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TURNABILITY PROPERTIES OF A TRACKED VEHICLE UNDER TRACTION ON A DRY SOIL

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INTRODUCTION The aim of this paper is to develop a simulation analytical method to predict turnability properties of the tracked vehicles under turning motion. For this purpose, the experiment on vehicle model for turning motion is carried out; the tractive efforts exerted on the vehicle in turning motion, the steering ratio as well as their influences on the turnablity are investigated. Based on this investigation, the simulation analytical method is proposed.

SIMULATION ANALYSIS Input for the simulation analysis method is the terrain-track system constants, the dimensions of model vehicle and the measured slip ratios for each steering ratio ε and tractive effort T_4. Outputs are ground contact pressure, turning radius, thrust, compaction resistance, amount of sinkage and turning resistance as well as tractive effort. First, the thrusts, the compaction resistances, the amount of sinkage and the ground contact pressure are calculated using the analytical method for the vehicle in ahead running motion. Next, assuming a lateral trim angle of the vehicle θ_{lat}, the ground contact pressure distribution for turning motion is calculated. Then, using the newly calculated ground contact pressure distribution, the amount of slip sinkage of each track is calculated. The following step is to calculate the new θ_{lat} angel based on the above calculated amount of slip sinkage of the inner and outer track. With this new angel, by similar step, the ground contact pressure distribution(1) is repeatedly recalculated until the difference of θ_{lat} converges before and after. After the calculation of the ground contact pressure distribution, the turning radius R, the amounts of slip as well as the terrain-track system constants in equation, the turning resistance moment, and the tractive effort are calculated.

The amount of slippage $J_o(x)$ at the point P, from Fig.1, can be calculated as the integration of the track slip velocity $V_s/\cos\alpha$ from the time $t=0$ to $t=t_1$ in equation (1) and from this equation the amount of slippage of the outer and inner track are developed as in equation (2) and (3). The turning resistance(2), from figure (2), can be calculated by the equation (4)

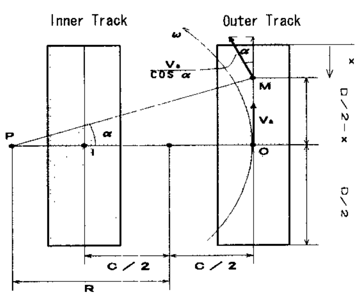

Fig.1 Amount of slippage

$$J_o(x)=\int_0^{t_1}\frac{V_s}{\cos\omega t}dt=\frac{V_s}{2\omega}\log\frac{1+\sin\alpha}{1-\sin\alpha} \qquad (1)$$

$$J_o(x)=\frac{i_o}{1-i_o}\cdot\frac{2R+C}{4}\log\frac{\sqrt{(\frac{D}{2}-x)^2+(R+\frac{C}{2})^2}+\left|\frac{D}{2}-x\right|}{\sqrt{(\frac{D}{2}-x)^2+(R+\frac{C}{2})^2}-\left|\frac{D}{2}-x\right|} \qquad (2)$$

$$J_i(x)=\frac{i_i}{1-i_i}\cdot\frac{2R-C}{4}\log\frac{\sqrt{(\frac{D}{2}-x)^2+(R+\frac{C}{2})^2}+\left|\frac{D}{2}-x\right|}{\sqrt{(\frac{D}{2}-x)^2+(R+\frac{C}{2})^2}-\left|\frac{D}{2}-x\right|} \qquad (3)$$

$$M_o(x)=B\int_0^d\tau(x)\left|x-\frac{D}{2}\right|dx \qquad (4)$$

where i_i, i_o are slip ratios of the inner and outer track

Since the direction of the shear resistance occured under the track is changing bacause of the vehicle is under turning motion, measured terrain-track system constants are adusted for arbitrary direction.

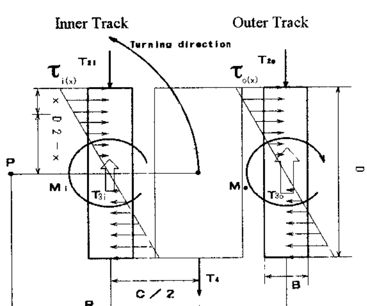

Fig.2 Several forces acting on on a vehicle at turning motion

To varify the simulation analysis, serious of experiments werre carried out. In these experiments, the steering ratios were 1.00, 1.25, 1.60, 2.20, 3.20. The tractive effort T_4 also changed in 5 steps: 0, 98, 147, 196, 245 N. Moreover, the vehicle was run with turning motion both to the left and right directions. With the combination of these various values of steering ratios, tractive efforts and direction of turning, the number of experiments will maked up to 50 and the achieved results were taken as the average value.

Fig. 3 compares the measured and calculated values of the amount of sinkage of the inner rear sprocket, S_{rim} and S_{ric}, at different steering ratios ε. In this figure, for each steering ratio, 5 points are marked for 5 different values of tractive efforts with which the actual experiment is carried out. The calculated values of this amount of slip sinkage match up to the measured ones with high punctuality.

Fig 4 compares the measured and calculated values of the amount of sinkage of the outer rear sprocket, S_{rom} and S_{rim}, at different steering ratios ε. The amount of sinkage at outer track, similarly to the case of inner track, increases as steering ratio increases. The calculated values agree well with the measured values of this amount of slip sinkage.

Fig.5 compares the calculated and measured tractive efforts, T_{4m} and T_{4c}, at different slip ratio ε. The calculated values of this tractive effort match up to the measures ones with high accuracy.

CONCLUSION From several results of the experiment and the simulation, the following part will summarize new information regarding the turnablity of the tracked vehicle under traction:

(1) The rear sprocket sinks as the tractive effort and steering ratio increases. Moreover, with the increase of steering ratio and for the case of traction, the amount of sinkage of rear sproket of the outer track is greater than that of the inner one while the contrary tendency can be observed for pure rolling state.

(2) With the increase of tractive effort , the slip ratio at both the inner and outer track will increase and the amount of slip ratio of the outer track is greater than that of the inner one. On the other hand, with the increase of steering ratio, the amount of slip ratio of the outer track tends to increase while the contrary tencency can be observed for the inner one.

(3) Thrust at both the outer and inner track increases as the tractive effort increases. With the increase of steering ratio, the thrust at the outer track increases while that at the inner one decreases .

(4) The contact pressure distribution shows the peak value almost directly under the track rollers and rear sprocket.

(5) The turning resistant moment M that occurs at one track with the track width B, track length D, can be calculated by the following formula.

$$M = B\int_0^D \tau_0(x)\left|x - \frac{D}{2}\right|dx$$

where $\tau(x)$ is the lateral shear resistance at x distance from the front edge of the track.

(6) The proposed simulation analytical method has a high punctuality when calculating the turning radius, the amount of sinkage and the tractive effort.

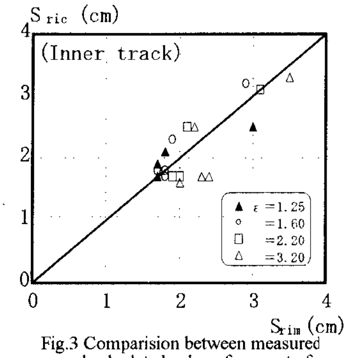

Fig.3 Comparision between measured and calculated value of amount of sinkage of the inner rear sprocket

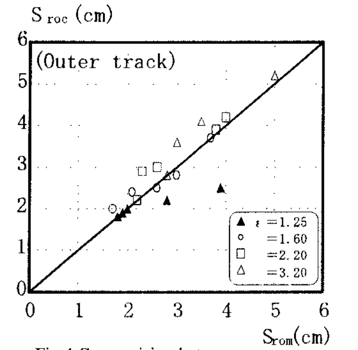

Fig.4 Comparision between measure and calculated value of amount of sinkage of the outer rear sprocket

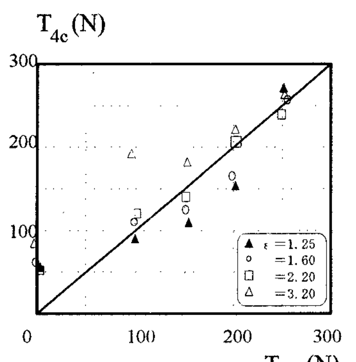

Fig.5 Comparision between measured and calculated value of of tractive effort

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