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A STUDY UPON TRACTION SYSTEMS FOR TECHNOLOGICAL MACHINES WITH AUTO PROPULSION

asist. univ. ing. drd. Adrian Sorin Axinti
Universitatea "Dunarea de Jos" Galati

ABSTRACT:

This paperwork presents a comparison of traction systems used for heavy machines that needs to move on public roads. (construction devices, agriculture machines, etc.). Here are presented traction charts implemented on this systems in contrast with ideal charts of traction. This study is realized for choosing an efficient traction system for cereal harvesters.

1.Basic issues.

Traction machines and digging and transport vehicles can be moved on any kind of public road, including working areas. Motion systems for this category of vehicles are equipped with mechanical transmissions, hydraulic, electric or mixed.

Transmission (driving system) function is to take torsion moment produced by the engine and transmitting it to the driving wheels, allowing changing moving speed and traction forces depending on the conditions of work. It also to be mentioned that transmissions of traction machines or machines used in construction have to allow transmission of motion to other parts used for work (power plug, hydraulic pump, power bridge, etc.)

Transmissions used in auto vehicles, can be classified based on different criteria:

- **how power is transmitted** from the engine to the drive shaft, can be: hydraulic, mechanical, electrical or mixed (hydro-electrical, electromechanical, etc.)
- **how gears are transmitted** from the engine and drive shaft, can be: in steps or progressive, or **adaptive**.

Transmission in steps can allow a limited number of gears so the vehicle can move between the lower or higher speed with a limited number of gears.

Adaptive transmissions can allow between a range any gear so the vehicle can move between the lower or higher speed with an unlimited number of gears.

This paperwork is made for presenting types of characteristics of traction realized by usual transmissions for adapting of the best traction system purpose for cereal harvesters.

2.Characteristics of classical traction systems

Mechanical transmissions in steps are the most used systems on auto vehicles, because are the most simple from the point of view of construction method and they are very safe. Motor moment is transmitted to the drive shaft from a modifying mechanical system in fig.1. Transmission scheme with a single driving bridge in back (4x2)S is shown in fig.2.

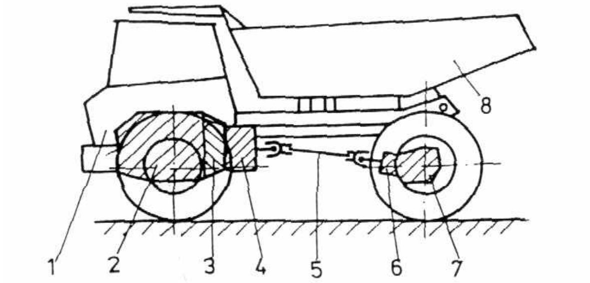


Figure 1. Transmission mechanical system of the driving torque o the driving wheels.
1-shake; 2-engine; 3-clutch; 4-gear box; 5-longitudinal transmission; 6- main transmission; 7-coupled with; 8-carrier-box

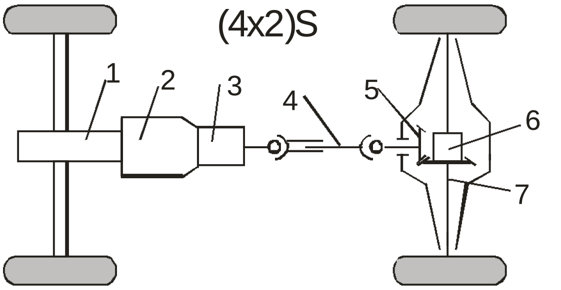


Figure 2. 4x2 Back transmission type diagram. 1-engine; 2- clutch; 3- gear box; 4- longitudinal transmission; 5- main transmission; 6- differential; 7- planetary shafts

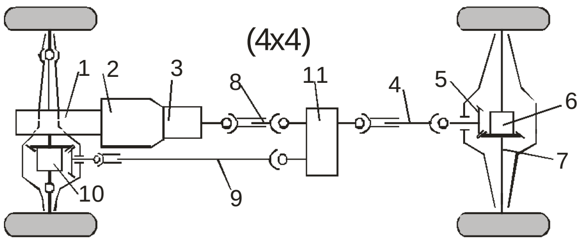


Figure 3. 4x4 Back transmission type diagram. 1-engine; 2- clutch; 3- gear box; 4, 8 and 9 longitudinal transmissions; 5- main transmission; 6 and 10- differentials; 7- planetary shafts; 11- reduction distributor

This transmission is made of the following subassemblies: clutch 2, gear box 3, longitudinal transmission 4, main transmission 5, the differential 6 and planetary shafts. The clutch takes the motion in transmission from thermo engine (fig. 2).

In figure 3 is presented the general scheme of the transmission of an auto vehicle with two driving wheel shafts and in figure 4 is presented general scheme of the transmission of an auto vehicle with three wheel drive shafts.

In construction of the auto vehicles with two or more than two wheel drive shafts is also used the distributor or reduction distributor 11 (fig.3 and 4).

Also, are used longitudinal transmissions 8 and 9, main transmission, and planetary transmission 12.

The general organization of a vehicle's transmission is determined by the place where the engine is coupled with the wheel drives, which is very important for the constructive parameters, the dynamic properties and for linking of the vehicle.

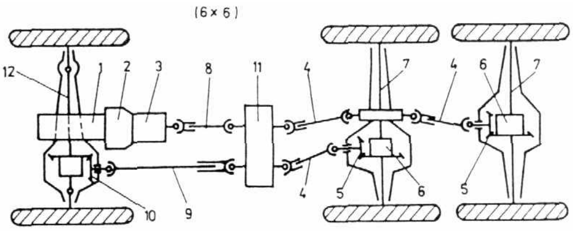


Figure 4. 6x6 Back transmission type diagram. 1-engine; 2- clutch; 3- gear box; 4, 8 and 9 longitudinal transmissions; 5 and 10- main transmission; 6 and 10- differentials; 7 and 12- planetary shafts; 11- reduction distributor

Traction chart realized by the mechanic transmission is presented in fig. 5 in comparison with theoretical chart defined by: F · v = const.

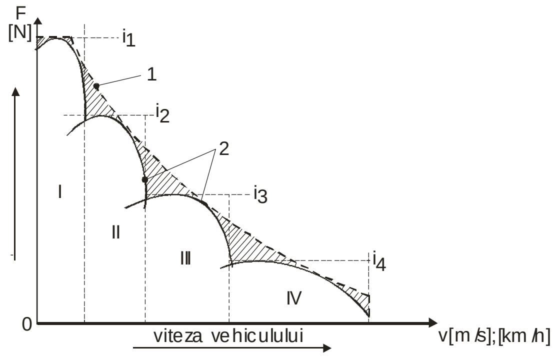


Figure 5. Traction characteristics of a mechanical tranmission whit four speed stairs
1- traction characteristics theoretical; 2- traction characteristics for the transmision ratio; i_1; i_2; i_3; i_4 of gear box; I; II; III; IV- transmision ratio; ▨ - theoretical characteristics approximation zone

Hydrodynamic transmissions are mounted in mechanical transmissions, and this the reason that they are named hydromechanic transmissions.

This transmission is used for auto vehicles which when are in full action the moving resistances changes frequently and which needs frequently change the senses of direction and speeds (they are also used for washing machines or for transportation machines, forestry tractor, vehicles used on rough terrains etc.)

In figure 6 is presented the blueprint of a hydromechanic transmission with hydrodynamic clutch. Engine 1 moves pump P of the hydrodynamic clutch 2 which rotate turbine T. Through friction clutch 3, gear box 4, wheel drive shaft 5 and transmission 6, the motion is transmitted to drive wheels 7 of the auto vehicle.

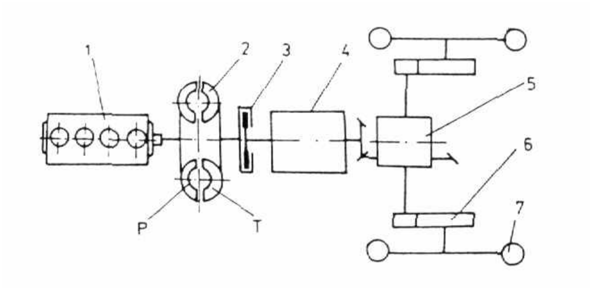
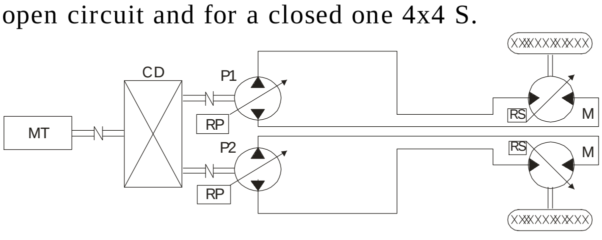


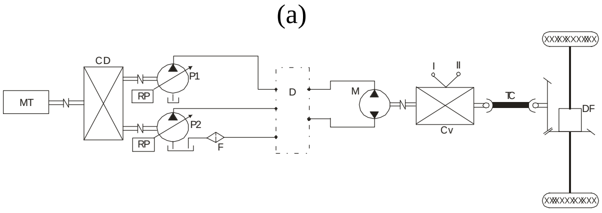
Figure 6. Main diagram of a hydro-mechanical transmission whith hydrodynamic clutch.

Traction chart obtained with hydrodynamic transmission is almost the same with the chart from mechanical transmission and is presented in fig. 5.

Hydrostatic Transmissions are used on heavy vehicles (heavy automobiles, construction machines, agriculture machines etc.)
A hydrostatic transmission is made of a hydrostatic pump, powered by the auto vehicle’s engine and an hydrostatic engine, which drives directly or through a transmission the wheel drive of the auto vehicle.
Obviously, the transmission includes safety and tuning elements, sensors for reading pressure and temperature, hydraulic blocking devices of the wheels, devices for automatic setting of the debit of the pumps for maintaining of a constant load of the thermo engine on different working stages.
By the way of positioning of the elements, thermo engine, hydrostatic pump, hydrostatic engines, wheel drives a lot of transmission schemes can be created and implemented.
In fig. 7 are presented usual schemes of hydrostatic driving of the traction system for an open circuit and for a closed one 4x4 S.



(a)



(b)

Figure7. Hidrostatic drives for traction systems
a – open circuit driving; b- closed ciruit driving

In fig. 7a, is presented a mode of driving in **closed circuit** of a machine with rubber wheels with **primary tuning** (PT) of cylinder capacity and **secondary tuning** (ST), known as **mixed tuning**. The system is composed by internal burning engine; cinematic distribution box which allow that pumps P1 and P2 (equipped with individual regulators) to be driven simultaneously. Pump circuits are linked to engines M, with variable cylinder capacity with secondary tuning (ST), engines that are hydrostatic and low-speed with two ranges of speed.
This idea is implemented in the case of a frontal loaders with draft direction with small and medium power (20 – 40 kW), 4x2 S. This solution can be used also for 4x4 when using four hydrostatic engines mounted on the rim.
In figure 7b, is presented a way of driving in **open circuit** of a machine with rubber wheels only with primary tuning of cylinder capacity. The system is composed from internal burning engine, distribution box, pump P1 and P2 equipped with regulators, hydraulic distributor, engine with fixed cylinder capacity, gear box with two gears, cardanic transmission and differential.
This solution is utilized in making of frontal loaders with articled chassis, excavators, loaders, which uses traction systems (4x2) S.
This solution can be extended to the 4x4 machines too, when using 2 hydraulic engines on a gear box and two outputs for cardanic transmission. (front – rear).

3.Adaptive hydrostatic traction system for front loaders

Adaptive hydrostatic transmissions are used especially for heavy machines on which the moving system is used also on its technological cycle. It is the case of frontal loaders of very heavy weight (120-250) kW, auto scrappers, auto graders, heavy tractors and some agricultural machines.
Specific to this kind of machines is the fact that traction force is used for the job of the machine (cutting earth, pulling some equipment, moving on rough terrain etc.) For moving of this machines on public roads, realization of common speeds is needed. (30-60) Km/h.
In this situations, for using the energy efficiently produced by the thermo engine the continuing adaptation of parameters of the system is needed. This thing is realized watching continuously the command of the machine operator who decide which operation is to be made and the parameters realized by the traction system through continuously measuring

and comparison. This thing is realized using specialized transductors and a microcontroller which allows acquisition, saving and calculation and control of execution components from traction system. (primary regulation, secondary regulation, acceleration regulation etc.)

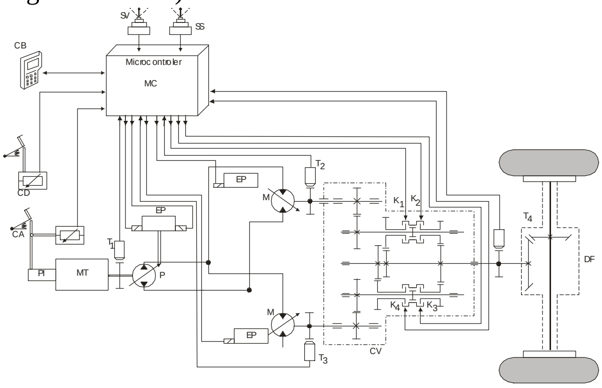


Figure 8. Adaptive hydrostatic system for a front loader whith (4x2)S deplacement transmission.
M T- thermo engine; PI- injection pump; CA- acceleration control of the treadle MT; CD- control of the treadle for the specifical volume pump; CB- computer board; MC- microcontroller; SV- speed for handle choice; SS- the way handle choice; EP- electrical control of proportional regulator; CV- automatic gear box with electrical control of speed regime (power-shift); P- specifical volume pump with servo-driving specifical volume electro-hidraulic for close circuit (A4VG); M-variable specific volume hidraulic motor with servo-driving specifical volume electro-hidraulic (A6VMN); K1; K2; K3; K4 – signal electrical control coupling-uncoupling of speed stairs; T1; T2; T3; T4 – speed inductive traducers

Such an adaptive system is presented in figure 8, which is used for frontal loaders with the shovel capacity between 2 and 5 m^3.
For adaptive traction systems, with automatic gearbox and mixed tuning of cylindrical capacity, electronically driven with microprocessor is presented in fig.9
The electronic control of the processes of energetic consumption, the electronic characteristic of power adjustability and the control of the dynamic parameters of the process realized by the microprocessor, leads to the realization of a drive characteristic very close to the theoretical (ideal) characteristic. This is achieved from the secondary tuning of the engines and from the simultaneous coupling of these on various gears of the drive of the automatic gearbox.

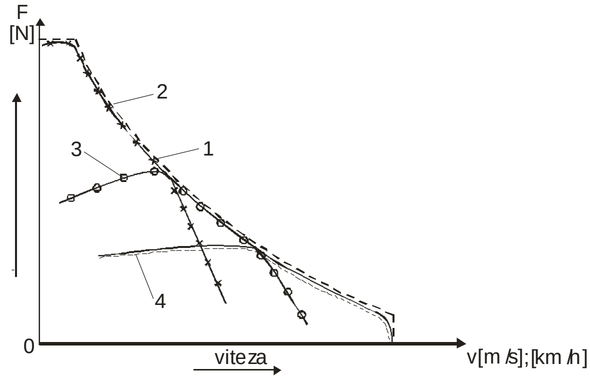


Figure 9. Traction characteristic of the adaptive hydrostatic system.
1-theoretical characteristic; 2- the specific characteristic; 3- the medium requirement characteristic; 4- the specific characteristic of the process

The three characteristics 1, 2 , 3 and 4 that materialize the theoretical drive of the craft characteristic are obtained from following sequence driven by the microprocessor.
Chart 1 is obtained from the maintenance of the hydraulic engines M1 and M2 on the maximum cylindrical capacity and the coupling by the k1 and k2 signals of the drive ratio i1 and i3 of the gearbox.
Chart 2 is obtained from coupling the M1 engine and the activation of the modification of the cylindrical capacity of M1 engine, coupled on the i2 gear step by the k2 signal.
Chart 3 is obtained from the coupling M1 engine and the modification of the cylindrical capacity of M1 engine, coupled on the i2 gear step by the k2 signal.
The functioning of the reverse traction system is obtained from the activation of signal k4.

4.Conclusions

As a result of the study on the operating systems used as traction systems for the auto propulsion machines that roll on bumpy land, comparing the mechanical, hydraulic, and hydrostatic systems. Whole mechanical drive systems offers good solutions both from the point of view of the compactness at high and low values of the necessary moment. Over these values, the achievement of a mechanical drive creates so many size problems and even command ones.
Hydromechanic drive systems that use turbo transmission solve traction problems mentioned above in high power transmissions, for drives

with output moments of (30-300) daNm, but with exploiting regimes constant.

For the transitory work regimes specific to exploiting traction systems of the transport machines, the low efficiency of the turbo transmissions limit their use especially at high output moments.

Hydro mechanical traction systems that use hydrostatic driving component gave especially in the last 30 years optimal driving solutions for the following reasons:

- were implemented hydrostatic components which covers the whole range of output moments (low, medium and high)
- offers compact solutions for driving systems, because of raising the pressure of exploitation to 45-50 MPa.
- offers safety solutions on overload;
- offers command possibilities in transitory regime which allow automation of the energetic transfer process with characteristics very close with the ideal one.
- they are reliable.
- energetic transfer is very good. (85%)

In conclusion, designing of an adaptive traction system is proposed for driving a cereal harverster.

Referances

[1] **Axinti G**. – *Actionari hidraulice pentru utilaje tehnologice* – Note de curs, Facultatea de Inginerie Braila.

[2] **Axinti G.** – *Contribution of the dynamic processes modelling for hydrostatic movement systems of the automativ tehnological equiments* – in " Scientific Bulletin of the Politehnica" University of Timisoara, Ramania – the 6th International Conference on Hydraulic Machinery and Hydrodynamics – Timisoara, octombrie 2004, pg 293-298.

[3] **Axinti G.; Bordea C.; Nastac S.; Axinti A.S.;** - *The modelling of the front loaders bucket loading proces with the granular materials*, in " Scientific Bulletin of the Politehnica" University of Timisoara, Ramania – the 6th International Conference on Hydraulic Machinery and Hydrodynamics – Timisoara, octombrie 2004, pg 299-303.

[4] **Mladin Gh.** – *Masini de tractiune si sisteme de transport*, vol I; II – Editura IMPULS – Bucuresti 1999.

[5] **Mihailescu St.; Bratu P.P; Goran V** – *Masini de constructii*, vol I, II, III – Editura Tehnica – Bucuresti 1984.

[6] **Untaru M.; Cimpean V; Hilohi C.; Varjescu V.** – *Constructia si calculul automobilelor* – Editura tehnica – Bucuresti 1974.

[7] * * * *Antriebs und Steuerungstechnik fur mobile Arbeitsmaschinen* – Mannesmann Rexroth- Catalog de aplicatii 1992.

[8] * * * *Componente hidraulice si electronice*, prezentare program de fabricatie Mannesmann Rexroth – 1998.

[9] * * * *Prospecte si cataloage ale firmei Bosch – Rexroth* – 1998-2004.