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Multifunctional power unit concept with hydrostatic drive system.

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***Abstract.* - Peace and war. Two periods that cyclically replace each other in history. What they have in common is that industry must serve both. Current events, such as the Russian-Ukrainian conflict and the threat of terrorism, require preparedness. In addition, it is necessary to economically and adequately satisfy the constant demands of peacetime. Based on this line of thought, we have created an agricultural power plant concept that can also be manufactured under Hungarian conditions. The primary goal of the project is to develop a hydrostatic drive system concept that will serve such a machine.**

Keywords - Concept, Power Plant, Hydrostatics, Drive

I. INTRODUCTION

In response to today's conflicts, NATO has determined that member states must spend at least 5% of their GDP on defense spending, which essentially means purchasing military equipment. Furthermore, the general level of preparedness must increase. [1.]

The main beneficiaries of all this are large, multinational arms companies, while the purchasing countries, at significant national economic costs, merely accumulate dead capital.

One of the goals of the concept being presented is to point out the economic benefits of their own development and how development reduces external dependence. Another goal, which is also economic in nature, is to examine how the power machine created as a result of development meets the needs of other sectors of the national economy.

II. THE CONCEPT

The expectations for the development were defined as follows:

- The development should be as simple a construction as possible, in order to be easy to manufacture and operate.
- The development should be usable by as wide a circle as possible.
- The development should meet the needs of military use.

The user group, although we have tried to define it as precisely as possible, is presented in Figure 1 without claiming to be complete.

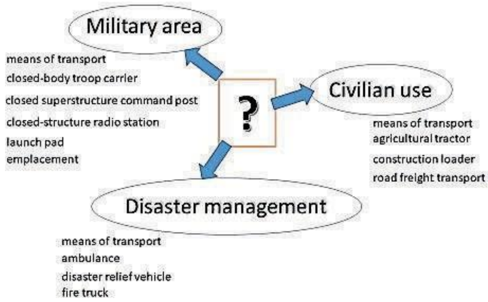

Fig. 1. Areas of application

The concept of a universal tool is not new. There are some very successful tools, such as the Unimog, a product manufactured by Mercedes, which is based on a van. [2]

Our idea differs from these existing tools in two significant points.

1). We did not take a truck as the base machine, but an agricultural tractor,

2). In order to meet the different needs in different areas of use – typically travel speed – and to ensure easy variability, we chose a hydraulic drive.

There is also practical experience with the hydraulic drive, since the Forscrit E 516 agricultural harvester was already manufactured with such a drive in the 1980s.[3.]

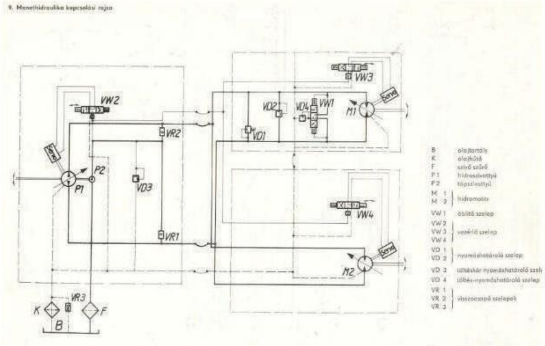

Fig. 2. E-516 combine travel hydraulics system.

Although the schematic diagram of the drive system provides assistance in the design, from the perspective of the concept design, the design of the drive system still represents the greatest challenge, as it must be adapted to the unique needs of different designs.

III. CONCEPT DETAILS

As the basic machine, we chose the form and construction of an agricultural power plant - a tractor - due to its universal nature. Its frame structure is a longitudinal and cross-beam system made of welded U profiles, on which the power unit, the drive train, the 180o rotating operator's cabin and all additional elements can be placed. The frame structure is illustrated in Figure 3, together with the listed elements.

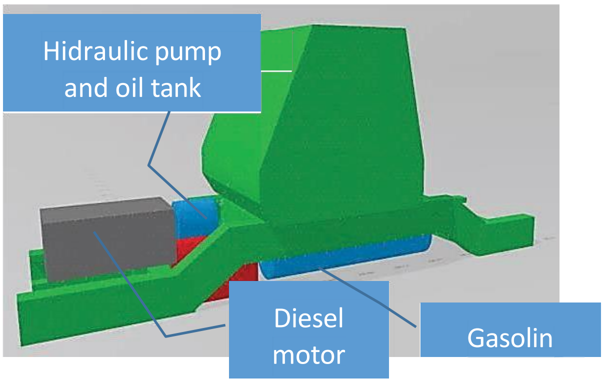

Fig. 3. Frame structure and main structural elements

This basic structure is the same in each variant. Differences occur in the chassis, drive system and bodywork.

Chassis. The chassis is suitable for:

• four wheels,

• two wheels and two tracks, and four tracks.

The individual chassis elements can be freely exchanged according to needs, as their drive systems are compatible. Its construction is shown in Figure 4.

Fig. 4. Track model.

Superstructures. To accommodate superstructures, the basic frame is supplemented with a so-called frame extension. This increases the length of the basic model and makes it suitable for:

• low or medium-height platform, i.e. loading area,

• raised, open platform,

• for receiving closed boxes, - which can be:

o troop carrier with rear opening ramp,

o command post, o communication

center, o chemical protection station,

or o even a cold storage room, or

• for using the chassis of the base machine as a platform. Figure 5.

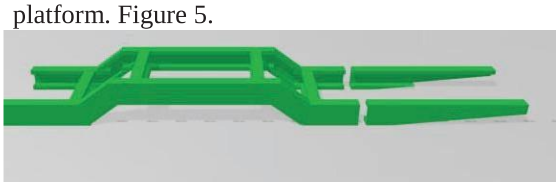

Fig.5: Frame extension

Drive chain. As mentioned earlier, perhaps the most important element of the concept is the hydrostatic drive system, against which the basic requirement is to ensure different travel speeds in different application areas. The system must be able to achieve any value within the speed range of 4 km/h and 100 km/h. Several alternatives for the design of the drive system are included in the concept. In order of complexity, we have to consider the following options:

1- A hydraulic motor drive located on a central drive shaft. (two-wheel drive) Figure 6

2- Two central axles with one hydraulic motor per axle (four-wheel drive)

3- Wheels driven by two independent hydraulic motors. (two-wheel drive)

4- Four independent hydraulic motor driven wheels. (four-wheel drive)

We performed preliminary calculations for all four cases to determine the theoretical functionality of the design and to determine the size and power requirements of the required power source (internal combustion diesel engine).

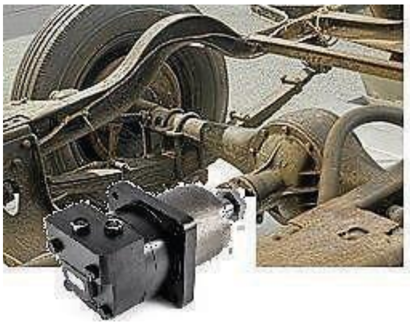

Fig.6: Rigid rear axle, direct hydraulic drive mounted on the differential

In determining the initial data, we relied on the data of the previously mentioned E-516 combine harvester, which, according to the manual: [5.]

P_{max}= (228 LE) 168 [kW] n=2200 [1/min]

M_{max}= 961 [Nm] n=1400 [1/min]

v_{max} = 20 [km/h] without degree four-wheel drive

Q = 196 [l/min] by swallowing liquid $p_{üzemi}$ = 350 [bar]

Based on these data, we chose the Deutz TCD 4.1 L4 Agri type as the power source. Picture number 7 [4.]

Fig. 7: Deutz TCD 4.1 L4 Agri

Characteristic data:

P_{max} =126 [kW] n=1900 [1/min]

M_{max} = 699 [Nm] n=1500 [1/min]

The hydraulic system was optimized and calculated based on these data.

The calculation determined:

- The size and fluid delivery of the hydraulic pump that can be driven by the selected resource, at an operating pressure of 350 bar (The data of the hydraulic pump are presented in Table 1 of the results chapter.)
- Based on the volumetric flow, the fluid intake of 1-2-4 hydraulic motors and from this, the speed and torque of the hydraulic motor.
- The speed and torque that can be transmitted to the driven wheel from the speed and torque of the hydraulic motor, in the case of direct drive and indirect drive.
- The magnitude of the starting torque calculated from the vehicle's mass.

IV. RESULTS

Selected tractor wheel dimensions: 320/85R28

During calculations, we calculated with a vehicle weight of 5 tons.

From these calculated data, a comparative evaluation could be carried out, based on which it could be decided whether a given drive design can meet the expectations and technical parameters of a given purpose of use.

TABLE. I. Operable hydraulic pump data

Típe	Q [l/min]	n [1/min]	p_{max} [bar]
A10VSO s 32	252	1800	350
A20VLOseries10	2x230	2700	350

Fig. 8: A10VSO series 32 140 [7]

Fig. 9: A20VLO Series 10 [7]

The evaluation and summary data of the drive design methods are contained in Table 2.

TABLE. II. Summary review

	1 hm. thq.	2 hm. thq.	2 hm. direkt	4 hm. direkt
Th/rot	200	2x200	2x200	4x200
Rev/rot	2000	2000	2000	317
Rev	426	425	200	317
Speed	100	50 (leszabál yozva)	50	75
Usage.	Truck	Tractor	Half a catterpillar	Full track

Legend:
1 hm. thq. – 1 hydraulic motor placed on a central shaft.
2 hm. thq. – 2 driven central shafts, driven by 1-1 hydraulic motor. 2 hm. dirkt – 1 – 1 hydraulic motor placed on wheels, either on the front or rear wheel pair.
4 hm. direct – four-wheel drive with 1 – 1 hydraulic motor on each wheel.
Th/rot – torque per motor available in the drive [Nm]
Rev/rot – speed of the hydraulic motor/s used in the drive [1/min]
Rev – Wheel/track speed [1/min]
Speed – maximum travel speed achievable with the vehicle [km/h] Usage – Possible area of application of the drive.

Fig. 10: A10 VER Series 52 45 Motor [8]

V. FINDINGS

In the case of a solution mounted on a 1 hm central shaft, the single pump and 4.7/1 differential ratio are used, and the design is capable of a maximum speed of 100 km/h.

2 hm. in a solution mounted on a central axle, with the double pump it is able to maintain the speed of the single-axle solution, i.e. 100 km/h. In addition, it can be suitable for receiving 4x4 wheels or caterpillar tracks, thus fulfilling an off-road vehicle function. Remaining at a total weight of 5 tons, regulated to max. 50 km/h

2 hm direct drive in the case of semi-tracked reduced to 50 km/h the configuration may be suitable for a semi-tracked solution

With 4hm direct drive, the double pump is the most suitable, even driving 4 motors does not limit the system. In this case, the maximum speed achieved is 75 km/h.

The calculated data supported the basic conceptual idea that a vehicle structure that can meet universal requirements can be created with a hydraulic drive system. The correctness of the concept is also supported by similar research by Chinese experts. [6.]

In the theoretical system, dual regulation can be implemented, which on the one hand • means regulating the charge level of the driving diesel engine. This allows the speed of the central hydraulic pump, and thus the amount of fluid flow available, to be regulated.

- A second control circuit can be implemented on the application side, by throttling the hydraulic motors, which relates to the pressure and/or amount of fluid flow.

In continuing to develop the concept, we still need to do:

- specific weight calculations for the basic machine and the superstructures assigned to different areas of use,
- sizing of additional hydraulic systems (e.g. PTO drive, 3-point suspension, loading boom, or propeller drive.)
- buoyancy calculations,
- design plans
- cost calculations.

We hope that this will create a development direction that will help domestic vehicle manufacturing.

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