

Armoured Fighting Vehicle - Future Perspective

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Armoured fighting vehicles (AFVs) by and large had an evolutionary development trend from the first generation tanks to the present fourth generation tanks. Over the few decades, the comparative weighting parameters like overall weight, power to weight ratio, silhouette, average ground speed etc have gradually improved. In the earlier generation tank designs newer technology developments in subsystems have been the only change in the improved design. Gradual improvements in fire power, mobility were seen in an incremental fashion with parallel technology developments. Direct changes due to doctrines of war or field operational requirements came up in the later generation tanks. However the present fourth generation tank has already reached a saturation of design/performance trade-off, with tightly packed power pack, turret and crew compartments with full compliment of equipment. The improvements in lethality, firing accuracy, and advanced target acquisition systems have reduced the survivability time in intense combat environment. 120/125 mm gun still holds the forte as main weapon, but missile firing through gun, laser designator system, and advanced night vision system have come in place. Survivability is enhanced by advanced explosive reactive armour (ERA) and counter measures for laser and IR threats. The engine design has seen new revolutionary trends in common rail direct injection (CRDI), higher injection pressure, more compact self cleaning air filtration system. Metal matrix and advanced composites are gradually replacing heavier conventional steel parts. The present design drivers are, improved survivability through hard kill, active protection systems, lighter, higher field mobility by light-weighting design approaches with composites, and exotic materials, enhanced fighting capability with advanced electronics, communication systems, networked systems, situational awareness, operationally superior weapon system with good sensor architecture and host of other design improvements. The survival of belly armour from 5 kg TNT to 20 kg TNT is arduous by any standards unless some huge innovation comes through. The overall tank crew of four vs three is still in debate with one extra crew adds up to seven tonne of weight and operational parameters taking a beating, like tactical mobility and trench crossing abilities etc. Autoloader, remotely operated unmanned turrets are possible in future, and electrical turret drive replacing hydraulic drives. As the tank design is in a technology cross over stage with demand drivers and new technology developments, there is a need to relook on the weapon platform its role for future. The future theatre scenario may also have possibility of unmanned ground vehicles in

tandem with AFVs doing a designated role. The day, hybrid drives replacing mechanical transmission may not be far off.

The current technology developments, and the possible innovations that are likely to mature in coming few years will shape the design of future AFV. In Combat Vehicles Research and Development Establishment (CVRDE), Chennai, it was felt necessary to look into future, and address the design drivers for a radically newer design. Future technologies for combat (FTC-2017), vehicles a two-day seminar, was organised by CVRDE, bringing R&D, Academia and Industry to come together on a single platform. Due to the initiative of Dr P Sivakumar DS and Director CVRDE to bring innovative design and futuristic technology for AFVs, this seminar was possible, and drew overwhelming response. The seminar threw up many design trends like CRDI Fuel injection system with high injection pressure, and highly downsized engine design and developments. Topics on various technology developments viz. Compact design, with better utilisation of materials, technology derivatives, and software simulation tools to keep weight and size in control, were presented. The highlights of technologies covered in the papers are briefly summarised as follows:

Configurations, simulation studies on hybrid drive systems have discussed the possibilities for future hybrid systems. Innovative approach paper on simulation of mine blast with hybrid composite plates was presented. Design for Future Main Battle Tanks (FMBTs) is discussed for key influencing attributes like, number of crew, armament weight, transportability, survivability, tactical mobility, operating range, trafficability, theatre of operation, system modularity on overall configuration is discussed in the paper by Hafeezur Rahman and co-authors. Hybrid electric vehicle design is being explored for AFVs for obvious reasons of extended range and higher electrical power availability, silent operation, etc. In paper on hybrid electric vehicle for AFVs, P. Sivakumar has reported the current global electric vehicle scenario, research trends, configurations for AFVs and applicable technologies of traction motors and power electronics. Configuring and optimising diesel engine for hybrid application based on operating torque and speed points, mathematical modelling with MATLAB Simulink approach is discussed in a paper by Hari Viswanath, *et al.* Downsizing of engine, with high power output requires adaptation of newer design approaches, high pressure injection CRDI, high turbocharger pressure ratios, combustion effectiveness enhancement, and packaging subsystems effectively. Prasad and co-authors in their paper

details the design approaches required for high power density engine design.

Thermodynamic simulation of turbocharger with variable geometry turbine affects the overall engine performance in a CRDI engine. Anand Mammen Thomas, *et al.* have carried a detailed thermodynamic simulation study for CRDI development. Jensen Samuel and co-authors in his paper describes about development of control strategy for CRDI fuel injection system for AFV application. Taking an existing CRDI system, mapping and generating thermodynamic simulation, generation of CRDI Software for new configuration and test bed evaluation, and approach to AFV requirements are covered in detail. Thermal management of vehicle cooling system is a major area of concern in AFV cooling system as water, lubrication, and air for combustion are cooled in a special architecture. CFD based simulation of entire air flow path from inlet to exit louvers and heat dissipation is discussed in paper by Jayesh Namjoshi, *et al.*

Compact heat exchangers are being developed with different fin geometries to cater for different air flow capacities to improve heat dissipation performance. CFD simulation, optimising fin parameters to achieve thermal performance has been studied by Krishnan and Gowtham in their paper. The study of present and futuristic gun systems including conventional gun system, electro-thermal-chemical gun, liquid propellant gun are compared to predict possible futuristic development trend in paper by A.K. Roy and co-authors. Target acquisition in combat environment involves interface of various techniques to acquire threat information in adverse conditions. Paper by Zahir, *et al.* covers various aspects like optics, gimbal design, embedded control etc on development of sighting systems.

Significant studies on current rolled homogeneous armour, ERA, metallic, composite, low weight armour, high nitrogen steel, etc, are highlighted in the paper by Bhav Singh and co-authors. Armour design is big challenge as the total AFV weight is dictated by protection levels required and finally the overall weight. Active studies in this area is necessary to meet future AFV design challenges. Light weighting of tracked vehicle systems with composites for dynamic systems like Road wheels, top rollers, axle arm etc is discussed in paper by Subodh Kumar Nirala, *et al.* The paper studies the composite wheel design with FE analysis and MBD simulations. Possible manufacturing aspects and NDT methods are described.

Aluminum metal matrix composite of Al2014-10 % SiC was studied experimentally and through ANSYS for transmission clutch housing component to replace steel or cast iron housing. The paper by Dhanalakshmi and co-authors reports strain behaviour for various extrusion ratios and the micro structure of the extruded parts. Weight reduction, with use of appropriate material selection will be one of the drivers in futuristic design of subsystems and parts. Study of BLDC generator for the design to meet thermal performance behaviour in operational environment with severe weight restrictions requires CFD simulation for thermal behaviour. Shankapal, *et al.* in their paper have brought out performance and thermal response of 5 kW BLDC generator.

Situational awareness in the battlefield of own forces and threats in real time is key to combat superiority and for survival. Mathematical modelling of Indian Regional Navigation Satellite System (IRNSS) receiver has been made for satellite signal acquisition, tracking, range position estimate in paper by Naveen Pitchumani and co-authors. Sanjit Mahajan and Muralidharan in his paper on blast studies on armoured vehicle structure has modelled the vehicle structure including weldments, fasteners, and transient dynamic blast load effect was studied in the model. The entire vehicle response, deformation, and stress levels, velocity and acceleration values are established.

Dimensional analysis for scaling of blast event is essential for the blast simulation of armour structures at a relatively lesser run time and as well as to optimise the number of field experiments which play a vital role in arriving at an optimum configuration and these are discussed in the paper by Dhiraj, *et al.* An MBD study on AFV is computationally intensive and new mathematical approach is being discussed by Ilango Mahalingam and Chandramouli in their paper. Performance of the gun system subjected to terrain excitations coupled with its own Inertia properties dictates the final performance. Study of turret response in frequency spectrum, elevation dynamics, comparison of various control algorithms like liner linear quadratic regulator (LQR), back-stepping are discussed in paper by Jakati Ambarish and co-authors. Multi Body Dynamic (MBD) tool is used to evaluate the vehicle performance in typical general staff qualitative requirement (GSQR) profiles like trench, ditch etc, with sprocket torque requirements and as well as the response of the vehicle in typical manoeuver. Balamurugan and Srinivasan in their study of AFV have predicted the vehicle performance using MBD.

Future tank design is a great challenge, considering the emergence of various new technologies and the need to effectively integrate it in the vehicle. A priori configuration model to evaluate the tactical mobility, and protection requirements w.r.t to weight and volume of various systems can lead to a compact fighting vehicle. Structural and space optimisation studies are must for optimum use of material. Light weight track, and improvements in tractive efficiency will enhance mobility. This is one area where more R&D effort and focus is required to surge ahead. Interface of all weapons and sensors, Active Protection System (APS), Laser Warning System (LWS), through single FCC is a must for use of turret system. Situational Awareness Unit (SAU), Battlefield Management System (BMS), Advanced Land Navigation System (ALNS), Communication sets, driver navigation aid can be integrated into single system. Reduction of multiple displays, sights, between the crew is to be thought about. Early tradeoff on essential and desirable functions, technology maturity level estimates can be carried out.

As a Guest Editor, I sincerely thank all the expert reviewers for their valuable suggestions and inputs. I take this opportunity to thank all authors who had contributed for papers and completed the corrections suggested by reviewers. My special and sincere thanks to Director DESIDOC and the Defence Science Journal team for unstinted cooperation and support.