PROPULSION MODULE FOR UNMANNNED VEHICLE

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Abstract

Solution of the propulsion system of the unmanned vehicle elaborated and built in the Laboratory of Internal Combustion Engines Military University of Technology is shown in the paper. Unmanned vehicles are about to play key role in modern warfare. There are many types of unmanned vehicles. Those which can operate in urban areas, especially inside buildings are considered as a most useful for modern army. Most unmanned vehicles are battery operated, causing low range or low speed of the vehicle. Internal combustion engines are not proper for operation inside buildings, due to exhaust gases produced by engine. Connecting two types of propulsion system, defect of range in battery and gases in combustion engines are eliminated, because we can program vehicle to not turning on engine inside buildings. Using a module for those types of vehicles, we can design entire gamut of unmanned and even manned vehicles, decreasing design costs and repair time due to parts repeatability. Using a prepared propulsion module, design engineer can freely determine length, width and wheel track of designed vehicle. Designed modules enable vehicle fast return to combat ability, due to parts repeatability. One module, used as a host, can reconstruct damage vehicle. There is possibility of using different engines, enlarging list of available modules. Economic factor has also big meaning, due to parts repeatability.

Keywords: *unmanned vehicle, hybrid propulsion system, UGV, electric generator, electric propulsion motor*

1. Introduction

Vary forms of combat, extorts putting new solutions in vehicles design, reducing direct soldiers engage in combats with high risky missions. Wide ranges of unmanned vehicles, operating in risky conditions for soldiers, are introduced. Handling a solution of the vehicle is complicate, requiring contradiction of requirements. Vehicle must be capable of silence approaching. This can be achieved by using electrical driving engines and battery. Long operation time, operation in time of cutting off from own regiment, require use of extra power source such as combustion engine or fuel cells, enabling recharge the battery. Other systems, which must be implemented on vehicle board are: engine control unit, remote control for all systems, video transmitting system (stereoscopic). From the other hand, possibility of terrain traversing, inside building operation, stairs traversing impose limitation of vehicle external dimensions. Those limitations cause maximum utilization of available space. It can be achieved by searching/design proper components with low mass and dimensions at high power. Not all solutions are possible. Preparing a combustion engine for custom order isn't cost-effective and took long time for testing. During the project, components of most advantage properties were searched and selected, but there are still problems with holding in required shape and total mass of vehicle.

In paper, achievements of propulsion module of UGV and effect of accepted solutions on shape of the vehicle are presented.

2. Power source

UGV power source consist of generator ZPP5.0 DTYEO with power of 5 kVA, feed by 7.5 kW YANMAR Diesel engine. Diesel engine was selected due to operating comfort with refuelling, because most of combat vehicles are feed by diesel fuel. The consequences are enlarged

weight of the vehicle and dimensions of power source unit. To decrease weight of generator, frame and all extra equipment were dismounted.

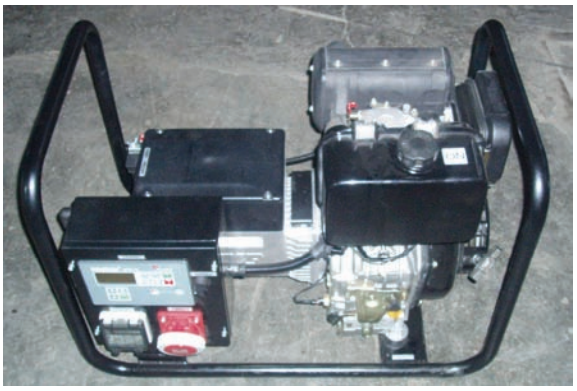

Fig. 1. Electric Generator

3. Propulsion engines

Vehicle is propelled by individual electric engines, feed from battery with use of engine controller unit. Battery is recharged, if necessary, from generator. If controller detect voltage under 40VDC, and mission condition don't require extra silence, generator engine starts automatically and recharge battery.

Fig. 2. Electric engine of UGV

Particular elements of propulsion were selected to provide high dynamics level of vehicle and provide top speed over 30 km/h. Synchronous triple phase electric engines, with 48VDC nominal voltage (at the controller feed), were delivered with ACD4805 controllers, as a dedicated to those type of engines. Engines are pancake types. Main feature of those engines is big diameter and small length. In those engines it is easier to achieve high turning torque. Engine cooling is performed by radiators located at the engine housing. Top speed of those engines is 6000 RPM, generating 4.4Nm nominal torque moment. Engine can be overload up to 50% for 30sec., up to 2000RPM.

Vehicle is devoid of steering mechanism. Driving course is changed by wheels speed. Engine control is realized by controllers. Engines from one side are controlled by one controller to provide equal speed. Basic functions, operated from simple analogue outputs are: switching on the engine, adjustment rate of engine rotation, front/back switching speed, reduction of speed by 2, activating electric brake. Moreover, controllers measure state of work of engines, temperature, voltage and current, speed – fixed and real, and other parameters. While braking, controller can produce electricity from regenerative braking and recharge battery. In this mode, controller works as a rectifier.

4. Propulsion and suspension

Propulsion module of UGV is also a part of independent suspension of the vehicle. Electric engines are located in rocker arm rotation axis. Rockers are sets along vehicle. Rocker bearings are also supports for engine shaft. Engine propels directly flanged pulleys with tooth belts,

transmitting motive force to the wheels axis. Speed at the belt is reduced, doubling turning moment. Wheel is placed at the shaft of the one stage planetary gear, connected with wheel hub. Gear ratio is 1:7. Front axle is leading arm rockers and middle and rear axles are swing arm rockers. Total gear ratio of module is 1:14, increasing turning moment at wheels to ca. 62 Nm, decreasing rotation speed of shaft to 430RPM. This reduction enable vehicle to operate with speed of 32 km/h.

Propulsion module of UGV consists of:

- ACD4805 controller from DANAHER MOTION,
- PMS100 electric engine from PERMMotors GmBh,
- Belt tooth transmission with 1:2 ratio,
- Planetary gear from APEX Dynamics with ratio 1:7,
- Rocker arm,
- MANITOU Revolver X4 shock absorber,
- 8”x 6” wheel.

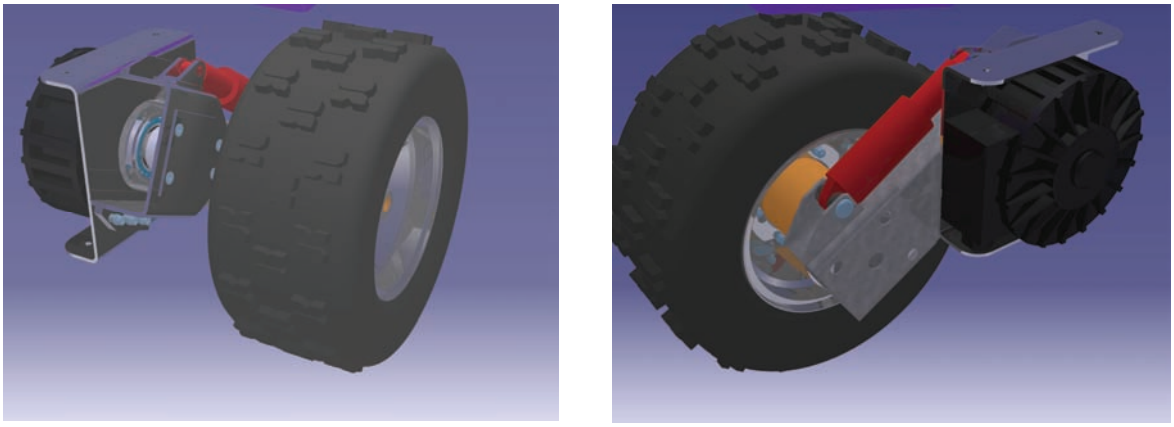

Fig. 3. Transmission module of UGV

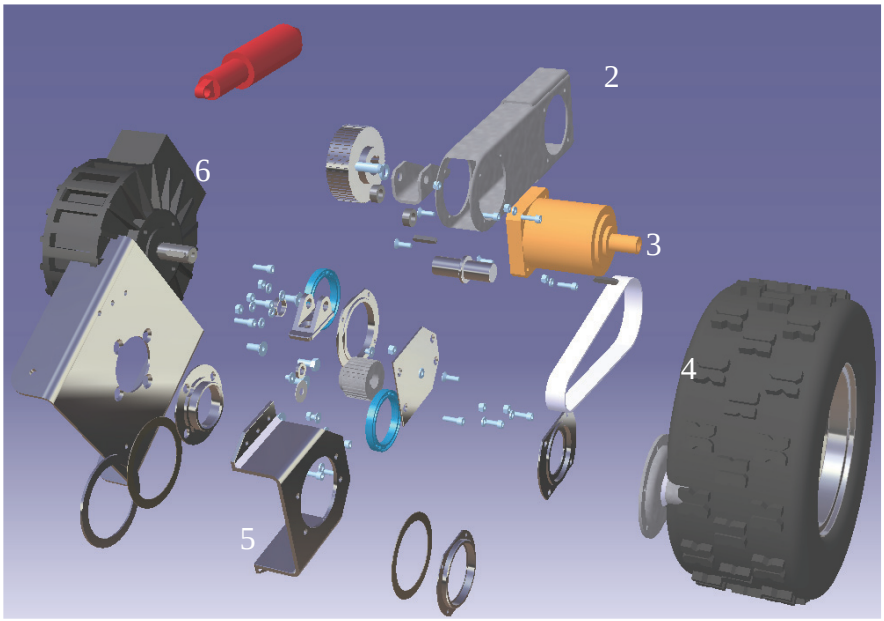

Fig. 4. Elements of UGV transmission module: 1- electric engine, 2- rocker, 3- planetary gear, 4- tooth belt, 5- propelled wheel, 6- belt wheel, 7- wheel hub, 8- wheel, 9- rocker housing

During the project, all elements of six modules were made. Also frame of the vehicle were made for UGV transmission and suspension elements assembling.

Fig. 5. Assembled rocker arms

Fig. 6. Rocker arm with planetary gear and bearings

Fig. 7. Rocker arm and belt transmission

Fig. 8. Rocker arm and wheel assembled on the UGV frame

5. Conclusions

Designed modules enable vehicle fast return to combat ability, due to parts repeatability. One module, used as a host, can reconstruct damage vehicle. Such solutions enable to create vehicles with 2 or more axis, with width and wheel track dependent from design, but assembled from those same modules. Additionally, there is possibility of using different engines, enlarging list of available modules. Economic factor has also big meaning, due to parts repeatability.

6. References

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