Light Weight Aluminum Cartridge Case Design for IED's Application - ANSYS

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Abstract: This paper describes the design analysis of the aluminum cartridge case, its testing, Analytical Simulation (ANSYS) and evaluation against Improvised Explosive Devices (IEDs) applications. Aluminum material is light in weight, non-corrosive and compatible with the propellant. Because of excellent properties, it is widely used in defence application sector. In the armament system, an effort is being made to reduce the cost, the weight of material from logistic point of view and its manufacturing process so as to meet the design requirements. Brass cartridge cases are being widely used in various types of ammunition for last 100 years *e.g.* armaments of small arm cartridges, artillery shell and power cartridges for fighter aircraft. Cartridges are made of either aluminum, steel or brass is filled with the propellants and pyrotechnic composition. With suitable means of ignition, the propellant generates the hot combustion gases at high pressure and temperature. These combustion gases are utilized to perform certain work on the system. The aluminum cartridge case for water disruptor applications plays a significant role in the destruction of the suspicious objects. This paper discusses the design aspects of the aluminum cartridge case for disruptor application of suspected IEDs. Performance evaluation parameters *i.e.* maximum pressure (P_{max}) and time to reach maximum pressure (TP_{max}) of aluminum cartridge have been carried out in a Closed Vessel (CV) using a Data Acquisition System (DAS). The material properties of aluminum such as tensile strength, percentage elongation and yield strength are determined using a Universal Testing Machine (UTM). Using the data obtained by the above methods, an attempt has been made to determine stress, strain and deformation of the cartridge case theoretically and numerically using ANSYS software. The results obtained by both methods are compared. The results are in good agreement with each other. It is observed that the percentage error for von -Mises stresses is 10.2 % using numerical and theoretical approaches. The percentage error between numerical and theoretical values of the hoop and longitudinal stresses are 6.71 % and 6.78 %. The percentage error between numerical and theoretical values of the hoop and longitudinal strains are 1.36 % and 3.64 %. The errors between theoretical and numerical values for radial displacements are 2.83 %. The novelty in this research work is that the design analysis of aluminium cartridge case is carried out using ANSYS software simulating the real-world problem. The analytical results are compared with numerical results. The actual pressure experienced by the cartridge case generated by the propellant burning is taken into consideration. This pressure is measured by a pressure transducer fitted over a specially designed test rig using a DAS. The sample of aluminum case is tested for hardness and microstructure. The results show there is no significant difference before and after the hardness and microstructure of the material. The results of ANSYS for stress and strain are in good agreement with theoretically calculated results and numerical analysis as percentage error is less than 11. This draws the inference for validating numerical and theoretical results. It is seen that 57.352 % saving in weight using aluminum cartridge is achieved. Using ANSYS, hoop stress 382.7 MPa, Hoop strain 4.32×10^{-3}, longitudinal strain 0.8602×10^{-3} and longitudinal stress 191.5 MPa are estimated. The main objective of this paper is to carry out design and analysis of aluminum cartridge case analytically as well as numerically.

Keywords: ANSYS, Cartridge, Closed Vessel, Disruptor, IEDs and Power cartridge.

1. INTRODUCTION

1.1. Cartridge Case

Design and analysis of any component play a very important role before its actual use in the system. The main objective of the paper is to carry out the design analysis of aluminum cartridge case. This design validation aids to demonstrate how the system will perform its intended function. The analysis gives a fair idea whether the component will survive during actual field trials. Power cartridge in a disruptor application utilizes aluminum as a material for construction. On initiation of the cartridge, it provides the gas pressure due to the propellant burning. This phenomenon of converting solid to gas poses a rapid chemical reaction liberating energy instantaneously. Power cartridges are gas generators consisting of a squib as a means of initiation, booster and the propellant. They are used to perform the destruction task of dangerous objects [1]. The water jet is produced and effective against suspected objects including IEDs. The various materials are being used in the manufacturing of cartridge cases such as brass, steel and aluminum depending upon cost, compatibility of explosives and its availability. A similar study was presented by Parate *et al.* [2] for design analysis of cartridge case using brass material. Using a brass cartridge case, the maximum and minimum hoop stresses are 315. 9 MPa and -5.2 MPa, the maximum and minimum von-Mises stress are 356

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