, as in the first proposition, we did not attach the CNG cylinders rack to the chassis by bolts. This assembly also includes bushings, such as spacer sleeves, which were inserted to minimize deformation of the box-shaped profiles.

We initially used classic engineering methods to select the best position to attach the gas cylinders rack onto the bus roof and joint assembly solution, which was then