

ROLLOVER TRACTOR CASE ANALYSIS AND RECOMMENDATIONS FOR SAFE MANAGEMENT

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Abstract: This paper presents the analysis of borderline cases overturning tractor in terms of movement on the ground with a large rise in the plane of longitudinal section of the tractor, in the case of a large slope in the transverse plane of movement as well as the inadequate speed. Statistical data on accidents in the operation of a tractor show that a large number of deaths and disability caused by poor assess the adequacy of the ground for the movement of tractors by farmers – tractor drivers. The recommendation's given in the paper are intended to contribute to reducing accidents in the operation of the tractor caused by erroneous estimates of the terrain which is moving tractor.

Keywords: tractor, rollover accident, safe management

1. Introduction

Safety on the family farm is one of the most important aspects of working in agriculture in general. It is also the duty of every farmer to ensure that all necessary measures to prevent possible accidents. Even the slightest distraction while we do the work that can lead to unforeseeable consequences, if the machinery and equipment used on an irregular, uncertain way.

Agriculture is according to the accidents that occur related to this branch of activity is one of the most dangerous sectors of the economy, and farmers have a very high risk of injury at work. The combination of heavy working conditions, long hours and work with agricultural machinery can cause serious consequences, whether it is improper use or inadequate maintenance of machinery and equipment. The best way to be on the safe side is to be aware of potential dangers, that they anticipate and avoid.

Tractor must be used with a large dose of responsibility of the driver (tractor).

When using a tractor should follow a few basic rules:

- maintenance
- check correctness before each use
- to avoid dangerous situations (driving on a slope, with channels ...)
- the use of tractors for tasks that are foreseen
- Security of filling the fuel tank
- Safe driving

Since many accidents that occur, only a small number of failures was caused by direction some devices tractor engine.

The picture gives a statistical breakdown of the number and causes of accidents while driving a tractor. It's clearly that the tractor rollover case is a tragedy which covers 27.66% of fatal accidents.

Causes of accidents with tractors -period 2005 - 2010

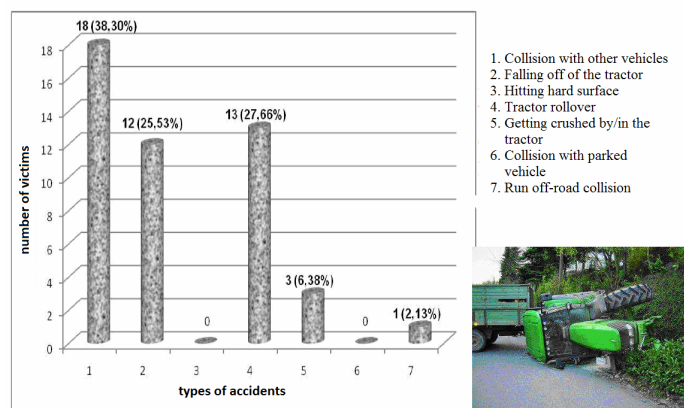


Fig. 1. Statistical breakdowns of accident's in R.Macedonia

Most are caused directly or indirectly without of precaution and unnecessary haste.

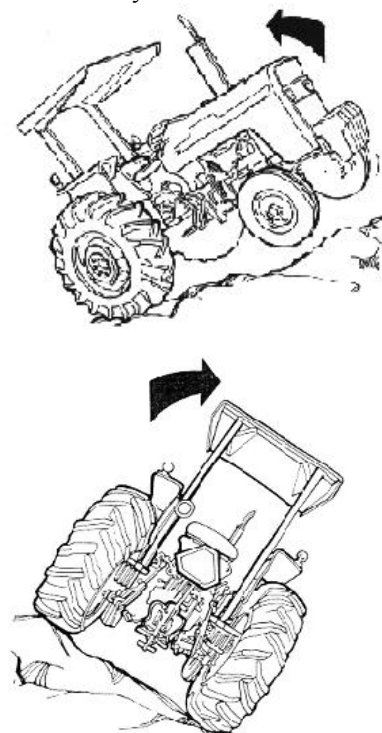


Fig.2. Rollover tractor cases

2. MATERIAL AND METHOD

The paper is presented a case of movement of tractor trailers along the route with an inclination of 20% (Fig.4) with known structural parameters given in the figure.

It is necessary to determine the maximum force on the hook which is attached trailer i.e. that maximum weight trailer can pull in those conditions without the occurrence of slip backwards. Also, it is necessary to determine the value of normal load on front wheels for safe movement of the tractor without a roll back (Fig. 3).

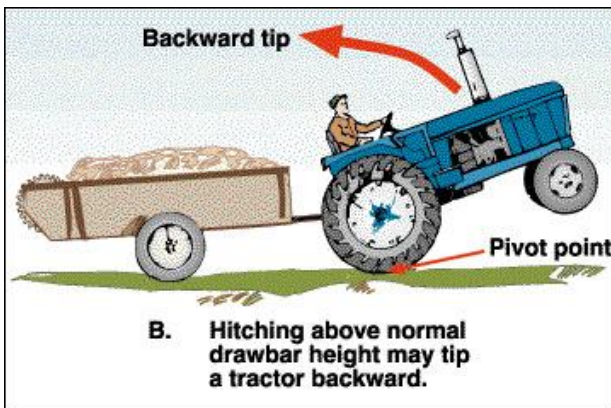


Fig.3 Backward tip of the tractor

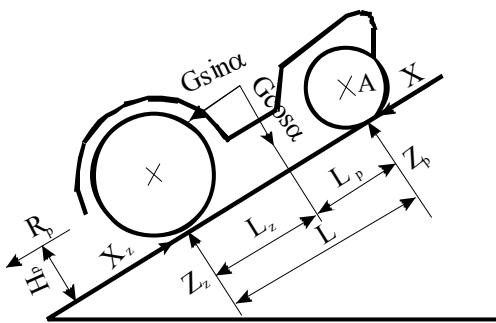


Fig.4.Schematic view of a tractor that moves along the slope of 20%

Using the basic equations of equilibrium and conditions for the value of power force - reaction of rear - wheel drive is the limit of adhesion is obtained as

$$X_z = Z_z \cdot \varphi$$

$$X_z = R_{opt} + G \cdot \sin \alpha$$

$$\Sigma M_A = 0$$

$$Z_z \cdot L - G \cdot h_c \cdot \sin \alpha - G \cdot L_p \cdot \cos \alpha - R_{opt} \cdot h_{opt} = 0$$

$$Z_z = \frac{R_{opt} + G \cdot \sin \alpha}{\varphi}$$

$$R_{opt} = \frac{G \cdot [\cos \alpha \cdot L_p \cdot \varphi - \sin \alpha \cdot (L - h_c \cdot \varphi)]}{L \cdot h_{opt} \cdot \varphi}$$

To determine the exact height of center h of gravity (a major factor in balance), it is necessary to analyze Fig. 5.

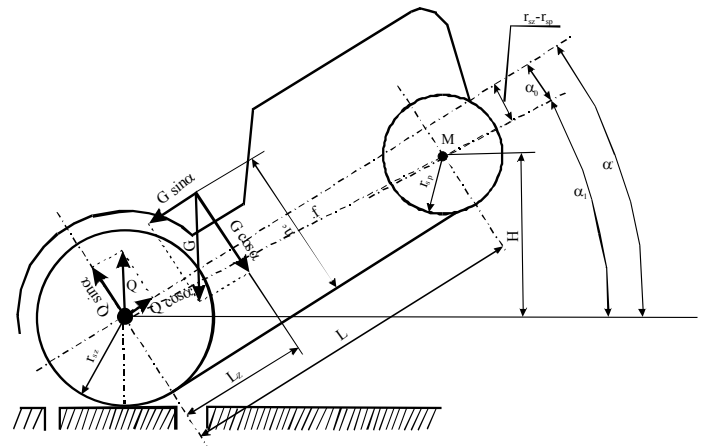


Fig. 5. Geometrical characteristic of moving tractor

Using the condition

$$\Sigma M_M = 0$$

Then, we have the equation's

$$G \cdot \cos \alpha' (L - L_z) + G \cdot \sin \alpha' (h_c - r_{sp}) - Q \cdot \cos \alpha' \cdot L - Q \cdot \sin \alpha' \cdot (r_{sz} - r_{sp}) = 0$$

$$h_c = \frac{Q \cdot [L \cdot \cos \alpha' + (r_{sz} - r_{sp}) \cdot \sin \alpha'] - G \cdot [(L - L_z) \cdot \cos \alpha' - r_{sp} \cdot \sin \alpha']}{G \cdot \sin \alpha'}$$

$$h_c = \frac{Q}{G} \cdot [L \cdot \cot g \alpha + (r_{sz} - r_{sp})] - [(L - L_z) \cdot \cot g \alpha' - r_{sp}]$$

Where

$$\alpha' = \alpha_0 + \alpha_1$$

$$\sin \alpha_1 = \frac{H}{c}$$

$$\cos \alpha_0 = \frac{L}{c}$$

$$\sin \alpha_1 = \frac{H}{L} \cdot \cos \alpha_0$$

$$\text{tg} \alpha_0 = \frac{r_{sz} - r_{sp}}{L}$$

To ensure movement without turning, the front wheels must not be burdened with at least 20% of the total weight $Z_p \geq Z_{pmin}$

$$Z_p = G \cdot \cos \alpha - Z_z$$

$$Z_z = \frac{R_{opt} + G \cdot \sin \alpha}{\varphi}$$

$$Z_p = G \cdot \cos \alpha - \frac{R_{opt} + G \cdot \sin \alpha}{\varphi}$$

3. RESULTS AND DISCUSSION

If you analyze a specific instance in which the following data are known (see Fig. 4):

- wheelbase wheel $l=2,4$ m
- Wheelbase of the front wheels $l_p = 1,6$ m
- Amount of torque $h_{pot} = 0,5$ m
- Radius of the front wheels $r_{sp} = 0,4$ m
- Radius of rear wheel $r_{sz} = 0,6$ m
- Total weight of tractor $G = 2000$ N
- Weight of the rear wheels $Q = 1460$ N

We can observe that for determining the limit of traction and stability of the tractor from overturning the movement of ups 20% play a determining influence on the real center of gravity of the tractor (h_c) which is directly dependent on the amount of mutual distance of the axis of the rear wheels and the axis of the front wheel or the height H (see Figure 5), and also need to be calculated and whether there is enough normal load of the front wheels if it is known that burden should not be less than 20% of the total weight of tractors.

For that purpose was made TRAKTOR software program which is written in the programming language Visual Delphi. The structure of the program is defined by making a form in which imported the necessary input data's and using the equations of equilibrium of the system calculated the total pulling force, the real center of gravity and the normal reaction of the front wheels of the tractor that would prevent the same backward. For known input output data's given in Figure 6.

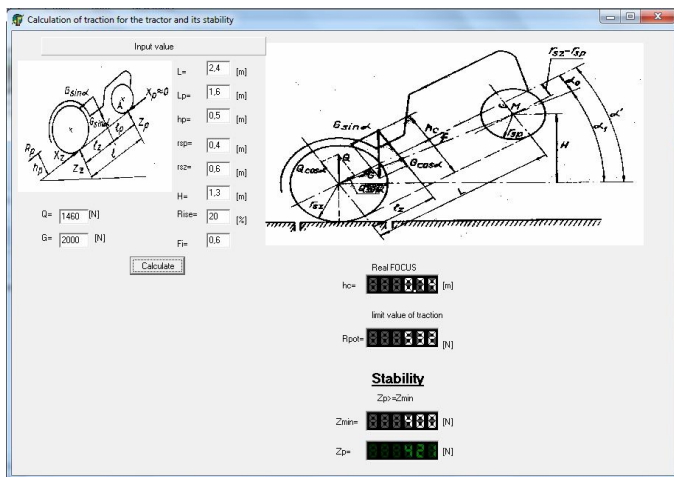


Fig.6.Input and output data display of TRAKTOR software

The calculation shows that the limit of the tractor drawbar force is 532N and the real center of gravity is at a height of 0.74 meters. It also shows that the normal force that occurs at the front wheels with intensity of 421N and is greater than 20% of the total weight of the tractor that is observed is the requirement of stability.

But if you reduce the amount of wheelbase distance to the rear wheels and front wheels for a value of 0,85 m events will increase the torque of 545N and displacement of the real center of gravity of 0,74m to 0,87m. In this calculation the size of the normal force of the front wheels will drop below the minimum

limit that force must not be under 400N of the particular case and will cause the tractor overturned. Outputs are shown in Figure 7.

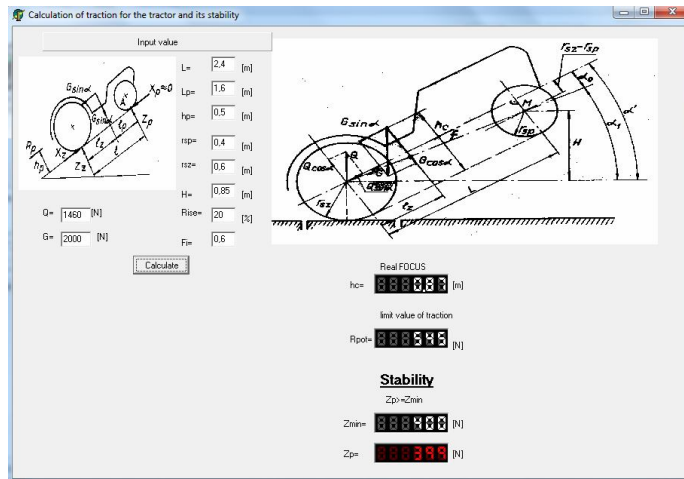


Fig.7.Input and output data display of TRAKTOR software in case of rollover the tractor

From Displayed we can conclude that the main parameter during construction of the tractor which can vary is the amount of wheelbase distance front and rear wheels, but also when this parameter would be constant in this case the main size for stability would be the size of the real center of gravity the tractor, which directly depends on the total weight of the tractor and wheelbase distance front and rear wheels.

Rear rollovers are particularly dangerous because they happen so quickly, giving operators little time to react. Research shows that it takes only 0.75 seconds to reach the critical point of no return where the center of gravity moves over the rear axle and outside the base of stability. From the time the tractor begins to roll over, the incident can take as little as 1.5 seconds (Figure 8).

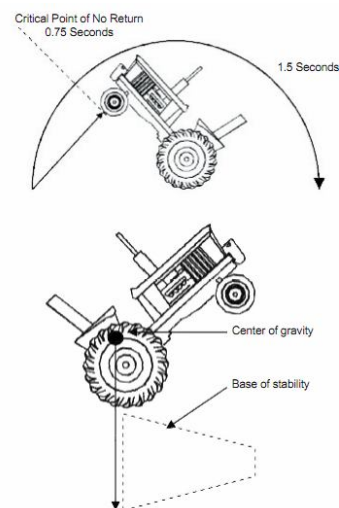


Fig.8. Critical positions of the tractor's rollover

What causes tractors to rollover?

- Sometimes a tractor tips over on its side. Other times, it tips over backward.
- These overturns occur very quickly – often in a second or two. Unfortunately, that doesn't leave enough time for the operator to escape.

- Some of the major causes of tractor overturns are:
 - driving too fast for conditions
 - running into obstructions, such as rocks, stumps
 - turning corners too sharply, especially with a narrow front end tractor
 - driving or turning too quickly on steep slopes
 - hitching above the normal drawbar height
 - operating with a heavy or shifting load in a front-end loader raised too high

Some useful tips:

-Avoid (where possible) work with a tractor on a slope, beside the canal, and depression (reduced speed. If you use the side-ports set them on top of the slope in order to increase stability.

-reduce speed when turning on (by increasing the speed in the curve – manifold is undermining the stability of the tractor effect of centrifugal force).

- do not allow others to drive a tractor – a tractor is designed for only one person (children often want to drive a tractor - do not agree)

-connection of the heavy connections to the tractor there is a possibility of raising the front end, setting the proper weights on the front end of tractors can be avoided.

-braking on a slope with the use of tractor engine

-proper and safe connection of connecting machines to the tractor, especially in the presence of a third party.

-mandatory use of lights on the roads.

-control the protection of the machinery moving parts.

4. CONCLUSION

The proper procedure for connecting the machine:

- Ensure that the space behind and around the tractor safe and clean, and without anyone behind the tractor,
- driving a tractor slowly back to port,
- stop and lock the tractor,
- Set the lever to neutral (parking) position,
- Connect the machine to the tractor.

In the phase of traction:

1. Attach the burden pulling only the drawbar. Secure the drawbar and pin.
2. Before you go downhill, move into a smaller speed that will be sufficient to control speed of the tractor without using the brakes to tractor stop or connection.
3. Try to balance the load primarily on wheels connection. Avoid overload the drawbar. Add front weights to improve stability. Slowly press the clutch, and avoid flicker. Use brakes cautiously to prevent the went into a tractor trailer.
4. Use the lever only the connections that are made for this use, and not as a drawbar.

5. Watch where you go, especially at the end of the order, the roads, around trees and low hanging obstacles.
6. To avoid overturning, carefully driving a tractor and Adjust your speed to security, especially when Drive over rough country, crossing over channel or slope and when you turn.
7. Fix the brake pedal tractors together when driving on roads that would provide a good wheels and brakes to avoid diversion tractor to one side.
8. Keep the tractor in the same speed when going downhill and uphill. Do not move by inertia or let the wheels to roll freely downhill.
9. Any machine and / or by pulling a trailer with total weight exceeds the weight of the tractor that they traction, it must be equipped with its own brakes for safe management of the stopping.
10. When the tractor is stuck or lodged in the tires country, go back to prevent overturning.
11. Always Inspect height especially when transporting tractor.
12. Do not activate the lever to switch High-speed, low speed or off-drives to all four wheels while the tractor is moving.

Key point's:

- It takes just a split second for a tractor to overturn.
- A rollover protective structure (ROPS) with a seat belt greatly reduces the risk of injury from an overturn.
- Always be on the alert for rocks, stumps and other hazards.

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