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UnSiL

Modification of Diesel Engine Design for Military Vehicles

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1. ABSTRACT

UnSiL Co scientists and engineers are currently working on an engine and drive design, which is presented herein. As well, there are some achievements presented. The document does not describe in detail the proposed technology based on a number of patents and know-how; however, the list of innovations gives an idea how the items can be used to improve existing internal combustion engines – the Diesel engine in particular. Capitalization of the presented technology in most cases does not require additional machinery, equipment, or any specific materials. The existing engine-building and automotive industry facilities, technologies, and materials can be used to manufacture parts and units for the improved engines.

The combined realization of measures mentioned and/or briefly described in sections 2.1. and 4.1 of this document should improve some of the major characteristics of the Diesel engine – like power and torque – by 1.75 times, in some cases theoretically even higher. Each of these means has been verified by either a built prototype, computation, or physical and computer models. Most importantly, all of them are produced by UnSiL Co professionals, who have strong and long-term expertise in the industry. Besides military applications, the document is about to present a very promising technology – the modernization of the four-stroke Diesel engine as a power plant for those applications. This absolutely unique technology converts the four-stroke engine in such a way that the new modernized one has the ability to operate in two different modes: four-stroke and two-stroke – alteration from one mode to another is not a problem. While the four-stroke cycle operation of the new modified engine has no difference in comparison to the original one, the two-stroke cycle operation of the newly designed engine has doubled power and torque – naturally each second stroke is the power one while in a four-stroke cycle – only every fourth one. Theoretically, the completely modernized engine, with the usage of other UnSiL Co techniques, may have power and torque 3.5 times higher than the original one. There is no magic in the new design performance since no dramatic changes have been made in the size and layout of the prototype; the new engine simply operates in two-stroke cycle mode under certain but very reasonable and practical restrictions.

2. Four-Two Stroke Diesel Engine for Military Vehicles

Military Vehicles as a term includes a wide spectrum of applications for military machines like tanks, combat vehicles, infantry fighting vehicles (IFV), armored gun systems (AGS), and supply heavy trucks. With modern combat tactics and according to military expert engineers, any combat vehicle requires as much maneuverability as possible to prevent enemy attack, leave a combat field rapidly and so on. This is translated into the necessity to increase vehicle power. However, a further power increase leads to adding weight to the engine and to the vehicle's overall weight, respectively. In fact, a combat vehicle needs extra power usually for a short period of time only as it mostly operates under normal operating conditions. As an example of such an extreme situation see Fig. 1 below – a flying tank. To perform such a maneuver, any tank needs an increase in power compared to normal operating conditions. UnSiL Co possesses the technology to create short-term engine power increases while maintaining overall vehicle weight and with only minor modifications to the existing engine design.

Fig. 1 A jump

2.1. Short Description

This innovation is about capability for a conventional Diesel internal combustion engine (ICE) to switch from a four-stroke operation mode to a two-stroke cycle regime and to hold it as long as it is needed during its operation. The proposed improvements on conventional four-stroke Diesel ICE,

besides allowing a Diesel ICE to switch from a four-stroke operating regime to the two-stroke one during the engine operation, also accelerate its gas exchange. The improvements concern the changes in a cylinder head, which is designed to perform the conventional four-stroke scavenging and two-stroke scavenging processes of working cylinders in order to provide a two-stroke mode of operation in addition to the existing four-stroke one. Scavenging in either a four-stroke or a two-stroke mode of operation is performed through the same originally designed intake and exhaust valves. In comparison to conventional Diesel engine, supercharger like the Lysholm compressor or a screw compressor with the inter-cooler is introduced. The arrangement of intake and exhaust valves in the cylinder head and valve-operating system itself are changed as well. Other parts of Diesel ICE remain unchangeable.

2.2. Expected Results

The engine with the proposed improvements is capable almost to double (1.7 – 2.0 time increase) its output power and hold it up for a short period of time (this short period depends on a type of the engine) without overheating. This feature allows the vehicle power-to-weight ratio to be doubled upon necessity in accordance with the vehicle operation conditions.

2.3. Eligible Areas Of Application

1. Diesel engines for combat tanks

2. Diesel engines for infantry fighting vehicles (IFV)

3. Diesel engines for military heavy trucks

4. Diesel engines for special purpose vehicles (i.e. emergency vehicles, fire trucks, etc)

2.4. Key Technical Challenges

A combat vehicle with the proposed designed Diesel engine gains the following very important advantages:

- For a short period of time the doubled engine output power and torque dramatically increases the vehicle's maneuverability;
- A vehicle increases its acceleration characteristics and, as a result, reaches the set speed 1.7 times faster than a vehicle with a conventional Diesel engine.

3. Fields of Implementation for the Innovation

3.1. Combat Tanks

Fig. 2 M1 "Abrams"

The average characteristics of modern combat tanks may be presented with the specifications of the very common American tank M1 "Abrams" (see picture above). The vehicle's weight is approximately 60 tons, the maximum speed is 72km/h and the vehicle's power is set to reach the speed of 36 km/h within a 6 sec period of time. These traveling characteristics are provided by a 1,500HP power plant, which is either a Diesel engine or a gas turbine engine. The modern tendency for better maneuverability leads to the further power increase of the tank engine up to 2,200HP. The Diesel engine power plant for combat tanks is preferable as it provides less fuel consumption and correspondingly longer range for each refill. The inconsistency of a tank power plant with higher horsepower is that the maximum power is required only for a short period of time during the combat tank life span. It is required either during a combat operation or in some other extreme occasions, despite the fact that usually a tank uses only 700-800HP for a plain motion at a constant speed and under other favorable (for its engine's operation) traveling conditions. The proposed innovation is to provide:

- the use of a suitable 1,000-1,500HP Diesel engine produced by any Diesel engine manufacturers, as a prototype for a future combat tank power plant. The engine prototype with the proposed

improvements will make available the power of 2,000 to 3,000HP for a short period of time only and double the tank's power-to-weight ratio during a combat operation;

- the avoidance of designing an entirely new Diesel engine of higher power for a future combat tank;
- designing a combat tank with the highest power-to-weight ratio and dominant maneuverability during a combat operation;
- the possibility of installation of additional fuel capacities/tanks onboard to increase the vehicle's traveling range.

3.2. Combat Vehicles

Fig. 3 IFV "Bradley"

The picture above (Fig. 3) presents the main US Army combat vehicles IFV M2 A1 and A2 "Bradley" also commonly used by UN peacekeeping forces. They are equipped with the Cummins Diesel engines VTA903-T500, with a power of 500HP, and VTA903-T600, with a power of 600HP. The implementation of the proposed improvements in these Diesel engines will increase M2 A1 and M2 A2 vehicles' maneuverability while doubling the power-to-weight ratio during a combat operation. Moreover, the new Cummins VTTA903-T750 and T800 can also be boosted with implementation of the proposed innovation.

3.3. Military and Other Heavy Trucks

Fig. 4 Trucks equipped with Detroit Diesel engines

It is possible to use the proposed improvements for heavy truck Diesel engines. Developing countries in different regions of the world like China, India and others currently do not have very stringent restrictions on truck exhaust emissions. Hence, heavy trucks with boosted Diesel engines can be introduced to the market of these countries soon after they pass emission control. A truck with such a boosted Diesel engine gains the ability to attain a set speed 1.7 times faster than trucks with conventional engines. The feature is mostly useful when a truck passes a vehicle in the opposite traffic lane, as well as overcomes a rise without switching the gear and slowing down vehicle speed. It is also a very important feature for a military truck under extreme conditions like exiting poor road conditions (swampy or sandy off-road), pulling another vehicle, or lifting heavy load. In many others situations the existence of extra power availability becomes a critical issue.

3.4. Special Purpose Vehicles

Fig. 5 Oshkosh truck

Fig. 6 Launch system

Boosted Diesel engines may benefit special purpose vehicles such as emergency vehicles, fire trucks, mobile launch systems and others as they operate with doubled output power, in certain special cases. The above two examples illustrate cases when extra power becomes a critical issue for a vehicle. Thus, on Fig. 5, the truck has to overcome different road obstacles and for this, it needs additional power for short periods like a few minutes. On Fig. 6 after the strike completion the mobile launch system has to change its location as soon as possible because, the electronic and radar

navigation systems of the opposing side may easily define the launcher position and return fire in response. To fulfill this maneuver the additional driving force to the launch system power plant is needed, again for a short period only. It must be outlined that cases when the so-called boosting regime is in place can be easily tested and controlled by using existing technologies, means and techniques within the industry.

4. Diesel Engine Concept for Heavy Duty Vehicles

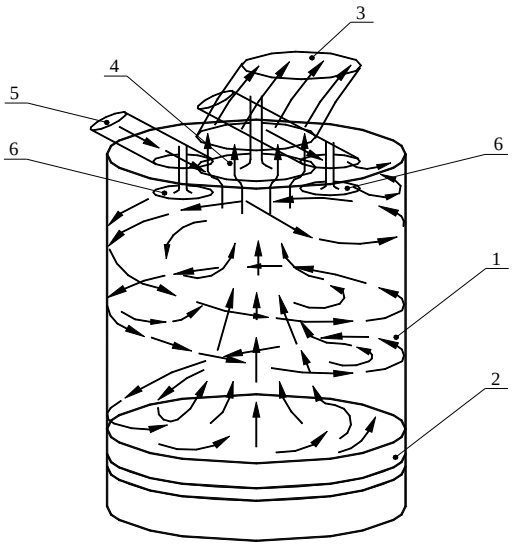
Theoretical research conducted by UnSiL Co scientists and engineers rests behind the proposed technology. Presentation of the theory is not the purpose of this document, however some statements making a basis for the technology are offered in the following section (4.1.).

4.1. Brief Engineering

The proposed UnSiL Co improvements to the conventional four-stroke Diesel engine accelerate its gas exchange and allow the Diesel to switch from four-stroke to two-stroke for a short time during the engine's operation. The improvements concern changes in the cylinder head, which is designed in a way to perform both the conventional four-stroke scavenging and the two-stroke scavenging of cylinders in order to provide a two-stroke mode operation. Scavenging in the four-stroke and two-stroke mode is performed through the same intake and exhaust valves. In comparison, the conventional Diesel engine has superchargers like the Lysholm compressor or a screw compressor where the inter-cooler is introduced, the arrangement of intake and exhaust valves in the cylinder head and the valve-operating system itself are changed as well. Other Diesel engine parts remain unchangeable. This feature allows the doubling of the vehicle's power-to-weight ratio when it is necessary.

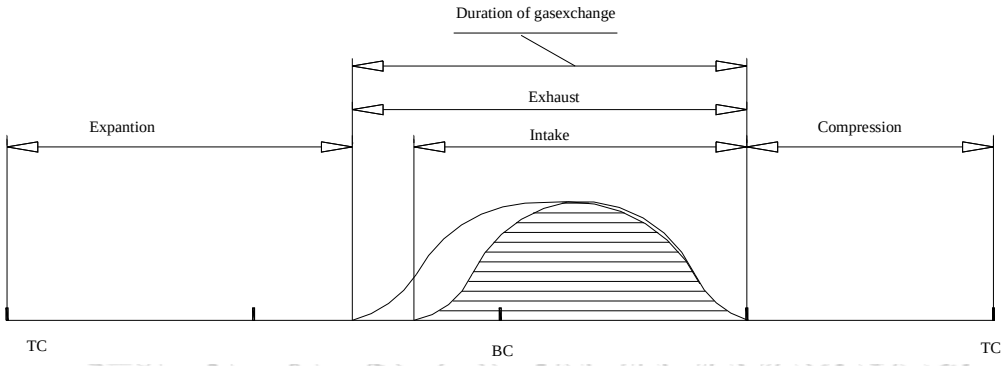
A vehicle with the proposed Diesel engine design gets doubled engine power within a certain period of time that increases its maneuverability and provides additional power which in turn means the higher acceleration and better maneuverability.

The essence of the innovation is to improve gas exchange during a two-stroke regime of Diesel engine operation. A four-stroke gas exchange is performed like in conventional four-stroke Diesel engine. A two-stroke gas exchange is fulfilled through intake valves and exhaust valves instead of the scavenging ports as it is usually performed in a conventional two-stroke engine. The schematic gas exchange takes place as shown here.



Intake valves 6 are located on the periphery of the cylinder head and exhaust valve 4 – along the cylinder's axis or with a small offset to it. The fresh air, first compressed in the engine

turbocharger and additionally compressed and cooled in the supercharger like the Lysholm compressor or a screw compressor with inter-cooler, is supplied into working cylinder 1 through tangential inlet passages 5 placed at a certain angle to the plane of the cylinder head. Then the fresh air starts swirling as a dense bed along cylinder 1 walls, and displaces to the center and wrings exhaust gases from the cylinder walls to the cylinder centre axle. As soon as it meets the bottom of piston 2, it turns and expels exhaust gases, concentrated along the cylinder axle, through exhaust valve 4 into exhaust passage 3. To lower residual gases ratio and to cool hot surfaces, the cylinder scavenging, accompanied by the discharge of some amount of fresh air charge into the exhaust system, is performed. Phases of gas exchange are typical of a conventional two-stroke Diesel engine. A screw compressor or the Lysholm compressor supercharger with inter-cooler is complemented to a conventional Diesel engine. The arrangement of both the intake valves and exhaust valves on the cylinder head as well as the valve-operating system is changed in order to provide four-stroke and two-stroke modes of operation for the same engine. The fuel supply system (like Common Rail for example) is chosen and adjusted in such a way as to provide a fuel supply in full correspondence with the number of working strokes.



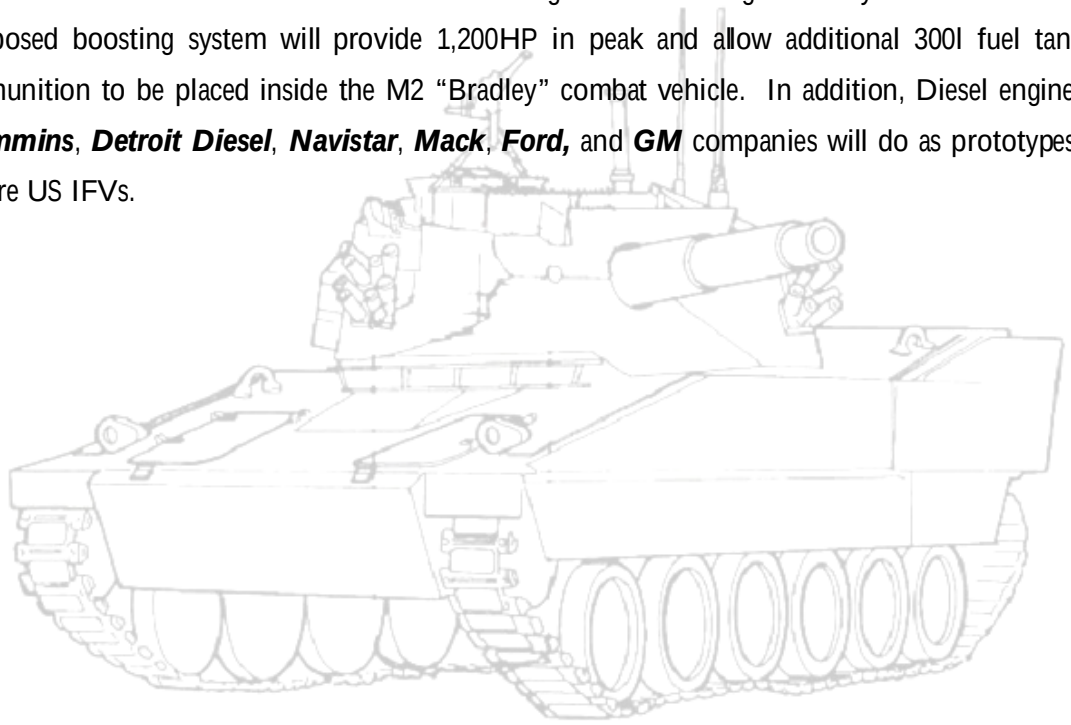
Contrary to a conventional two-stroke Diesel engine, there are no scavenging ports in the proposed design and no burnt oil losses throughout the ports. It will produce no more harmful emission than the emission coming out of the conventional four-stroke Diesel engines. The above presented diagram illustrates valve and port timing.

4.2. Engine Prototype Examples

Any suitable 12 cylinders Diesel engine with turbocharger and bore/stroke of 150mm/180mm or being close to these parameters, providing 1,500HP output power can be chosen as the engine prototype for a future US combat tank. The engine prototype, equipped with the proposed boosting system, will provide output power of 3,000HP in peak and the equal range without refueling to a combat tank with the same engine without boosting. The 10-cylinder Diesel engine

made from the 12-cylinder prototype by cutting off 2 cylinders will provide the peak power of 2,500HP and the arrangement onboard space additional fuel tank of 400l volume. The 8-cylinder Diesel engine, made from the 12-cylinder prototype by cutting off 4 cylinders, will provide the peak power of 2,000HP and arrangement into onboard space additional fuel tank of 800l volume. Appropriate Diesel engines of ***Caterpillar***, ***John Deere***, ***Detroit Diesel,*** and ***Cummins*** companies will do as prototypes. Thus, the proposed improvements implementation will increase the engine output power and the range without refueling of a future US combat tank up to 1.6 times in comparison with combat tanks of their main competitors such as Germany, France, Russia, Great Britain, Ukraine, Italy, and Japan.

The Cummins VTTA903-T800 Diesel engine after cutting off 2 cylinders and with the proposed boosting system will provide 1,200HP in peak and allow additional 300l fuel tank or ammunition to be placed inside the M2 "Bradley" combat vehicle. In addition, Diesel engines of ***Cummins***, ***Detroit Diesel***, ***Navistar***, ***Mack***, ***Ford,*** and ***GM*** companies will do as prototypes for future US IFVs.



5. SUMMARY

UnSiL Co is one of the fastest growing engine designing company due to its advanced technologies and know-how. UnSiL Co has been engaged in a variety of projects related to engine, power plant and drive design like car engine modifications, heavy duty Diesel engine improvement, Diesel engine modernization while being rebuilt, hydraulic transmission, hybrid power train, S-cycle and S-engine, free-piston compressor, and compound supercharger development.

Several projects are developed for different clients. Among them one is the 4-2-stroke Diesel engine prototype built for the very common tractor engine. Another engine for special purpose machine is slightly modernized in such a way that the same engine can produce about 12% more power while the original lay out, weight, dimensions, and specific fuel consumption (per hour) are almost unchanged. In other words the new design provides higher specific power. The examples mentioned in section 3 and 4.2 do not restrict the technology application whatsoever, meaning that many more engine designs are suitable for improvement and modernization under the proposed technology, however UnSiL Co believes that military vehicles power plants would have the most technological effect.