Running Characteristics of a Tracked Vehicle on Sandy Soil

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1. Research Aim: The aim of the research is to study running characteristics of a tracked vehicle on sandy soil by experiment and simulation program.

2. Research results:

2.1. Simulation analysis: Simulation was established to analyze running properties of tracked vehicles based on the consideration of the forces developed to the vehicle in running condition and on their equilibrium equations.

For turning motion, for example, the equilibrium equations [1] were established from which the tractive effort T_4 can be calculated :

$$T_4 = \frac{1}{R}\left\{\left(\frac{T_{3i}}{\cos\theta_{ti}} - W_i \tan\theta_{ti} - T_{2i}\right)\left(R - \frac{C}{2}\right) + \left(\frac{T_{3o}}{\cos\theta_{to}} - W_o \tan\theta_{to} - T_{2o}\right)\left(R + \frac{C}{2}\right) - M_i - M_o\right\}$$

where θ_{ti}, θ_{to} are the trim angle of the inner and outer track.

W_i; W_o are the weight component of the vehicle for the inner and outer track.

T_{3i}, T_{3o} are the thrusts for the inner and outer track

M_i, M_o are the turning moment of the inner and outer track

T_{2i}, T_{2o} are compaction resistance of the inner and outer track.

R is the turning radius

C is the distance between center lines of the two tracks

The turning moment for turning motion was considered as the moment to overcome lateral shear resistance.

2.2. Experimental method and result: Experiment was carried out in a soil bin using two identical model bulldozers of 1/10 model scale of the actual 40 tf bulldozer. The two vehicles are connected with a draw bar and the first vehicle towed the second one. The first one was an experiment object while the second one was a mean to set different running condition for the first one. For the turning motion, the first vehicle as a study object was runned with steering ratio of 1.25 and with five speed steps (the rotary speed of the rear sprocket of outer track are 3.5, 4.0, 4.5, 5.0, 5.5 r.p.m) while for straight motion the rotary speed of the rear sprocket of front vehicle was set at 5.7 r.p.m. To set different running condition, the rotary speed of the rear sprocket of rear vehicle at the straight running motion was set at 9 different values. Measured values are effective tractive effort, sinkages, turning radius, and slip ratios for the turning motion while at the straight running motion the driving torque and contact pressure distribution were also measured.

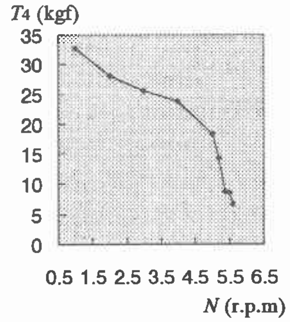

Fig.1 Effective tractive effort T_4 and rotary speed of rear sprocket N relation -straight running motion

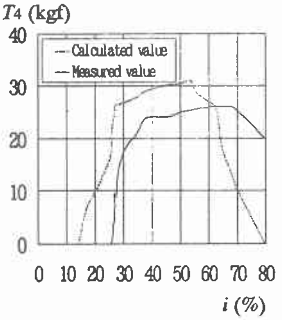

Fig.2 Measured and calculated tractive effort T_4-slip ratio i straight running motion

Fig.1 and 2 show some of the experimental and simulation result for straight running motion.

The simulation program [2] can predict for certain punctuality the tractive effort and slip ratio relationship and can be used to predict optimum slip ratio with careful determination of terrain-track system constants and other input data.

The result for turning motion at steering ratio 1.25 is shown in Fig. 3, 4, 5 and 6.

Fig.3 shows the relation between effective tractive effort and rotary speed of the outer track sprocket. The figure shows that effective tractive effort increases with the increase of the rotary speed of the sprocket of the outer track.

Fig. 4 shows the relation between slip ratio and rotary speed of the sprocket of the outer track. The slip ratio of the outer track is always bigger than that of the inner one and both slip ratios increase with the increase of the rotary speed of the rear sprocket of the outer track.

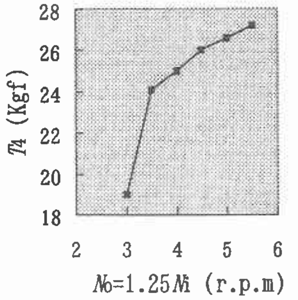

Fig.3 Effective tractive effort T_4 and rotary speed of rear sprocket of the outer track No

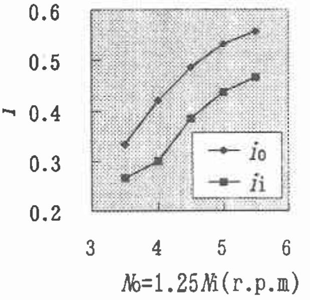

Fig.4 Slip ration i and rotary speed of rear sprocket of the outer track No

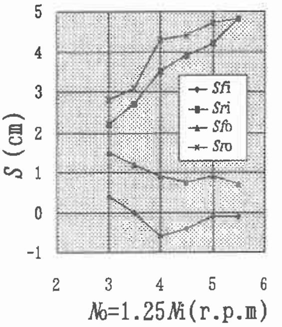

Fig. 5 Sinkage S and rotary speed of rear sprocket of the outer track No

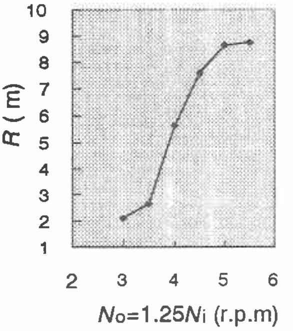

Fig.6 Turning radius R and rotary speed of rear sprocket of the outer track No

Fig.5 shows the relation between the sinkage and rotary speed of the rear sprocket of the outer track. The sinkages of the rear sprocket S_{ri} for inner track and S_{ro} for outer track increase with the increase of rotary speed of rear sprocket of the outer track.

Fig.6 shows the relation between the turning radius of the vehicle and rotary speed of the rear sprocket of the outer track. Turning radius increases rapidly with the increase of rotary speed of rear sprocket.

Conclusion:

1. The experimental and simulation results for straight running motion were matched with enough punctuality. The established simulation can be used to analyze running properties of tracked vehicle especially to predict tractive effort and slip ratio relationship in order to determine the optimum slip ratio.
2. For turning motion, the effective tractive effort, slip ratios and trim angles of both inner and outer track and turning radius increase significantly with the increase of rotary speed of rear sprocket of the outer track at the same steering ratio.

References

1) T. Muro, K. Morioka and T.D.Thai: " Turnability properties of a tracked vehicle under traction on a dry soil", Memoirs of the Faculty of Engineering, Ehime University, Vol. 15, pp.237-248, February, 1996.

2) T. Muro, " Terramechanics- Land Locomation", Gihoudou Press, pp.189-235, 1993.