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SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

INVESTIGATION OF THE POSSIBILITIES TO IMPROVE THE DYNAMIC PERFORMANCES OF DAC 2.65 FAEG LIGHT OFF-ROAD ARTICULATED VEHICLE

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Abstract: A light off-road articulated vehicle is a vehicle with maximum weight less than three tones and consisting of two equal vats connected to each other through a central pivoting bearing which allows moving both parts around the vehicle longitudinal central axis. This type of vehicle is very rare. Generally, it has stayed at a prototype stage. One of these type of prototype is DAC 2.65 FAEG which were made in Brasov, Romania and it is studied inside of the laboratories from "Henri Coandă" Air Force Academy. At the beginning of 90s the prototype DAC 2.65 was the subject of systemic tests organized in civil and military areas as we can see in some pictures which were kept and taking into considerations some sayings of witness who were present at those events. Unfortunately the documents made on those occasions have not been found. From the careful visual examination of the disassembled components and from the discussions with some enthusiasts who have continued to use the operational vehicles which worked in different periods of time, some important ideas and conclusions have been drawn. These ones will be presented.

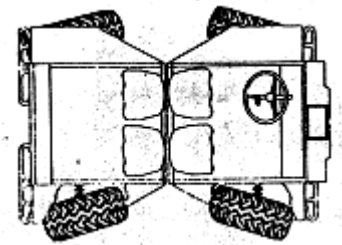
Keywords: light off-road articulated vehicle, DAC 2.65 FAEG, dynamic performances

1. INTRODUCTION

A light off-road articulated vehicle is a vehicle with maximum weight less than three tones and consisting of two equal vats connected to each other through a central pivoting bearing which allows moving both parts around the vehicle longitudinal central axis (Fig. 1).

In the late 80's, the designing engineers from the National Institute of Road Vehicles (INAR) and ROMAN/DAC Truck Factory conceived a light off-road articulated vehicle named DAC 2.65 FAEG. It was made in some variants depending on the existing subassemblies.

Fig. 1 A light off-road articulated vehicle



From the five vehicles which were made (plus another two that remained at the body stage), two of them had Wankel engine (maybe identically with the CROCO/RHINO engines), one of them had a Fiat Panda 1.4 liter engine and two vehicles had Dacia 1.4 liter, 65 HP engines. Only one from the last

two ones is still functioning and all the following details will refer to this model (Fig. 2).



Fig. 2 DAC 2.65 FAEG

2. THE LIGHT OFF-ROAD ARTICULATED VEHICLES MADE UP TO NOW

This type of vehicle is very rare. Generally, it has stayed at a prototype stage. It was suggested to be used in the military field but until now we do not have the information that it has been implemented.

The main technical characteristics common to the majority of these vehicles that have been made so far are:

- off-road utility vehicle consisting of two vats connected with a “Center Rotational Articulation”; the first vat has the power unit (the most part) and the driving control point and the second vat is empty and it could be used for special equipment;
- no suspension but center articulation - 45 degrees of travel;
- amphibious vehicle using only the wheels or combining wheels/propeller system;
- 4 Wheel Drive;
- 4 Wheel Power Steering.

The **advantages** of this type of vehicles are:

- remarkable crossing capacity due to 4x4 system and to the central pivoting bearing which allow the vehicle to follow the ground conformation permanently, by keeping all the wheels in contact with land; moreover, the vehicle has enormous approach and rear overhang angles which allow it to attack very high obstacles;
- very good maneuverability (swiveling radius less 10 m) due to the possibility of steering using all the wheels;

- very good stability due to very low center of gravity;
- the theoretical impossibility to be stuck in the mud due to very wide wheels which determine a very high upward force, the wheels which are acted directly from a covered body and due to the simple conformation of the “belly” of the vehicles which allow it to crawl without any problems on the muddy ground;
- simple and robust construction;
- it could be equipped as a amphibious vehicle (optional) because it is calculated to move on the water by using the wheels alone or combined with a propeller or a system of propellers which are trained by a power take-off from the rear axle differential.

The **disadvantages** of this type of vehicles are:

- little ground clearance which could make problems when the obstacles are attacked between the front wheels; the obstacles have to be attacked only by one wheel at a time;
- finding an engine capable to move the vehicle because this one must have a small volume, high power and it has to be easily maintained at the nominal temperature; it is working into a tough, not ventilated environment (into the first vat);
- the necessity of an automatic transmission which is going to work into a tough, not ventilated environment as well;
- the lack of suspension which could create comfort difficulties for the occupants of the vehicles;
- the lack of a covered body (because of the necessity to decrease the total weight) which can cause discomfort to the passengers.

From the patterns made so far, according to [1], we can enumerate:

- **Croco** was an amphibious light off-road articulated vehicle equipped with Terraires, created in 1981 at Croco Company, Switzerland. They were manufactured in Karlsruhe but the Company belonged to TAG (Techniques d'Avant Garde) directed from Ryad by Akram Ojjé, sponsor of William race cars of F1 in 1982. In 1983, manufacture of the Croco was stopped. 57 vehicles were stocked in containers and it seems Swiss Army and also Saoudian Army brought a few tens copies. In the early 90s, the stock was bought



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by M. Richard of MS Transaction, Scy-Chazelles, France, to sell them.

- **Rhino** of VMB VESTA Mashinenbau GmbH & Co manufactured from the mid-80s at Rheinstetten near Karlsruhe replaces Croco until mid-2000. Nowadays, it is named the „Alligo Cross Country Vehicle”.

Nowadays, Coot 2 is the only "Center Rotational Articulation" off-road utility vehicle in its class produced by a specialized company.

The technical details of these three models are presented in table 1.

- **Coot 2**, 2004. The original Coot was built from 1968 to 1982. A new Coot, the Coot2, marketed from 2004 is manufactured by Globalnet Industries Inc, Fairview, Illinois.

Table 1 Technical details

Item	Measure unit	Value/type		
		CROCO [2]	RHINO [3]	COOT2 [4]
Weights and dimensions				
Overall length	m	2,70	3,05	2,49
Overall width	m	2,00	2,13	1,47
Overall height with hood	m	1,95	2,08	2,00
Ground clearance	m	0,28	0,25	0,324
Wheelbase	m	1,62	1,62	1,60
Track	m	1,65	1,65	-
Unload vehicle weight	kg	900	1250	726
Gross vehicle weight	kg	1 400	1750	1294
Engine				
Type	-	CROCO rotary engine (NSU-Wankel license), single rotor	4-cylinder Diesel engine, turbocharged	KOHLER V TWIN
Displacement	cc	440 (equiv. to 880)	800	800
Compression ratio	-	7.6	23	-
Maximum output	HP(kW)/rpm	30(22)/5500	28(21)/-	27(37)/3600
Maximum torque	Nm/rpm	45/3600	60/2800	-
Weight	kg	32	73	-
Remarks	-	oil-cooled rotor, engine air-cooled by centrifugal blower	water cooled	-
Transmission				
Type	-	Belt-drive torque converter + 2(+1) speed gear box	4+2 speed from 2 mechanical synchronized gearboxes	hydrostatically
Differential transaxles	-	automatic locking device.	jointed shaft to worm-gear	-

				differentials
Wheels and tires				
Type	-	low-pressure flotation tires	low-pressure flotation tires	-
Size	-	31x15.50 – 15	31x15.50 – 15	28x9 – 12
Wheels	-	aluminum	aluminum	steel
Inflation pressure	at	0,5	0,5	-
Maximum speed				
land 1st gear	km/h	25	23	-
land 2nd gear	km/h	50	72	32
water (with the wheels)	km/h	4		-
water (with outboard motor)	km/h	8		-
Other features				
Range	km	500		-
Petrol consumption	l/h	6	4,5	-
Body	-	2 mm steel plate	2 mm steel plate	-
Carrying capacity	-	2 - 6 occupants or 500 kPa payload	500 kg	4 occupants

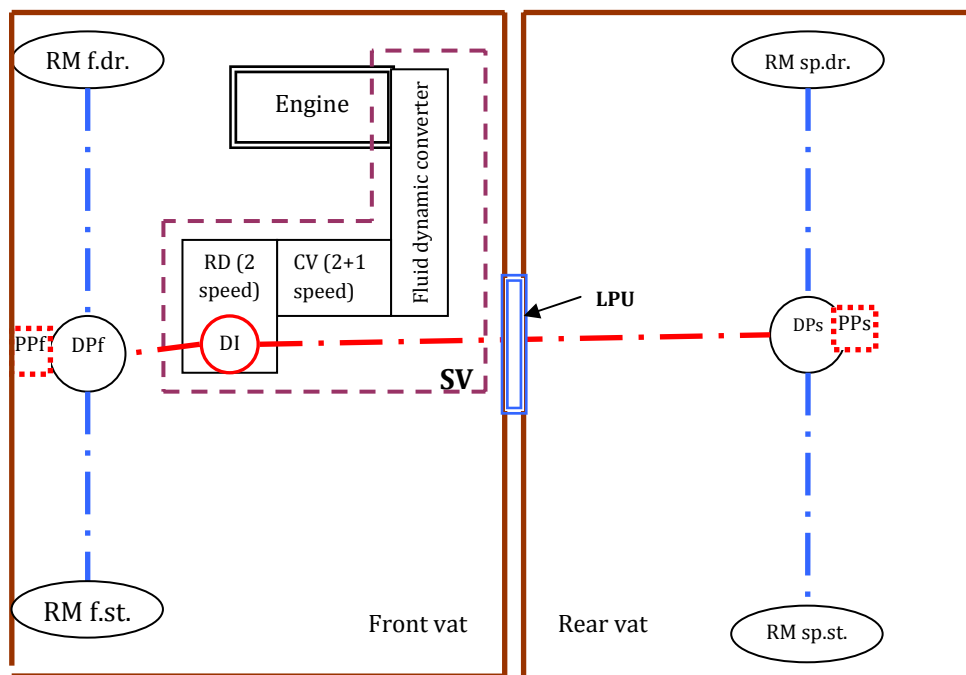


Fig. 3 The power unit scheme of studied DAC 2.65 FAEG

3. THE LIGHT OFF-ROAD ARTICULATED VEHICLE MADE IN ROMANIA- DAC 2.65 FAEG

The studied DAC 2.65 FAEG vehicle (the power unit scheme in figure 3) has a power unit conception and a body identical to CROCO/RHINO vehicles. The declared performances are similar to CROCO/RHINO, too. Apart from this issue, there are no other similarities because the used components were

from the serial automotive industry production at that time.

In figure 3:

— . — . — - planetary shaft

— . — . — - cardan shaft

CV – gear box

RD – distributor and reduction gear

DI – front rear splitter unit

SV – gearshift

DP f(s) – front (rear) differential

RM f(sp)st(dr) – front (rear) left (right) live wheel



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LPU – central single pivoting bearing
PPf(s) – front (rear) power take-off

4. POSSIBILITIES TO IMPROVE THE PERFORMANCES OF THE DAC 2.65 FAEG PROTOTYPE VEHICLE

First of all we have to say that at the beginning of 90s the prototype DAC 2.65 was the subject of systemic tests organized in civil and military areas as we can see in some pictures which were kept and taking into considerations some sayings of witness who were present at those events. Unfortunately the documents made on those occasions have not been found.

From the careful visual examination of the disassembled components and from the discussions with some enthusiasts who have continued to use the operational vehicles which worked in different periods of time, some important ideas and conclusions have been drawn. These ones will be presented.

We can see that some important ways will result in order to optimize the performances of the vehicle.

The engine unit

The vehicle's engine is Dacia model, 1398 cmc capacity, 65 HP. It is an engine quite efficient and unpretentious. It has a good power per volume unit and it is adapted to the disposal space from the front vat. Its power and torque engine are theoretically enough for the necessities of the vehicles. There were not done endurance tests.

There were technical problems with the cooling of the engine during overloading and summer time. This phenomenon happens due to the unsuitable place where it works and the weak ventilation from front vat. The radiator of the engine cooling system is placed outside the vehicle's body but the cooling liquid subway has a complicated architecture.

Furthermore, for approximately 60 cm, one of the cooling liquid pipes is close to the muffler (3-4 mm). Thereby a supplementary heating of the cooling liquid is made.

The position of the ventilator, placed in front of the engine inside of the front vat is really improper. This one does not have the possibility to absorb fresh air in order to cool the engine directly (to ventilate it) because there is not a hole in front vat. This one is almost hermetically covered with a metal floor. The ventilator only "carries" the hot air from the front to the rear space inside the front vat.

The cooling system radiator was initially cooled by using two electrical fans which were engaged by thermocouples. They were replaced by a single bigger electrical fan which has the air supply output really superior. Furthermore, a sufficient wide hole in the front wall of the front vat was cut in order to allow an optimal fresh air ventilation of the engine (Fig. 4).

The cooling of engine oil is made by two oil radiators placed outside the body of the vehicle, too (Fig. 4).



Fig. 4 The radiators of the vehicle

The air filter is undersized for an off-road vehicle because it is a half of a normal Dacia car air filter. Furthermore, it is placed into an

inadequate position, below the passenger from the right of the driver (co-driver seat).

Possibilities to improve the engine performances

The best method to improve the engine performances is to... change the engine with a modern, small and powerful one, using the “trendy” method of “downsizing”. These requirements are better satisfied by the Otto engines. Moreover, these ones have the advantage of the easy starting during the cold period of year.

The next operations are necessary to be done in order to solve the technical problems which were reported until now in the case of keeping the Dacia engine:

- both electrical fans will be changed with at least another bigger power electrical fan (executed work);
- a hole will be cut into the front surface of the front vat in order to assure a good air ventilation of the engine (executed work);
- the architecture of the exhaust gases subway will be modified so that the exhaust system will not supplementary heat the engine (its cooling liquid); thermal insulating materials will be used in order to cover the exhaust system and to protect the passengers of the vehicle;
- the air filter will be changed with another bigger one (a wet air filter could be used) and its position will be modified in order to make the access of the fresh air to the engine easier.

The gearshift

The vehicle has a fluid dynamic converter paired with a gearbox (2+1 velocity unsynchronized stages) plus a manual locking front rear splitter unit. All this system has a common oil bath. The gearbox/splitter unit ensemble has an extra reduction gear in two steps and a distribution gear to the front and rear axles. There were not reported technical problems with this part of the vehicle. Still, there was one exception: in case of overloading, the fluid dynamic converter overheats. The transmission oil could be expired. This one will be changed and some endurance tests are going to be done.

In order to completely describe the transmission, the differentials of the axles are limited to slip type with worm and wheel gearing.

5. CONCLUSIONS: POSSIBILITIES TO IMPROVE THE GENERAL CONFORMATION OF THE VEHICLE

As we can easily notice in figure no. 3, the vehicle has two power take-off (PTO) units corresponding to the front and rear axle's differentials (Fig. 5). In the original project, the PTOs were designated to act the capstan (the front one) and the propeller and the group of propellers (the rear one).

An original solution for the military area can consist in using the rear PTO to act an electric generator with multiple possibilities to be used. The space for it is not a problem because the rear vat is almost empty and it is at the users' disposal. In case of the electric generator placed into the front vat, this one can generate electrical power from the position which normally is used by the co-driver (the passenger from the right of the driver).

A very interesting project could be done to design a hybrid vehicle. In this case, the electric engine can be placed into the rear vat coupled on the rear PTO. The necessary batteries could fill the rear vat. In this situation the vehicle could use the combustion engine in order to march to the conflict area and, after this, it is going to approach quietly the enemy by using the electric engine.

But all these ideas could be developed in the future depending of the financial resources taking into account that the electric engines and mainly the batteries are very expensive...

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