DEVELOPMENT AND EXPERIMENTAL RESEARCH OF THE CENTRAL PRESSURE CONTROL SYSTEM FOR AGRICULTURAL TRACTOR TYRES

Simion Popescu[1], Radu Ciupercă[2], Mircea Nastasoiu[1], Florin Loghin[1]

[1]Transilvania University of Brasov, Romania, [2]INMA Bucharest, Romania

KEYWORDS - agricultural weels tractor, tire inflation pressure, central tire inflation system, experimental testing.

ABSTRACT - The first part of the paper presents the construction of the central pressure control system of tyre inflation pressure for the four-wheel drive agricultural tractor (U1010 DT), using components from an all-road military wheel vehicle. From the compressed air reservoir the air is directed to the central pressure control system, where from, by means of the rotating valves mounted in the axes of the axles, the air reaches the tyres. The last section of the paper presents the results of experimental research conducted on the influence of the air volume in the reservoir on the response rate of the real-time control system of tyre inflation pressure. The developed and experimentally tested constructive solution can be applied to tractors already in use with minimal adaptations depending on the concrete construction of the tractor, or can be included as an option in axle manufacturing.

INTRODUCTION

Agricultural soil compaction is highly influenced by the pressure in the contact surface between the wheels of tractors and self-propelled machines and road (soil) (2, 5). The shape and size of contact surface and, implicitly, the value of average pressure of tyres on soil, depend on the constructive and exploiting factors of wheels' tyres. Among the constructive factors, the tyres carcass (radial or crossing), the shape of tyres contours (toroidal or eliptical) and the tyres dimensions (diameter, width) have the greatest influence (5). Among the tyres exploiting factors, the most important one is represented by tyres inflation pressure, as the low pressure tyres present a diminished risk of soil compaction in comparison with high pressure tyres (2). Therefore, a viable solution would be the control of the tyres inflation pressure during the travelling, by equipping of tractors and machines with central control system of the tyres inflation pressure, similar to those used for all-road wheels vehicle (for example, military vehicles).

The central pressure control system for agricultural tractor tyres during the travelling, usually comprise the following equipments (3, 4): equipment for preparing the compressed air, equipment for distributing the compressed air and equipment for measuring and control pressures. At a world level, there are a series of solutions and constructive systems of inflation pressure control system in tractors tyres during the vehicle movement, which can be classified in two main groups:

a) Installations where air is conducted through a single pipe, which separately controls tyres valves. The air rotative distributors placed on wheels axles are not under pressure, as between the tyre and the distributor is interposed a pneumatic valve, which opens only at a certain pressure of the system. That is way, when air is evacuated from tyres (during their deflating) there is a clear difference between tyres pressure and opening pressure of tyre

valve. In order to measure the air pressure in tyres one has to command „slow inflation" for keeping always open the valve of pressure control in wheels tyres.
b) installations where air is directed by two pipes, electrically or pneumatically operated, which ensures the permanent measuring (electrically) of air pressure in each of wheel tyres. Through remote transmitting system of information related to pressure amount it is possible to settle different pressures in wheels tyres belonging to the same axle (for example, for ploughing, when the wheels on right run on the furrow).

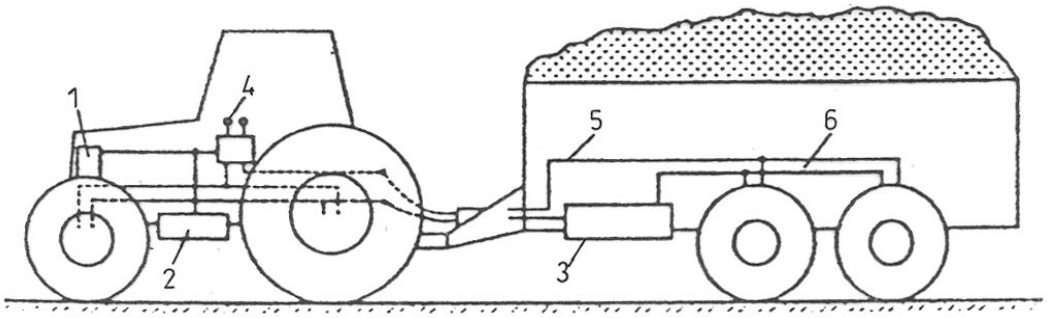

Figure 1. Scheme of central inflation pressure control instalations in tractor-trailer tyres: 1- compressor; 2, 3- reservoirs of compressed air; 4- control unit; 5-control and regulating pipe; 6- pipe for filling (inflating) the tyress.

The centralized inflation pressure control system in agricultural machines tyres can be applied both to tractor and its coupled machines. Figure 1 shows the scheme of a centralized regulated system of both tractor tyres and trailer tyres pressure (3), using two reservoirs of compressed air: one for the tractor 2 and the other 3 for the trailer.

The control and regulating device on tractor's board (fig.2) allows to pre-establish the reference value of tractor travel speeds according to works performed (for example a value of 8 km/h for soil preparing works), as well as loads values (charges) on front and rear axles of tractor (3].

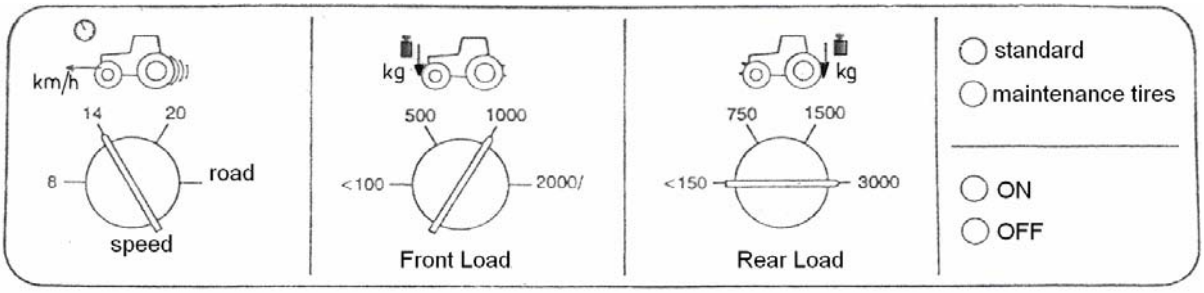

Figure 2. Control and regulating device of a partial automatic of central inflation pressure control system in tractor wheels tyres.

In view of increasing the efficiency of central inflation pressure control system in tractor wheels tyres during the movement there are concerns (researches) focused on designing self-actuated regulating systems (fig. 2), equipped with suitable sensors which concomitantly measure the following dimensions (parameters): wheels sinking depth into the soil, loads on wheels axles (front and, respectively, rear axle), tractor speed and wheels slip. Values of pressure within the system (reaction value) are delivered as electrical signals and compared with reference values (input value), resulting in a deviation signal. By means of a

switch, the deviation signal automatically controls the pneumatic circuit for one of two respective states: pressure raising or pressure diminishing in tyres (3,4).

The advanced systems of controlling and regulating the tyres pressure can be also equipped with electrical sensors for measuring the parameters characterizing the concrete state of soil, for instance the degree of soil loosening and the humidity. Therefore, we can pass to necessary corrections for regulating the tyres air pressure on basis of a pre-established strategy created by the operator (driver), as he can better focus on monitoring the working process or the tractor-machine system.

DEVELOPMENT OF THE CENTRAL INFLATION PRESSURE CONTROL SYSTEM FOR TRACTOR TYRES

Conceiving, designing and constructively-functionally achieving a central inflation pressure control system in tractor wheels tyres during the travelling on the soil (adjusting the pressure during the travelling) was applied to for a four-wheel drive agricultural tractor U1010 DT (made in Romania), using components from an all-road military wheel vehicle. The tractor is equipped with an engine nominal power of 100 HP, and rear wheels equipped with tyres of 16.9-38 type. The tractor's mass is of 4200 kg, out of which 2600 kg on its rear axle and1600 kg on its front axle.

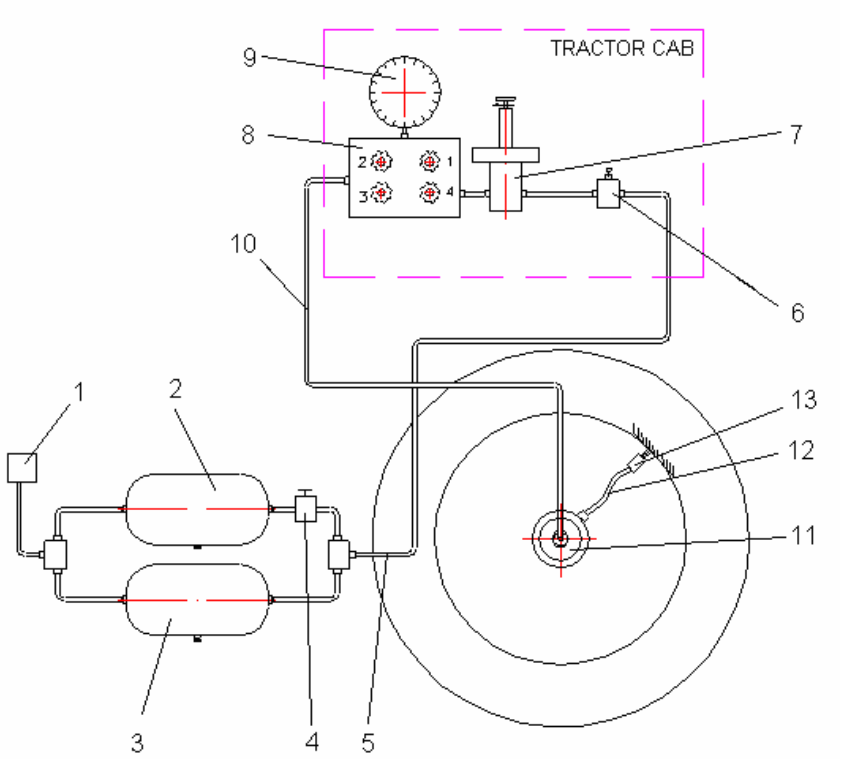

Figure 3. Scheme of central inflation pressure control system in the tyres of the agricultural tractor U 1010 DT:
1- tractor's compressor; 2- tractor's compressed air reservoir; 3- additional compressed air reservoir; 4-stop valve; 5- supplying pipe; 6- direction valve; 7-pressure regulator; 8- group of control valves; 9- pressure gauge; 10- connecting pipes with air distributor; 11- rotative air distributor; 12- connecting pipes with wheels shutter.; 13- wheel shutter.

For manufacturing this installation of central inflation pressure control system there have been used the components of centralized installation belonging to a military vehicle. An additional compressed air reservoir, connected in parallel to the normally tractor tank was mounted on the tractor. The scheme of the installation is shown in figure 3.The air generated

by compressor 1 of tractor feeds the tractor's air reservoir 2 as well as the additional reservoir 3, the two reservoirs being able to act separately or to be connected in parallel through the intermediate of tap 4. The air leaves the reservoirs through the feeding pipe 5 and passes into the group of control, regulating and measuring the pressure (mounted in tractor's chamber) and, from here, through the rotative distributors 11 and pipe 12, it reaches the shutters 13 of tractor wheels tyres.

The equipment of control, regulating and measuring the system pressure comprises a direction valve 6, the pressure regulator 7, endowed with adjusting knob 3 and indicating scale 2 and, a group of control valves 8. The system pressure is measured by gauge 9. In order to increase the tyres pressure (tyres inflation) it is actuated the knob 3 of pressure regulator so that the needle 2 indicates the aimed pressure. The air from tractor tank inflates the tyres according to required pressure, shown by gauge 9, after what the pressure remains steady due to regulating valve. For reducing the tyres pressure (tyres deflating) the needle of regulating valve is placed at required pressure, so that the tyres air is released into atmosphere till the moment when the pressure reaches the established value, also indicated on gauge 9 dial. If the installation circuit remains permanently open, then the pressure in tyres will be kept at the value established by the regulating valve (indicated by gauge 9).

EXPERIMENTAL RESEARCHES AND RESULTS

For experimentally study the behaviour of installation of central inflation pressure control system in the wheels tyres of the agricultural tractor U 1010 DT, a programme of tests has been elaborated, according to which was measured the time necessary for inflating the tyres, framing within two given values, for the following 10 domains (rates) of pressures variation, namely: 0.8...1 bar; 1...1.2 bar; 1.2...1.4 bar; 1.4...1.6 bar; 0.8...1.2 bar; 0.8...1.4 bar; 0.8...1.6 bar; 1...1.4 bar; 1...1.6 bar; 1.2...1.6 bar. The installation was alternatively fed from a single tank (of $V_1 = 40$ dm^3 volume) and, respectively, from both tanks coupled in parallel (with $V_2 = 80$ dm^3), thus achieving 20 testing variants.

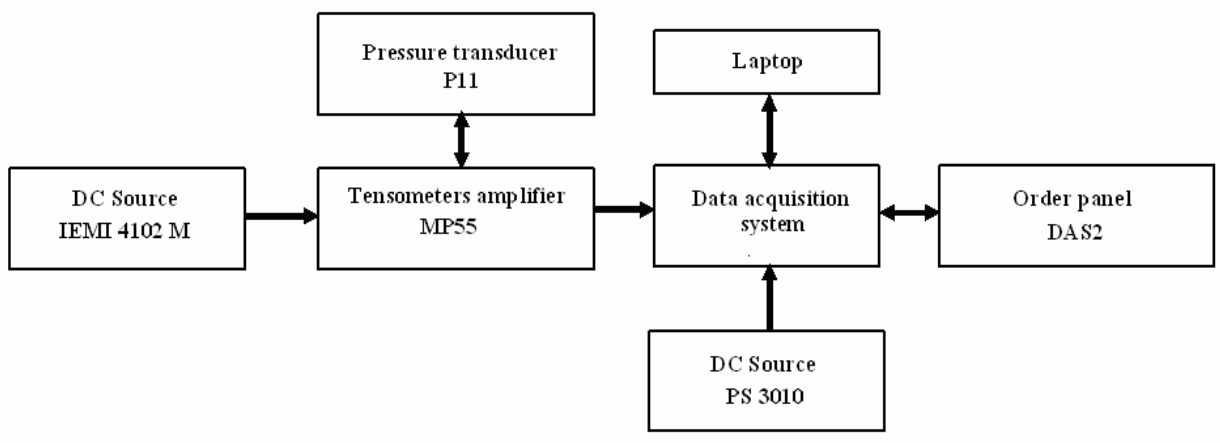

Figure 4. Block scheme of installation of measuring the inflation pressure of tractor tyres.

The experimental researches have been achieved within the laboratories of National Institute of Agricultural Machines (INMA) of Bucharest/Romania. In order to reach the experimental researches has been designed and manufactured an installation of measuring, acquiring and processing the data (fig. 4), comprising the following parts: power source of direct current PS 3010, power source of direct current IEMI 4102 M, inductive pressure

transducers HOTTINGER TIP P1, tensiometer amplifier MP55, Laptop DELL, data acquisition system DAS 3 with switch panel DAS2.

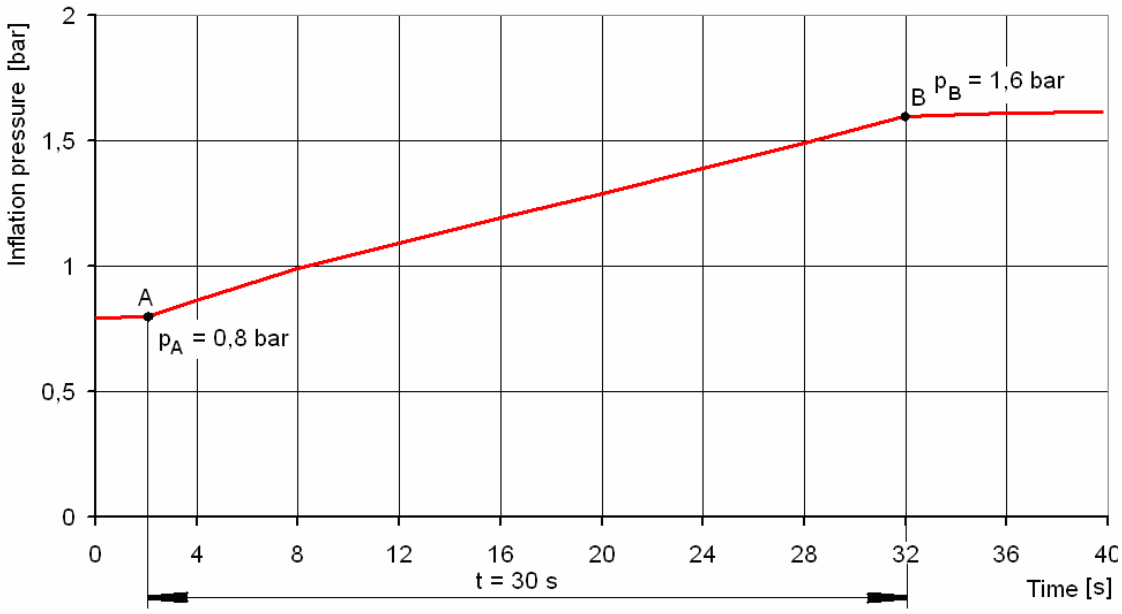

Figure 5.Variation in time of pressure when pressure increases from 1.0 bar to 1.6 bar in case of connecting in parallel both compressed air reservoir

After processing the experimental data there have been drawn up the diagrams of variation in time of air pressure in the system (installations) for the 20 variants of testing. Figure 5 shows, as example, the graphic of time variation of inflation tyres pressure when it is modified from its initial value 0,8 bar to 1,6 bar when both tanks of compressed air are coupled. In that case the period of time in which the tyres were inflated is of about 30 sec.

Tab. 1 Values for experimental measurements determined by calculation when testing the centralized installation of regulating the air pressure in tyres

Pressure adjustment range (bar)	Pressure Difference Δp		One reservoir $V_1 = 40$ dm^3		Two reservoirs $V_2 = 80$ dm^{3}l		Relative growth speed
	bar	kPa	t_1 s	v_1 kPa/s	t_2 s	v_2 kPa/s	%
0.8...1.0	0.2	20	6. 69	2.98	6.31	3.17	1.06
0.8...1.2	0.4	40	14.90	2.68	13.10	3.05	1.14
0.8...1.4	0.6	60	24.05	2.49	21.13	2.84	1.14
0.8...1.6	0.8	80	35.15	2.27	29.80	2.68	1.18
1.0...1.2	0.,2	20	8.20	2.44	7.04	2.84	1.16
1.0...1.4	0.4	40	17.54	2.28	15. 07	2.65	1.16
1.0...1.6	0.6	60	28.63	2.10	23.84	2.52	1.20
1.2...1.4	0.2	20	9.43	2.12	8.07	2.48	1.17
1.2...1.6	0.4	40	28.34	1.41	16.50	2.42	1.72
1.4...1.6	0.2	20	11.15	1.79	8.84	2.26	1.26

In order to establish the influence of variation interval of pressure on system time of response, the measured data have been centralized in table 1, where have been also shown the values of average variation speeds of pressure between the two limits of pressure of pre-established range (lower and upper limit), calculated by means of relation***:*** $v = \Delta p/t$, in kPa/s (where Δp is the variation interval of pressure, in kPa and t - the time (in s) consumed for adjusting the pressure between the 2 values of settle range.

CONCLUSIONS

The installation of central inflation pressure control system in the tyres of the agricultural tractor during the travel was manufactured for agricultural tractor (4x4) U 1010 model. The tractor equipped with this installation has been used at experimental researches regarding the influence of tractor wheels tyres pressure and intensity of tractor's wheels traffic (number of passages over the same track of wheel) upon the soil compacting degree, characterized by values of penetrating resistance and soil apparent density for different depths.

Analyzing the experimental researches regarding the behaviour of the installation of central inflation pressure control system in the tyres of the agricultural tractor, the following findings have been resulted:

- the period of time of the modification of pressure when tyres are inflated from 0.8 bar to 1.6 bar has lasted approx. 30 sec when a single compressed air reservoir is connected; from 1.0 bar to1.4 bar the period of time has been of about 9 sec by using a single compressed air reservoir; from1.0 bar to 1.2 bar pressure the period of time has been of about 7 sec when coupling both tanks;
- the average speeds of pressure variation ranging within lower and upper regulating values depend on value of interval and number of tanks used in the installation. For the pressure range of 0.8...1.2 bar have been obtained speeds of variation of pressure of 2.68 kPa/s by using a single air reservoir in comparison with the speed 3.05 kPa/s when using two reservoirs coupled in parallel. For the interval of pressures of 0.8...1.6 bar have been obtained pressure variation speeds of 2.27 kPa/s when coupling a single reservoir, in comparison with 2.68 kPa/s speed, in case of using two reservoirs, coupled in parallel.
- the installation of central inflation pressure control system in the tyres tested within the experimental researches has fulfilled the constructive and functional requirements.

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