

# A Literature Survey on Turret Assembly in off-road Vehicles

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## ABSTRACT

The Paper is focused on literature review done on design of Turret Assembly used in off-road combat vehicles. The requirement of off-road combat vehicles (ORCV) for defence is of great concern because of increasing terrorist activities in different regions of India over the past years. The present study undertakes a designing of armoured turret assembly for off-road combat vehicle (ORCV). As the turret design is totally a new concept for Original Equipment Manufacturers (OEM), therefore this paper addresses gaps in the design of turret assembly.

**Keywords—** Off-road Combat Vehicle, Turret Assembly, Robust Design.

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## I. INTRODUCTION

The requirement of off-road Combat vehicle (ORCV) is a great consent because of increasing terrorist activities in different regions. Government is investing on up-gradation of armoured vehicles with its night fighting capabilities and weapon accuracies.

The research came into existence due to requirement of Gunner's hatch/ Turret having 360° traversing motion with foldable perimeter protection with suitable detachable mount to mount and effectively fire through Light Machine Gun (LMG) which can enable firing at an elevation of 60° or more and depression of 10° or more on the roof of off-road combat vehicle.

Present study deals with the designing of turret assembly from scratch on vehicle. Until recent times, only gun-mount assembly was provided on another Combat Vehicles. But in present time for the safety of the crew members, turret assembly was designed with the perimeter protection in specification as requested by MOD. This has led to the simultaneous change and refinement in design in addition to the research in manufacturing of turret assembly and fitment on the vehicle by keeping in mind the requirement. Design of perimeter protection assembly should be done in such a way that time required for folding and unfolding should be minimum & torque required for 360° traversing motion of detachable mount

assembly along with perimeter protection assembly should be less.

## II. LITERATURE AND PATENT REVIEW

The use of armoured vehicle become necessity for the safety of defence troops engaged in counter insurgency, providing them protected mobility and for movement of small independent team operations in different regions due to increase in terrorist activities. Turret is one of the requirements from MOD on the off-road combat vehicle. Thus, for designing and developing the turret assembly design parameters, material selection, manufacturing process and its application plays a significant role. Literature and patent review were done by keeping in mind the above points.

The inventors patented a turret assembly in which inventors described about the different parts used for designing the same. study described about the sub-assembly of mounting plate and ring in which mounting plate is fixed to roof and ring is engaged and having rotary motion. He included the study of the turret assembly further comprising a support block coupled to the mounting plate, wherein the plurality of vertically disposed bearing wheels includes a first wheel coupled to the support block, and wherein the plurality of horizontally disposed bearing wheels includes a second wheel coupled to the support block. further comprising a

plurality of support blocks arranged concentrically with an opening of the mounting plate [1].

Berkovich et al. patented the turret assembly without deck penetration for minimizing exposure of combatants to enemy forces when accessing above deck equipment, comprising a base plate on top of which is mounted at least one fireable and remotely operable combatant interfaceable implement, said base plate being rotatable about a substantially vertical axis and supported for rotation by bearing means mounted within a deck of a military facility. A hatch displaceable connected to said base plate, for normally covering a hatchway formed in said base plate and for exposing said hatchway when displaced and a rotatable disc of a slip ring unit carried by said hatch. In their study they also described about the hatch which is displaceable connected to the base plate by means of four arm assemblies which allow the hatch to be lowered and displaced laterally from the base plate and then to be returnable displaceable so as to cover the hatchway. the hatch displacement initiator comprises a handle connected to an interior facing end of an axle assembly rotatably mounted within the hatch for applying a displacement initiating force to the hatch, and a locking bar, e.g. a flexible locking bar, connected to an exterior facing end of the axle assembly and having Substantially the same angular disposition as the handle, rotation of the handle in a first rotational direction causing the locking bar to be positioned in abutting relation with an upper Surface of the base plate whereby to prevent the hatch from opening, and Subsequent rotation of the handle in a second rotational direction opposite to said first rotational direction causing said locking bar to be disengaged from the base plate [2].”

“Kiel et al. patented the gunner protection of the turret on vehicle in closed position. Their invention described the ornamental design of the gunner protection with different perspective views [3]. Frank patented the collapsible camper shell turret system in which a turret base is mounted to a surface around an opening on the surface, at least two pivotally connected arms, including: a first arm having a first end and a second end, the first end connected pivotally to a turret ring on the turret base, the turret ring rotating 360°, a second arm having a first end and a second end, the second end of the first arm connected pivotally to the first end of the second arm and a mounting means connected to a distal end of the second arm and configured to support a shooting device. In a stowed position under the Surface, the second arm is collapsible against the first arm such that the second arm and first arm are parallel. In a deployed position, the first arm pivots approximately 270° out from under the surface and through the opening, surrounded by the turret ring, to extend above the surface and the second arm pivots approximately 270° about the first arm. The first arm and second arm are reversibly retractable back to the stowed position. The gasketed turret hatch protects the user and cargo inside the camper shell from damage by the elements. The camper shell has at least one muzzle depression stop removably attached to the top exterior of the camper shell. When the doors of the gasketed turret hatch are open, the movable two-part arm having a second arm connected to the first arm by the lock hinge swings up and out of the turret and locks into place, thus allowing the user to fasten accessories to the mount [4].

Greenwood et al. studied the combination of sling seat and waist belt assembly upon which a turret gunner can be

seated on military vehicle having a rotatable turret ring. The invention claimed the dimensions and fabrication of seat in such a way that turret gunner can be seated comfortably [5]. Adorni et al. claimed the invention of armoured vehicle provided with revolving overhead turret with armament which connects with the vehicle interior with the armoured rectangular hatch. Their study described about the overhead turret comprising a base and being connected to the armoured cockpit by said circumferential bearing to allow revolving of the overhead turret around a substantially vertical axis passing through a centre of said bearing, said base comprising a floor located completely external to the cockpit and a hatch attached to the floor by a pair of opposed hinges, wherein the hatch pivots about the hinges toward the interior space of the cockpit from a first position closing a passage in the floor to a second position providing communication between the overhead turret and the cockpit [6].

Patry et al. purposed the study of turret for a military vehicle which supports the oscillating mass comprised of medium calibre cannon having elevated orientation. The turret was designed and manufactured in such a way that insulation of turret with respect to the exterior was done so as to avoid any contamination and to ensure the evacuation of the combustion gases produced when the ammunition is fired. This study also claims the air tightness of the turret was by the oscillating mass and boundary friction kept low so as to reduce the disturbances in the aiming of the oscillating mass [7]. Armoured vehicle and tank with unmanned turret pivotable in azimuth via a turntable disposed on a roof plate containing a weapon which is pivotable in elevation was patented by Jilg et al. Their study also includes a panoramic viewing device, embodied as a glass optical direct viewing device, includes a viewing head disposed above the roof plate on the azimuthal axis of rotation of the turret. An optical viewing channel is guided through the passageway connecting the Viewing head with a viewing part in the crew compartment [8].

Wilson patented rotatable turret having gear box assembly for rotation of the turret assembly. Their study claimed the gear assembly which is fitted onto the pre-existing housing mounting brackets. The designing was done in a such a way that the input shaft extends through the gear assembly housing and includes an input shaft gear that meshes with a drive shaft gear. The size of drive shaft gear was maximised for fitment inside the gear housing. The sprocket is connected to the end of the drive shaft gear which is mechanically linked to the turret assembly for controlling the rotation of the turret assembly [9]. Arrighi patented the turret assembly which includes hollow casing with the addition of cannon also named as firearm. The turret assembly was divided into front portion and rear portion in which front assembly includes firearm and the rear portion or tail defines a rear cavity, which houses at least one between a projectile magazine and a mechanism to load the projectiles into the breech of the firearm. Both the portion are different from each other and assembled in such a way that they can partially communicate with one another [10].”

Carter designed the armoured vehicle gunner's protection cupola which provide protection from bullets and ballistic threats. This study claims the use of disposition of high-performance fibres in a shell of pliable material enclosed in the outer shell having flame resistance pliable materials which provide protection from fire and thermo acoustic

threats. The outer shell or carrier is provided with a plurality of straps and fasteners for positioning and securing the pliable materials to the rigid frame containing the rigid or semi-rigid ballistic materials and thus providing rear and side skeletal and muscular protection from bullets and ballistic projectiles, flame, and thermo-acoustical threats [11]. Another study of ballistic protection of turret was patented by Squires et al. which claimed the addition of ceramics tiles which was reinforced resin polymer with nanoparticles. Nonwoven material and multiple nanotextile layers were added with the ceramic layers for the increase in ballistic protection [12]. Alter et al. patented the study of structural components for armoured vehicles in which additional detachable armour plate was provided on the side of troops for additional safety. The study comprises of composite layered structure having honeycomb core in addition to the covering layers. Study also focused on the use of fixture elements which were used to fix the detachable armour plate to the fixed core plate [13].

“Cazalieres et al. patented light retractable turret having active system which was oriented in vertical extendable elevation and also in azimuth. This retractable turret is also having a protective cowl for active systems and used for closing the caisson. The active system constituted of first and second arm forming a deformable parallelogram arranged on either side of the active system and elevation and azimuth aiming means for said active system, the deployment being controlled by a first manual means activating the first arm, the orientation in elevation and in azimuth of the active system being controlled by a second manual means activating the second arm [14].”

“In another patent Kiel et al. claimed the study of blast shield on armoured vehicle which includes a turret having flat base plate which constitute all view panels including a ballistic glass windows and having front and rear lifting eye. The mounting of flat base plate was done on the turret which was fixed with the armour plate [15]. Ohnstad patented the dome shaped turret including the turret shroud with annular base and open upper margin. Optically clear dome structure built with anti-shock, anti-ballistic and anti-blast shockwave and came with the conclusion of less overall weight of the turret shroud, dome structure and gun shield than that of a conventional, metallic turret shroud, thus provided enhanced functionality of the turret system. The turret shroud was manufactured with multiple layers of a contour woven, fibre-reinforced, anti-ballistic, anti-shockwave material fabricated with the Kevlar material with certain degree of flexibility on impact by a striking the projectile for the purpose of dissipating projectile energy [16]. Johnson et al. patented the armoured cab for the vehicle in which three layers of armouring was done for providing the extra protection for the troops. Plastic material was sandwiched between the two layers of armoured material which was used in the walls of the cab. For angled section only two layers of armoured material was used. Material used for the manufacturing was kevlar sold by E.I. du Pont de Nemours and Company. Preferably, layers of an aramid material or other suitable plastic or synthetic material having the requisite strength and ballistic and explosion protection characteristics, are layered over the interior of all of the wall surfaces of the armoured cab with the exception of windows. The thickness of the aramid layer material may be approximately from 1/4 inch to 2 inches in thickness, and preferably is 3/4 inch in thickness [17].”

The study of addition of auxiliary plate having through holes and smaller cross-sectional area in front of main armour plate was patented by Ravid et al. The designing of additional plate was done in irregular and staggered shape to shatter projectiles of ballistic on the main armour plate. The study claimed the use of different material of auxiliary plate in front of main armour plate which thermoplastic and thermosetting material. The study was done on the ceramic material, metal and a backing layer behind main armour plate. Backing layer may include aluminium, fibreglass, aramid fibre, material or combination [18]. Barenyi et al. studied the effect of degradation of mechanical properties in heat affected zone by thermal cutting process. The study was carried out in TSteel software by using sample of steel Armox 440, 500 and 600 after their cutting by plasma and laser cutting process. They came with the conclusion that degradation of 20-30% mechanical properties in heat affected zone occurred after cutting of armoured material by thermal cutting process [19]. Robledo et. al designed the welding procedure of Gas metal arc welding process (GMAW) on MIL A46100 armour steel and came with the conclusion that designed WPS is a better option because of formation of narrow heat affected zone and increase in impact energy test as compared to the shielded metal arc welding (SMAW) [20].

The effect of hardness on the ballistic behavior of AISI 4340 and DIN 100Cr6 armour steel was studied by Demir et al. and came out with the result that AISI 4340 was having the better ballistic performance and 29% lighter in weight than DIN 100Cr6 [22]. Senthil et al. investigated the evaluation of ballistic resistance of Armox 500T steel plates having thickness 8mm against 7.62 API projectile with the velocity of approx. 850 m/s at 5 different angle of incidence which was varied as 0°, 15°, 20°, 25° and 30°. The simulation results showed the perforation of 7.62 API projectile up to 25° and at 30° the bullet rebound of a surface after deforming the armour plate [23]. Microstructural analysis of ballistic tests was done by Balakrishnan et al. on welded joints of AISI 4340 armour steel because of ballistic performance in comparison to base metal [24].

### III. CONCLUSION

The inventors patented a turret assembly in which inventors described about the different parts used for designing the same, materials used.

It has been observed from the literature that the shape of perimeter protection assembly has been modelled freely without any constraints for the particular application. Size and shapes are not discussed by any researcher. Weight details for turret assembly are not discussed in any of the refereed papers.

No literature shows the specification, size, type of the bearing, in bearing assembly for the particular application of the special armoured vehicle.

Design of gun mount was not specified in any of the literature. The size, shape and material used for perimeter protection are not described in any paper.

A summary of current challenges facing the industry and future expectations are listed to provide guidance to researchers and engineer

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