THE EXPLOITATIONAL CHARACTERISTICS OF THE AGRICULTURAL TRACTOR WITH 4WD EQUIPPED WITH LOADER AND DIGGER

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Abstract: *Tractor Rakovica with 4WD aggregated together with hoisting loader and digging machine represents a cobined Machine which has manifold application in civil engineering, agriculture, forestry, electrical and building industry etc. Tractor 4WD is aggregated in Industrija motora-Rakovica, together with loader and digging machine, aiming to designate characteristics of optimization of construction many investigations have been performed.Taking into consideration that such machine belongs to a group specifield by SAE J 1057 standard, dimensional measurement of loader has been performed according to SAE J 732 standard and dimensional measurement of the digging machine has been made according to SAE J 49. Besides these dimensional aggregate measurements according to specified standards, many othere investigations have also been performed and they included : pressure measuring in hydraulical installation under different operating conditions, gravity centre designating and arrangement of masses, time designation of several working operations and exploitational operating effects, intensity of breaking-off, internal and external noise, basic braking characteristics, stability characteristics and other general observations. For the investigation quantitativity, and regarding author's opinion in this work, only the most interesting results are specified.*

KEY WORDS: *TRACTOR, HOISTING, TRANSPORT, LOADER, DIGGER, EXPLOITATIONAL CHARACTERISTICS*

1. Introduction

Tractor aggregated with digger and loader represents a combined machine having manifold application in civil engineering, agriculture, forestry, as well as in road , railway and canal construction, electric power industry, management of water resources, etc. It is used for digging trenches, foundations, as well as for loading bulk building material, soil, chemical fertilizer and manure, small stones etc. [10].

From the aspect of dimensional control, all machines of this type fall into the group of machines defined by SAE J 1057 standard, while loader (TN-360) falls under SAE J 732, and digger (RK-2a) is included in SAE J 49.

2. D*imensions of aggregates by sae standards*

As above-mentioned, dimensional control of the loader (Fig. 1) is defined by SAE J 732 standard and the basic dimensions are:

A=3690 mm	I=1105mm	P=2050mm
B=3030mm	H=1310mm	R=2415mm
C=2480mm	J=52^0	b_e=1590mm
D=6291mm	L=45^0	k_{id}=230mm
E=86^0	K=305mm	l_p=1450mm
F=340mm	M=$60,5^0$	l_z=1500mm
G=555mm	N=80mm	G_t=4840 kg

A part from dimensional control, this work deals with other lifting, transporting and exploitation, features of the aggregate such as, for instance breaking-off and digging forces , pressure and temperature in hydraulic installation, periods required for fulfillment of individual operations, exploitation performance, volumes of buckets position of gravity centre in characteristic positions of working organs, estimation of stability, forces on foot brake, deceleration in braking and deviation from the given path, verification of functional characteristics and, at last, a general assessment of the quality of the aggregate. [1]

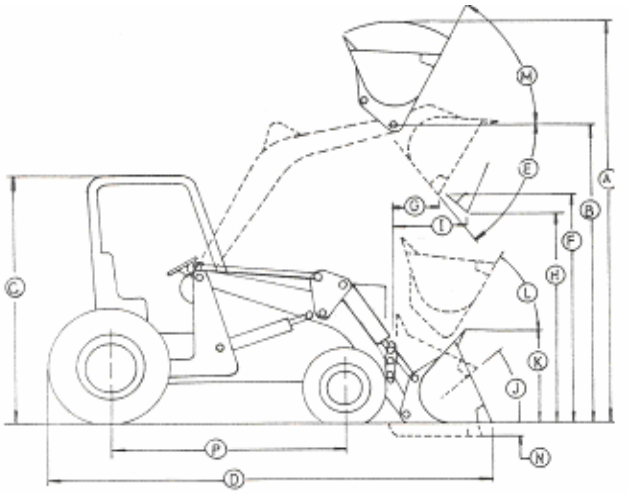

Fig. 1.Dimenzional control of the loader

Dimensions and designations of the digger (Fig. 2) are defined by SAE J 49 standard and amount to:

$\forall_0$=13,7^0 J=4350mm Q=170^0
F=3640mm K=3070mm U=12^0
G=3600mm L=1710mm K_I=1207,5mm
H=3240mm P=170^0

2.1. Volumes of loader and digger buckets

According to SAE J 742 standard, volume of loader bucket is declared as V_k=0,34 m^3, and by planimetring the bucket (TN-360) , it comes up to cca. V_s=0,27 m^3.

Depth bucket of the digger corresponds to type ''A'' by SAE J 236 standard. Its declared volume is V_K=0,172 m^3 By planimetring the bucket RK-2a, it comes up to cca. V_s=0,147m^3

2.2. Determination of gravity center and of masses

In determining the gravity center, a well-known methodology was used (Fig. 3.) and the following results were obtained:

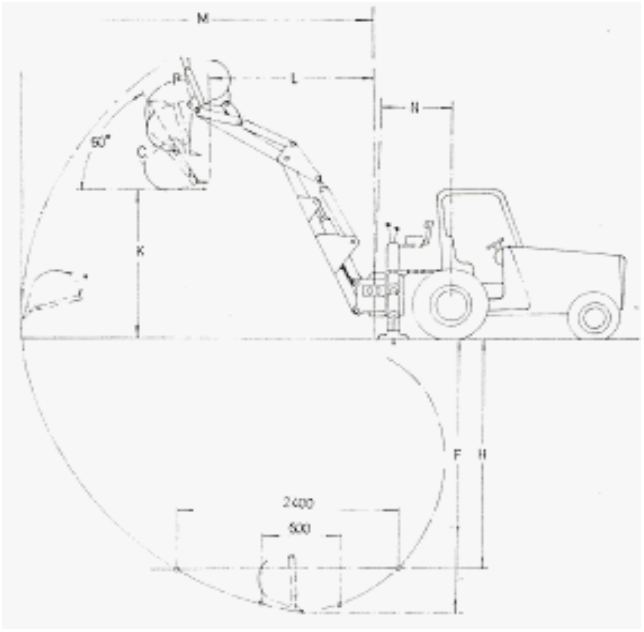

Fig.2 Dimensional and designations of the digger

- empty bucket of the loader in transport position b=568mm,z=360mm
- empty bucket of the loader in the position of maximal gantry b=597mm, z=389mm
- full bucket of the loader (820kg of gravel) in transport position b=996mm.

The total mass of the aggregate is 4840 kg.

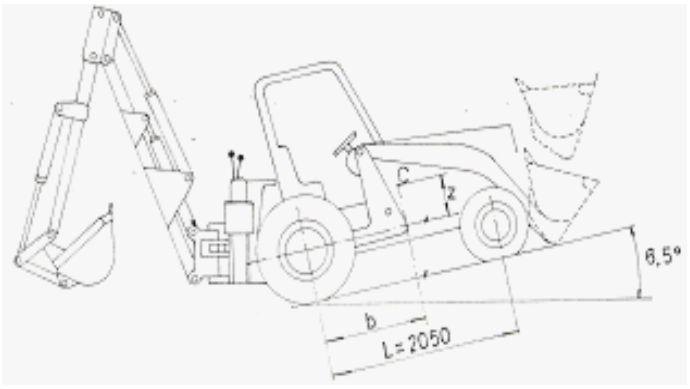

Fig. 3.Aggregate gravity centre determination

3. Hydraulic installation

Measurement of pressure in hydraulic installation was made for the following working operations:

- change of pressure in bucket grip cylinder, during the lifting of empty bucket (Fig. 4).
- change of pressure in bucket grip cylinder, during the lifting of full bucket (Fig. 5)
- during the stoppage of empty and full bucket of the digger opening pressure of relief valve of the loader and of the digger (Fig. 6).

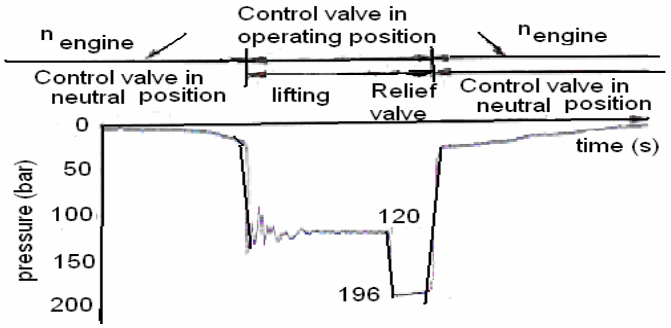

Fig. 4 Pressure change in bucket grip cylinder during empty bucket lifting

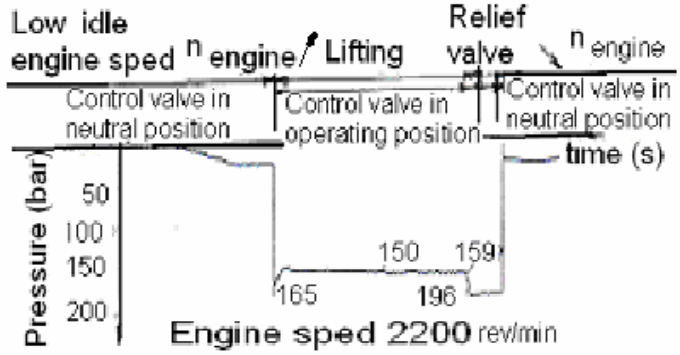

Fig. 5.Pressure change in bucket grip cylinder during full bucket

Measurements showed that the pressure in the cylinder of the grip of empty bucket, during the lifting, amounted to 120 bar, and during the lifting of a mass of 630 kg , pressure ranged

from150 bar (beginning of lifting) to 160 bar (end of lifting)

In the course of work with the digger, oil temperature stabilizes at 76^0C, and during the work with the loader at 59^0C, wherein environmental temperature was 14^0C. Fig. 7 show pressure change in bucket cylinder during the closing.

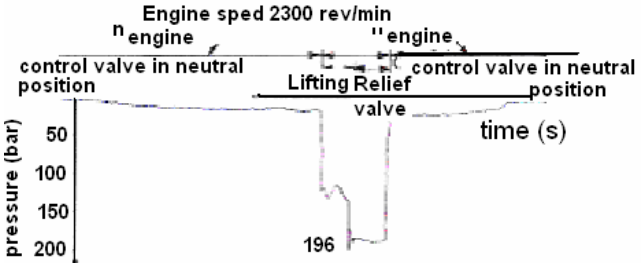

Fig. 6. Opening pressure of relief valve

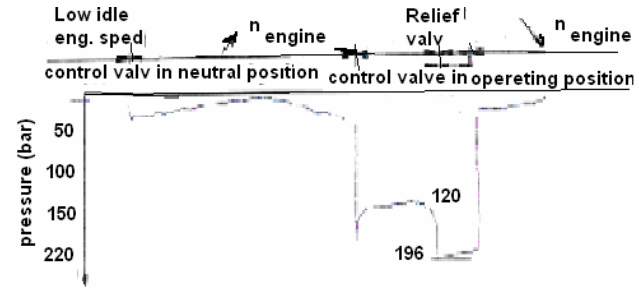

Fig.7 Pressure change in bucket cylinder during the closing

4. Periods of individual working operations

4.1. Digger

- full cylinder stroke of the arrow (stretched forth) – 2,7s
- full cylinder stroke of the arrow (shrunk) – 3,0s
- full stroke of bucket grip cylinder (stretched forth)- 4,7 s
- full stroke of bucket grip cylinder (shrunk)-3,2 s
- full bucket cylinder stroke (stretched out)-4,5 s
- full bucket cylinder stroke (shrunk)- 3,7 s
- period of unloading of the bucket (up to the angle of 45^0 to the horizontal) -3,2 s
- period of steering of the whole digger-3,2s

4.2.Loader

- lifting period of empty bucket - 5,0 s
- lowering period of empty bucket - 13,0 s
- dumping period of empty bucket (full angle)3,9s closing period of empty bucket (full angle) – 3,5 s
- lifting period of full bucket (639 kg)-11,0 s
- lowering period of full bucket – 3,0 s.
- dumping period of full bucket (full angle)-3,2 s
- dumping period of full bucket in relation to a horizontal surface – 2,5 s.

5. Determination of breaking-off force

The force of excavation of the digger is determined according to SAE J 49 standard and on recommendations of SAE J 1179 and it amounts to $F_{kop.}$=3870 daN, under oil pressure of 195 bar in the feeder. [2].

Loader breaking-off force (by bucket cylinder) was measured at 100mm from tooth top(20mm from the ground), whereby the requirements of SAE J 732 standard were satisfied. Loader breaking-off force amounted to $F_{kid.}$=1860daN, under oil pressure of 195 bar in the feeder.

6. Exploitational characteristics

6.1. Estimate of stability

For declared 0,36 m^3 volume of loader bucket, rated load (gravel (=1800 kg/m^3) amounts to 636kg. Measurements showed that gravity centre of that load, at maximal gantry, was at approximately 1300mm from the axis of tractor front axle.

Criterion of stability in civil engineering is that a 50% increase of load mass in static conditions does not cause rolling over.

For the existing aggregate, the position of the center of gravity was determined for the load of 820 kg. In that case, the coefficient of stability amounts to 6,6 > 2, confirming a satisfactory stability.

The coefficient of stability of work with the digger can be more precisely determined after the manufactaurer defines the maximal digging force and its arm from the bearing surface , both longitudinal and lateral stability, with testing in exploitation.

In determining exploitational operating performances, bearing surfaces are lowered to the ground, and steering angle of the arrow during dumping amounts to $40\text{-}50^0$, which corresponds to the length of 3-4 m from the digging spot. In such conditions of work, during measurements of periods of full and emtpy travels as well as of periods of digging and dumping , working performance for that operation amounts to cca. 20 m^3/h.

During the work with the loader, two empty and two full travels have to be performed on the route of 6-7 m, at the same steering angle as during digging, i.e. at angle of $45\text{-}50^0$.

By measuring empty and full travels as well as periods of loading and unloading, working performance amounts to about 28 m^3/h. [3].

6.2. Internal and external noise

In the course of exploitation, at maximal hand throttle, the noise in cabin amounts to cca. 96 dB(A). Under the same conditions, external noise at the distance of 7 m from the tractor amounts to 80 dB(A), and at the distance of 3 m it is 87 dB(A). [6] [8] [9]

6.3. Braking characteristics

During the measurement of braking characteristics, working devices of the loader and of the digger were in transport position. Total mass with the driver amounted to 4840 kg, and the mass of material grappled by the loading bucket amounted to cca. 792 kg. The tractor was fitted with pneumatics: front 7.50-20, rear 14.9-28.

Testings were made on dry, hard and flatsurface (asphalt). The tractor was running at a constant speed on a

section 20m long, and after the clutch was disengaged, it was braked by constant force up to the complete stoppage.

The measurement was made with loaded and unloaded bucket. The sender was put at the place of control for starting the front drive and force sender was positioned on foot brake pedal.

Unburdened loading bucket

- speed of the aggregate - 6,25m/s
- max. deceleration achieved - 3,05m/s^2
- max. force of activation of control brake 42daN
- stopping path with the force of activation of control
- brake not exceeding 60 daN - 8,2 m. (Fig.8)
- In the course of work with the digger, oil temperature stabilizes at 76^{0}C, and during the work with the loader at 59^{0}C, wherein environmental temperature was 14^{0}C.

Burdened loading bucket

- speed of the aggregate - 6,25m/s
- max. deceleration achieved - 2,57m/s^2
- max force of activation of control brake 47daN
- stopping path with the force of activation of
- control brake not exceeding 60 daN - 8,7 m

Deviation from direction in the course of braking with loaded bucket amounts to 0,27 m to the left. (Fig.9)

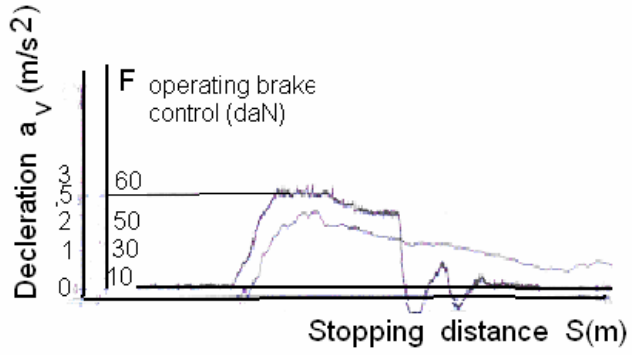

Fig. 8 Stopping distance (unloaded loading bucket)

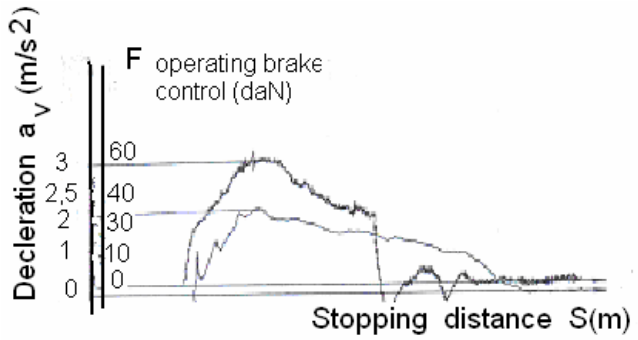

Fig. 9.Stopping distance(loaded loading bucket 792kg)

According to regulations, when the force of activation of control brake does not exceed 60 daN, deceleration has to be at least 2,5 m/s^2, and with respect to obtained values, braking characteristics of the aggregate satisfy in full. [2].

7. General observations

In order to further optimize the aggregate, it is necessary to remedy the noticed deficiencies as follows

- improve accessibility of hand throttle control to the operator during the wrok with the digger adapt minimal tractor speeds to the conditions of operation with the loader
- improve safety (protection of operator's feet at the maximal steering angle).
- improve protection of hoses from friction and possible cracks (armoured protection)
- improve the control of loading bucket when bucket grip is maximally lowere enable entrance to the cabin through the right-side door
- reduce the level of noise in the ca

8. Conclusion

On the basis of conducted researches and of general observation of the quality of the aggregate it can be concluded as follows:

As to the requirements of the working device of the digger, it can be said that it matches completely, provided that adaptation of the guard for operator's feet is made.

The working device of the loader can be used only with the bucket of declared volume. Work with larger buckets is limitted because of hydraulic system lifting power.

Working devices are foreseen for for assembling to several types of tractors. Therefore, a special adaptation has to be made for each type.

In our country, there is a great need for such agregates and to that end a better co-operation should be established between makers of working devices and manufacturers of tractors.

9. References

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