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टैक्नोलॉजी फोकस

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Multi-Role Combat Vehicles and Systems

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Technology Focus **focuses on the technological developments in the organisation covering the products, processes and technologies.**

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From the Desk of Guest Editor

The history of Vehicles Research & Development Establishment (VRDE) dates back to 1929 when the Chief Inspectorate of Mechanical Transport was formed at Chaklala (now in Pakistan). In 1947, the Inspectorate was shifted to Ahmednagar and was renamed as Technical Development Establishment (Vehicles). In the year 1965, two new establishments namely Vehicles Research & Development Establishment (VRDE) and Controllerate of Quality Assurance Vehicles (CQAV) were formed to cater to the R&D and inspection activities, respectively. VRDE was basically established for applied research and the technology development in the field of Combat Vehicles and Engineering, e.g., design and development of light tracked vehicle up to 25 ton class, all types of wheeled vehicles including transporters, trailers and specialist vehicles for strategic programme, and rotary engine for small Unmanned Aerial Vehicles. VRDE also has mandate to carry out road worthiness, EMI/EMC, fuel efficiency and emission compliance test of vehicles and all types of automotive engines.

Innovative and sincere efforts of scientists and technocrats of VRDE over the years have resulted in the successful design and development of wheeled vehicles like Wheeled Armoured Platform (8X8), Road Mobile Launchers and support vehicles for strategic programme, AERV, AAD, NBCRV, CBRN UGV, MDC and Rotary Engines for UAVs, etc. Many of these have been inducted in the Services. Design and development of Mounted Gun System is a new challenge taken up by VRDE.

I am happy that this issue of Technology Focus is highlighting information on Wheeled Armoured Platform (8x8), NBCRV, Anti-terrorist Vehicle, CBRN-Mini UGV, Rotary Engine, Integrated Starter Generator Technology for Rotary Engine, Electronically Controlled Fuel Injection and Ignition (EFI) System, Loader-cum-Replenishment Vehicle for Pinaka and Multi-purpose Decontamination System developed by VRDE. I am sure that the issue would bring to the knowledge of our users and readers about the achievements of VRDE.

As a Guest Editor, I convey my sincere thanks to the scientists, technocrats, academia and industry partners involved in the design and development and realization of these systems. Our rigorous efforts will further enhance our capabilities to meet the requirements of our Armed Forces through continuous improvements.

Jai Hind.

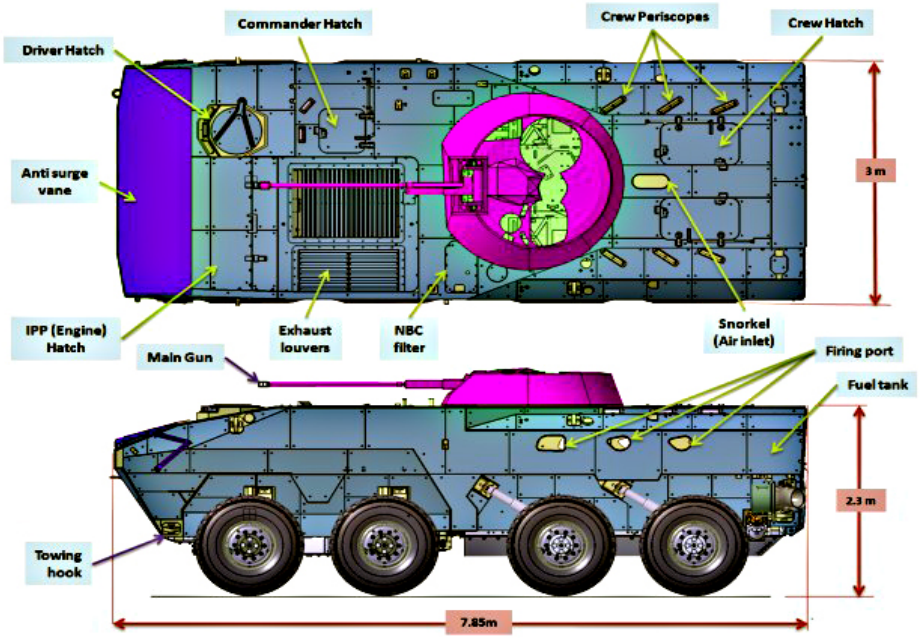
Maj Gen Ajay Gupta
Director, VRDE

Multi-Role Combat Vehicles and Systems

WHEELED ARMOURED PLATFORM 8X8

The Wheeled Armoured Vehicles (WhAP) showed their efficaciousness in the recent combat operations all over the world owing to their technical and tactical advantages with respect to faster deployability, reduced logistic footprint, lower maintenance and reduced fuel costs. These vehicles are able to move long distances at higher speeds, ensure reduced fatigue to crew and offer less wear and tear to road, vehicle, onboard equipment and ordnance.

To showcase the indigenous technical prowess, a technology demonstration programme was taken up by VRDE to develop a state-of-the-art prototype of WhAP in 8x8 configuration with features to meet the requirements of armoured personnel carrier (APC) for United Nation missions. The design of the prototype was in consonance with world trend with aims to achieve modularity, scalability and reconfigurability to adopt the platform for variety of roles in addition to UN APC. The indigenous WhAP has been configured around two distinct entities in the overall design, viz., the base hull and the modular mission payload; the later adopted to the user-specific requirements. Such design approach has numerous advantages in terms of cutting down on product realisation time, versatility to evolve variety of vehicles around a common platform, commonality in parts across various versions of the base platform, immensely helping in logistics and maintenance while in the field. Apart from military exploitation, additional care was taken to keep urban warfare requirements in the design.



Wheeled Armoured Vehicle and its Structural Diagram (below)

WhAP has been designed with contemporary specifications, which makes it comparable with the world class multi-axle combat vehicles. It

has excellent mobility, protection and firepower parameters. The following technologies has been developed and incorporated in this vehicle:

Seating and Crew Compartment

The vehicle platform in APC configuration can carry 10 persons; six troops in the rear, two in the turret compartment, and driver and stick commander in the front. The driver is seated in the front right of the vehicle and stick commander is seated directly behind him. The commander and gunner are seated right and left, respectively within the turret. The seating layout in the crew compartment follows centrally mounted, outward facing seats configuration to accommodate the requirement of firing port for every soldier in the crew compartment. The seats are suspended and mine blast attenuation type. Troop compartment has been designed considering crew ergonomics and comprises firing port and periscopes. The rear-door

Rear Door Ramp

ramp enables easy embarking and disembarking of troops. The troops are also provided with two escape hatches above the crew compartment. A side-mounted hydraulically operated winch has been provided for self-recovery. The vehicle is also provided with heating ventilation and air conditioning systems (HVAC) system for enhanced comfort of the troops in extreme weather conditions.

Integrated Power Pack

The Integrated Power Pack (IPP) of the vehicle consists of a high power engine that can be configured for 600 hp, 525 hp, and 450 hp power ratings. State-of-the-art features such as engine cooling system with hydraulic motor driven fans and fully automatic transmission with retarder are part of the IPP. A novel feature of exhaust gas dilution for reduced thermal signature has been incorporated in the power pack.

Integrated Power Pack

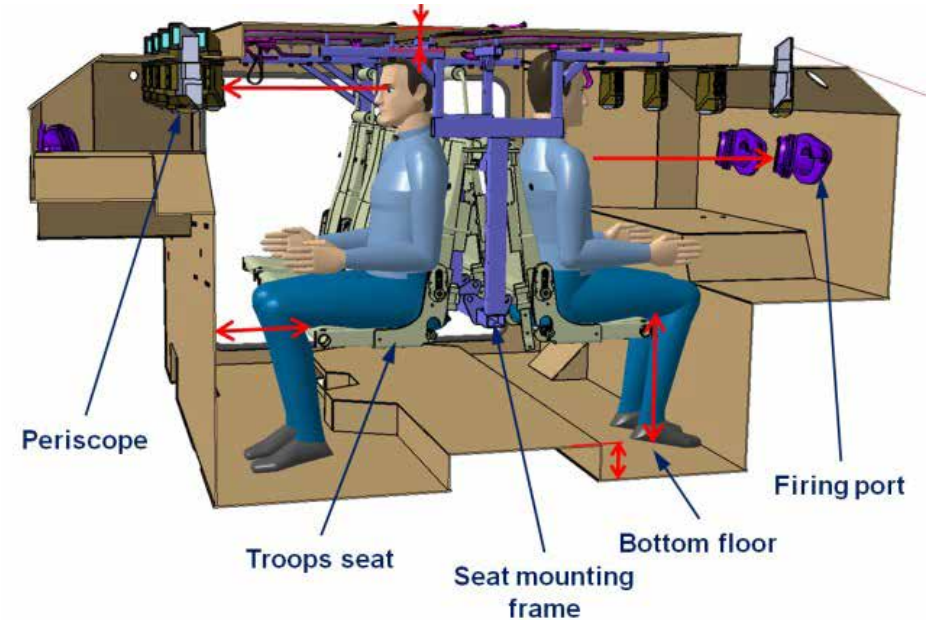
Armaments

The platform structure of the vehicle is designed to accommodate different types of weapon systems including manned turret-medium caliber, remote weapon stations, and high caliber weapons. Presently, an in-service 30 mm turret has been integrated on the WhAP.

Firing trials of the armaments were carried out at KK Range, Ahmednagar. The gun was zeroed on satisfactorily and firing of AP (T) at 1100 m was accurate. Firing of 7.62 PKT MMG was also accurate at 1100 m. The dispersion was within acceptable limits during burst firing mode with stab ON.

Amphibious Design

The vehicle is amphibious up to 24 ton. Reserved buoyancy of 15 per cent has been catered for in the design. The vehicle achieves positive trim angle by keeping center of buoyancy ahead of center of gravity by having a bigger

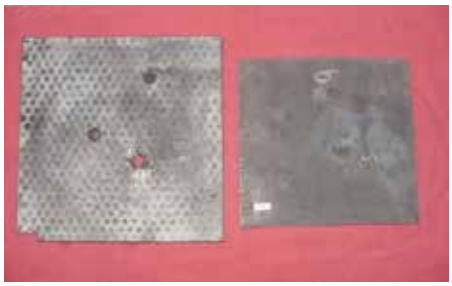


Crew Compartment Schematic

frontal volume and volume reduction in the rear without affecting the effective internal volume. Vehicular systems have been judiciously located to achieve desired trim angle. Anti-surge vane with its hydraulic actuation system has been provided to divert the oncoming water flow. Hydro-jets in the rear helps in propulsion in the water. Extensive computational fluid dynamics (CFD) simulation and scaled model testing were carried out before finalizing the design.

Ballistic Protection

The armour configuration of WhAP is based on the composites and steel armour. The hull, which is constructed of high strength steel with ceramic armour bolted-on, offers all round protection against 7.62 mm AP. The platform design caters equipping bolt-on armour to higher level of protection. Run flat tyres that enable the vehicle to be driven at reduced speeds in case of sudden tyre deflation, have also been incorporated as protection measure.



Armour Panel Testing

Blast Protection

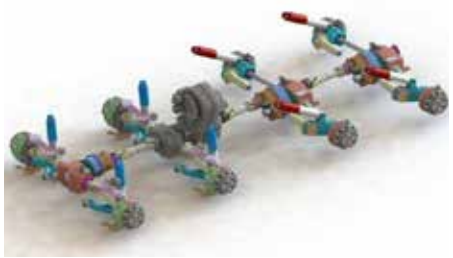
The vehicle has been designed to provide protection against land mine, meeting level III, STANAG 4569. The hull configuration evolved follows a 'V' type bottom with double configuration consisting of an inner panel and bottom panel. The bottom panel is designed to deflect the blast energy and get deformed to minimize the energy transfer to the vehicle. Further, blast resistant seats and energy absorbing mats at troop feet/ floor interface provide protection to crew as per STANAG 4569.

Floatation Trials

Blast Test Rig

Under Chassis Driveline

The vehicle comprises all independent wheel stations employing hydro-gas suspensions at both front and rear wheel stations. Trailing arm suspension configuration is chosen at rear to maximize the internal volume in the crew compartment. Multi-axle steering (front two axles) incorporated in this vehicle increases the manoeuverability by reducing the turning circle diameter.



Under Chassis DriveLine

Handling and Obstacle Crossing

The 8x8 vehicle has all wheel drive, which ensures superior off-road

mobility to the vehicle. It has high-speed mode for normal operation and low-speed mode for better traction capability. Centralized Tyre Inflation System (CTIS) provides different tyre pressures to achieve best possible mobility on different terrains.

Anti-lock Braking System (ABS) of the vehicle provides improved braking on surfaces with different friction. Mobility in water is achieved by means of specially designed amphibious gearing system, which is coupled to the last drive axle.

Developmental Trials

Developmental trials of the WhAP were carried out in two phases. On-road and Off-road mobility trials were conducted at National Centre for Automotive Testing (NCAT) at VRDE and a vehicle track at Mechanized Infantry Regimental Centre (MIRC), Ahmednagar.

Second phase of the trials with emphasis on sand mobility and on effect of high ambient temperature on vehicle performance were carried out at Mahajan Field Firing Range, Suratgarh. On realization of prototype, general checks and initial running in of the vehicle was carried out. In all, the vehicle went through the following trials: (i) on road performance trial on high speed track at NCAT, (ii) vehicle condition trials (vehicle mode: 8x8 and 8x4; CTIS and Highway mode at 80 bar; and Gross Vehicle Weight of 24770 kg), (iii) measured ambient condition (100 k Pa atmospheric pressure, 41 ^{o}C atmospheric temperature and 0.872 kg/m^{3} air density at test site), (iv) maximum speed performance with headlight, parking lights and the emergency flash lights ON position. The vehicle was driven in clockwise direction for two rounds of the entire high speed track and two rounds in anti-clockwise direction with full throttle at maximum speed of 104 km/h, (v) the fuel consumption test using the top-up method on tarmac road (average fuel consumption was 1.3 km/l); (vi) vehicle range measurement (distance traveled with full tank diesel was 478 km).





Developmental Trials

The vehicle also went through off-road performance like cross-country running with gradient climbing was carried out at MIRC 'A' vehicle track; Terrain Negotiation Test at mud track and sand track of NCAT; the vehicle was tested in 8x8 mode and the vehicle was able to negotiate the soft soil patch without difficulty; and Self-Recovery on different terrains including sand, cross-country and mud tracks.

NBC RECCE VEHICLE Mk I

In case of nuclear, biological and chemical (NBC) attack, there is a necessity to carry out extensive post event recce of contaminated area in order to assess the contamination levels. VRDE has developed NBC Recce Vehicle (NBC RV) on BMP-IIK with an aim to carry out survey, detection, identification, monitoring and marking of the radiological and chemically contaminated areas. It is also fitted with sample collection device, which can collect the contaminated soil and liquid samples and also possessed with data transmission capability to command centre.

To carry out the reconnaissance of contaminated area, the following instruments have been integrated with the vehicle:

Nuclear Recce Instruments

Roentgenmeter: Roentgenmeter measures the gamma radiation and exposure dose rate. It comprises an external probe for detecting the radiation, and a main electronic unit, which gives the bias voltage to the detector.

Pocket Dosimeter: It measures the dose of x and/or gamma radiation in an NBC environment.

Portable Dose Rate Meter: It measures the dose rate of radiation in an NBC environment. Primarily used in a fall out area after nuclear explosion.

Radiac Meter Personal Locket Dosimeter: It is worn on the wrist and records the gamma radiation and neutron radiation cumulatively.

NBC Recce Vehicle

Chemical Recce Instruments

Portable Gas Chromatograph: It is used to detect, identify and give warning regarding presence of chemical warfare agents in atmosphere. It also comprises a microprocessor data unit, which has a non-volatile memory for method parameter options and alarm levels.

Automatic Chemical Agent Detector: It can detect a range of chemical warfare agents and provides high degree of immunity from other background vapours. It also identifies and measures blister, nerve, blood and choking agents, and provides perimeter protection either as standalone or as networked together.

Residual Vapour Detection Kit: It is used by an individual to detect the presence of chemical warfare agent present in the atmosphere. It consists of detector tubes and sampling pump to draw a fixed quantity of air through detector tube. It can be strapped to the body of the individual for easy portability.

Navigation Equipment

Advanced Land Navigation System: It is used for traversing a path defined by reading coordinates from a military map. It guides the commander and the driver on real time indicating the path to be followed to reach pre-defined destination.

Meteorological Instrument

Solid State Anemometer: Also called as weather station, is a compact, self-contained station with no moving parts. The sensors and data acquisition computer are all contained in a single unit. The sensors measure the wind speed and direction, barometric pressure, and ambient air temperature.

Marking System: Once the recce instruments have detected presence of any contamination, the area needs to be cordoned off. A vehicle-mounted marking system has been developed consists of markers (Pickets) with flags indicating nuclear or chemical contamination. A fire control unit to controls the firing of the marker flags. The flags are made of fire resistant

Kevlar material. The marking pickets are fired using the pyro-cartridge and are remotely controlled by stick sitting inside the vehicle. The pickets when not required can be stowed in the boxes provided.

Sample Collection System: After the detection of contamination and demarcating the zone, recce vehicle collects the sample of the soil and water for checking the exact contamination level in the affected zone. The system allows for collection of 12 solid and 24 liquid samples, and is controlled remotely by the stick sitting inside the vehicle. The collected sample is then sealed and stored in the turntable provided outside the vehicle. This can be further taken to laboratories for analysis.

Communication: The collected data and information needs to be communicated to the Command Station in the battlefield for better flow of information to the commanders. The NBC Recce Vehicle is equipped with a Stars V Mk II radio set, which is capable of sending voice as well as data with the help of control console between vehicle and command centre. Crew members also possess radio sets for communication when they are in the contaminated zone outside the vehicle. To acquire data from various standalone stations and recce instruments deployed in the area, a communication link controller has been provided. A control console acquires data from the instruments for processing and storing it.

Other Features

- Crew of six for undertaking recce operations
- 30 mm turret for firing capability
- Amphibian capability with least preparation
- Sealed vehicle with over pressure facility through NBC filtration unit
- Drinking water facility for the crew
- Software for hazard prediction

Anti-Terrorist Vehicle

Terrorist strikes in urban areas has dictated the need for an agile, compact with weight and dimensional profile, highly manoeuverable armoured envelope adequately protected to carry 2/3 persons in hostile environment especially in the corridors of buildings, small gullies, constrained spaces of hideouts, etc., for anti-terrorist operation. VRDE has developed compact Anti-terrorist Vehicles (ATV), which can carry three combatants fully equipped for the operations. The vehicle, weighing three ton, provides all-round protection from small arms and hand grenades. It has also got situational awareness provision and six firing ports. A top hatch helps troops to exit in emergency.

The vehicle can be employed in the corridors of hostile terrains where it is difficult to operate in a normal wheeled vehicle. It has got a very low turning circle diameter, which enables it to turn around itself within a limited space. The vehicle is meeting varied requirements to carry out counter insurgency operation in urban areas.

ATV (Tracked)

ATV (Wheeled)

ATV (Electrical)

CBRN Mini Unmanned Ground Vehicle

The Chemical, Biological, Radiological and Nuclear (CBRN) weapons cause hazardous effects including contamination of environment and terrain. Unmanned Ground Vehicle (UGV) has an upper edge over conventional manned NBC recce vehicle, specifically in terms of personnel safety in confined area mission and dismounted recce operation. Tele-operated CBRN Mini-UGV, Suchak, developed by VRDE can be used for CBRN detection, remote monitoring, sample collection and digital marking of contaminated zones without risk of exposing the personnel.

CBRN Mini UGV Suchak

Suchak is a tracked platform with four flippers. It has an in-line transmission with hollow shafts for transmitting power from drive motor to main track and then to outer flipper tracks. The left side and right side tracks move in synchronization. The front and back flippers with independent orientation ensure mobility and stability of UGV during stair climbing, movement on rough terrain and water fording. Suchak has separate and easily maintainable compartments for battery and electronic units. Brushless direct current motors with servo controls have been used for driving and flipper operations because of their high efficiency and smooth operation. Embedded low power controllers along with suitable interfaces help in for driving, robotic arm operation, payload operation, and other auxiliary operations.

The multiple input and multiple output (MIMO) technology-based

Water fording

Rubble/debris crossing

Sand crossing

Step climbing

Ditch crossing

Sample collection

wireless communication link of the vehicle helps in exchange of command, control and feedback signals between the vehicle and operator control unit (OCU). Day and night vision system, obstacle detection and warning system and GPS/INS-based navigation system have been integrated on UGV. The hand-held portable and modular OCU facilitates tele-operation of driving and payload systems of Suchak. The contamination data is transmitted via wireless communication link to the OCU. UGV payload system is modular and can be customized for any role/alternate application in accordance with the user requirements.

Salient Features

- Ability to enter into hazardous areas to detect CBRN contamination, remote monitoring, digital marking of CBRN hazardous areas based on navigation data and collect soil/liquid sample using tele-operated robotic arm
- Deployable in secondary emission zones of nuclear radiations
- Capability to detect chemical warfare agents mainly nerve, blood and blister agents
- Capability to detect biological warfare agents mainly toxins, virus and bacteria
- Mobility: Stairs climbing, ditch crossing, water fording
- Day and night audio and video inspection
- Online transmission of data via wireless link up to 500 m near LoS and 1 km LoS to operator control unit on carrier vehicle
- Hand-held/vehicle mounted operator control unit

Rotary Engine for UAV Application

The Wankel engines are known for their high power-to-weight ratio. VRDE has designed and developed a Wankel-type rotary engine for Nishant UAV being powered by a rotary engine imported from UK. The developed engine weighs about 28 kg and generates power of 55 hp.

The flight trials of indigenous rotary engine integrated on UAV have been conducted at Kolar. During the flight trials, UAV achieved an altitude of more than 3.7 km against the required 3.6 km effortlessly before cruising for more than three hr. Based on the successful flight trials, proven ground trials and fulfillment of General Staff Quality Requirement (GSQR), rotary engine has been awarded provisional airworthiness clearance for LSP by Centre for Military Airworthiness and Certification (CEMILAC). Release note of delivery of engine to user agency, i.e., Aeronautical Development Establishment (ADE), Bengaluru, has also been awarded by CRI (GW&M), Directorate General of Aeronautical Quality Assurance (DGAQA). This is the first of its kind engine in India, which has achieved airworthiness certification in non-gas turbine category.

Rotary Engine Assembly

A 65 hp rotary engine is under development for conventional take-off and landing (CTOL) of UAV Panchi. Two prototype engines have been developed. The 65 hp rotary engine is integrated with electronic fuel ignition system, which has improved the specific fuel consumption of engine compared to existing 55 hp rotary engine. Thrust cradle dynamo meter performance has been demonstrated to ADE, CEMILAC and DGAQA. Engine is producing the required power of 65 hp and weighs about 32 kg.

The following technologies have been realized during the development of the rotary engine:

ISG Technology

The integrated starter generator (ISG) is a single electrical machine for starting the engine and after starting/cranking generates electrical power. Two variants of ISG have been developed and tested on indigenous rotary engine. This technology has removed the existing 2.0 kW alternator and 2.4 kW starter motor.

Hardware of ISG

ISG with Flywheel Functionality

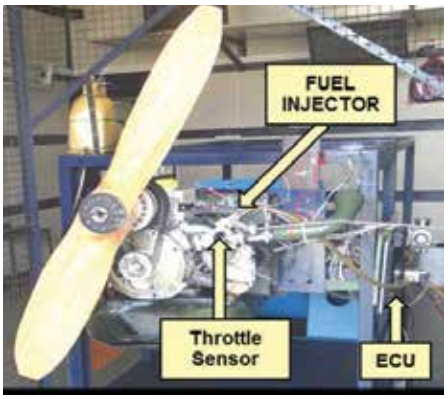
The laboratory has successfully designed, developed and tested the ISG with engine flywheel functionality for rotary engine and has tested it successfully on a 65 hp rotary engine. This technology has replaced the engine flywheel, engine alternator and engine starter motor with single unit called ISGF. This compact and lightweight unit has been mounted in place of existing engine flywheel.

Both, ISG and ISGF, have been developed first time in the country and tested on 55 hp and 65 hp rotary engines. The technology has enhanced the safety while cranking the engine and can be used in other commercial internal combustion engines.

Rotary engine with ISGF

Electronically Controlled Fuel Injection & Ignition System

To overcome the limitations of carburetors at higher altitudes, VRDE has developed an electronically controlled fuel injection and ignition (EFI) system called engine management system for 55 hp Wankel type rotary engine using COTS user programmable ECU, which has been adapted and configured as per Wankel rotary engine requirements. Engine mapping with different propellers load has been carried out on ground test bed at various places like Ahmednagar, Manali, Leh and Changa La, up to 17,500 feet above MSL.



Rotary engine with EFI system on test bed

Turbo Charging of Rotary Engine

VRDE, jointly with National Aerospace Laboratories (NAL) and ADE, has realized state-of-the-art turbo charging system for 55 hp Wankel type rotary engine for Nishant UAV. Turbo charging is considered as one of the most effective approaches towards increasing the power capacity at the sea level conditions as well to compensate the loss of power at high altitudes.

The successful development of turbo charging system for Wankel type rotary engine involved activities like selection of turbocharger, configuration and integration of turbocharger with engine, redesign of some sub-systems and development of support systems for turbocharger and finalization of design after successful testing of the system on thrust cradle.

The rotary engine integrated with turbocharger and other advanced technologies have been tested at ground level and successfully completed the target specifications. The engine has also been tested at various high altitude places like Manali, Leh and Chang La.

The turbocharger system was able to increase the performance of the base engine from 95 kg thrust to 107 kg thrust at ground level with a boost pressure ratio of 1.2. The performance of the engine was maintained till 10,000 ft where the base engine performance degrades by 25-30 per cent.

Turbo charged EFI engine on mobile test platform at Manali (6,752 ft)

Turbocharger EFI Engine on mobile test platform at Chang La (17,500 ft)

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Loader-cum-Replenishment Vehicle

The loader-cum-replenishment (LCR) Vehicle Mk II is used for transportation loading/ unloading of Pinaka multi-barrel rocket launcher pods from Pinaka rocket launcher to loader cum replenishment vehicle. The vehicle can handle Mk I & II Pod of Pinaka.

LCR Vehicle Mk II is integrated with a low built continuous crane, a platform and an emergency engine. The crane is operated through power from PTO/emergency engine and can be transported using standard rail wagon MBFU well bed type.

Technical Specifications–Crane

- Load moment: 20.85 t-m
- Load rating: 75 % of tipping load
- Lifting capacity at 5.5 m radius: 3.0 ton
- Height of lift at 5 m radius (from G/L): 4.8 m
- Slew angle: 3600 (Continuous)
- Slewing speed (adjustable): 10-12 degree/s
- Boom extension/retraction speed: 0.1-0.2 m/s

Loader-cum-Replenishment Vehicle

Salient Features

- Based on Tatra 8x8 ER (L) chassis
- Platform for holding the Pinaka rocket pods with guiding brackets and Nylon slings for handling and transporting four Pinaka rocket pods
- Emergency power pack for redundancy for all crane operations
- Span of crane outriggers: 5.8 m
- Crane tip control (CTC) for accurate vertical and horizontal movement of load
- Safe handling of pods by remote control operation of crane
- Rail transportable by standard MBFU wagon

Replenishment Vehicle

Multi-Purpose Decontamination System

Operations in an NBC environment requires decontamination of the personnel, equipment and terrain. Timely decontamination not only limits the speed of contamination but also enables troops to carry on with their mission. It is absolutely necessary that complete decontamination of man, equipment, vehicles and terrain be done to restore the potential of the force and to reduce casualties. VRDE has developed an integrated multi-purpose portable decontamination system (MPDS) for removal of NBC warfare agents from vehicles, equipment, personnel and their clothing.

Salient Features

Lightweight Components

All major components were selected based on design given in JSQR. The MPDS mainly consists of two triplex reciprocating pump, lightweight diesel fired boiler, and lightweight diesel engine and control panel. Special grade Aluminum alloy has been used for fabrication of frame to meet the requirement of weight less than 265 kg with sufficient strength to support major components as per JSQWR.

Compact System

The size of the compact system is 1138 (l) x 688 (b) x 850 (h) mm. Its volume is 0.62 cubic meter, which is less than the specified in JSQR

Multi-purpose Decontamination System

Redundancy in Pumps

The MPDS consists of two pumps as compared to imported system (one pump), which can accelerate the number of persons to be decontaminated; in case of exigency can carry out two decontamination operations simultaneously.

Ensured Safety of the System/ Operator

Safety mechanism like low water cut-off, temperature cut-off, pressure relief valve, steam safety valve and engine emergency stop have been incorporated. Safety switches can be set as per design parameters.

Current Status

The User Assisted Technical Trials (UATT) of MPDS were conducted at College of Military Engineering (CME), Pune. The equipment met all parameters mentioned in JSQR.

Editors acknowledge the contribution of Shri K Kamaraj, Sc 'G', of Vehicles Research & Development Establishment (VRDE), Ahmednagar, in preparing this issue.

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