Multi-body Dynamic Analysis of Ammunition Transfer and Ramming Mechanisms in the Autoloader of Military Tracked Vehicle

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Abstract
The present paper is focused on the multi-body simulation and rigid-body dynamic analysis of the Ammunition Transfer and Ramming Mechanisms in the Autoloader assembly positioned in the turret bustle of the military combat vehicle. The Autoloader assembly consists of the ammunition ramming and intermediate transfer mechanism to extract the ammunition from the autoloader and safely load it inside the gun barrel, thereby meeting the requisite rate of fire. The ammunition ramming mechanism is modeled with a linear chain assembly which consists of an assemblage of chain links, driving sprocket & idler assembly and supporting trays for the rollers. Suitable contacts and constraints are established by using penalty formulation between various parts of the linear chain assembly. The linear chain assembly was analysed separately through which suitable design modifications of the chain link wedge angles could be arrived at, to reduce the overall sagging. Subsequently, integrated multi-body dynamic (MBD) analyses are carried out by coupling the modified linear chain assembly with and without the intermediate transfer mechanism in order to push the ammunition smoothly inside the gun barrel. Suitable constraints are defined to actuate the intermediate transfer mechanism. Comparative dynamic analyses were carried out with different chain link wedge angles in order to achieve the desired ammunition acceleration. The ammunition pitch dynamics was observed to be higher without the intermediate transfer mechanism. This study would establish a useful guiding platform for validating the design, arriving at the optimal operation timing and also evolve the standard operating procedure of the Autoloader assembly for any military tracked vehicle.

Keywords: Tracked vehicles, Autoloader, Linear chain, Multi-body dynamics, Penalty contact

1. Introduction

One of the recent User requirements is an ammunition autoloader for military tracked vehicles in order to eliminate the crew fatigue while loading the ammunition manually and also to achieve an enhanced and consistent rate of fire. In order to cater for the smooth loading of ammunition inside the gun barrel, it is very essential to carry out detailed MBD analyses of the autoloader assembly and bring out suitable design modifications. S.C. Nie, et. *al.* (2020) has focused on the dynamic tracking control of the ammunition manipulator system by using Lyapunov functions-based dynamic surface control method which provided a stable solution and was validated with experimental results. Extensive literature survey was carried out on the autoloader systems of different fighting vehicles by J. Roopchand (2014). Miscellaneous levels of research are dedicated towards development of the autoloader assembly for military tracked vehicles. The present study is focused towards the development of a detailed MBD model of the autoloader assembly which consists of the ammunition ramming and intermediate transfer mechanism to extract the ammunition from the autoloader and safely load it inside the gun barrel. Suitable design modifications are carried out on the ammunition ramming mechanism in order to arrive at the best possible ammunition acceleration magnitudes with smooth insertion into the gun barrel.

2. Methodology

The Autoloader assembly consists of three main sub-assemblies- a. Ammunition compartment, b. Ammunition ramming mechanism and c. Intermediate transfer mechanism (shown in Figure 1). The ammunition ramming mechanism is modeled with a linear chain assembly which consists of a number of chain links, sprocket & idler assembly and supporting trays for the link rollers. Suitable contacts and constraints are established between different parts of the linear chain assembly. Requisite angular motion inputs are provided to the sprocket. The integrated multi-body dynamic (MBD) analyses are carried out by coupling the modified linear chain assembly with and without the intermediate transfer mechanism. Comparative dynamic analyses were carried out with different chain link wedge angles in order to achieve the desired longitudinal acceleration of the ammunition.

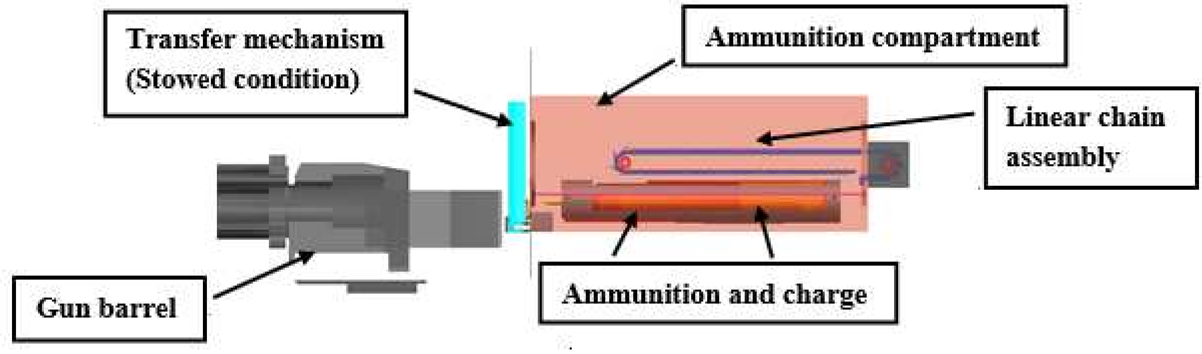

Figure 1: Schematic representation of the Autoloader assembly

3. Results and discussion

Figure (2) highlights the comparative dynamic sag levels of the frontal link in the linear chain assembly with 20 deg., 40 deg. and 90 deg. wedge angles which directly affects the force transmission.

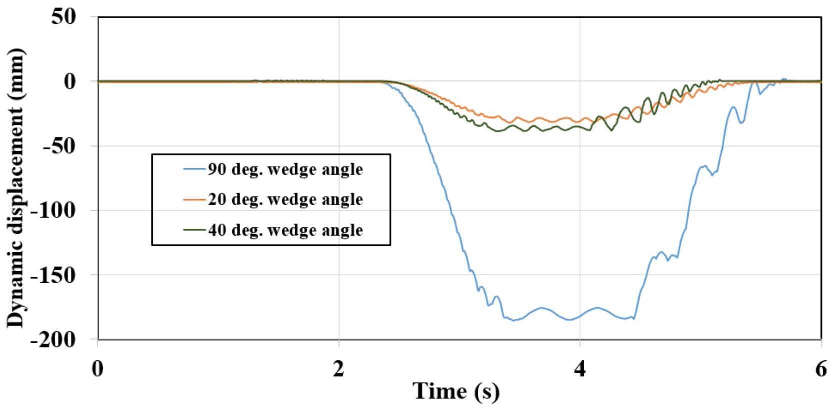

Figure 2: Comparative dynamic sag of the frontal link in linear chain

4. Conclusion

It was observed that with 40 deg. chain link wedge angle, the desired ammunition acceleration levels could be achieved. This study would establish a useful guiding platform for validating the design, arriving at the optimal operation time and also evolve the standard operating procedure of the Autoloader assembly for any military tracked vehicle.

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