

Development and evaluation of a New Cage Wheel for power tiller

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Abstract

In Sri Lanka, land preparation for the cultivation of paddy is done mainly using the power tiller. The moisture content of paddy soil is usually very high. Therefore, power tillers that are operated in the saturated or flooded condition often require special devices called "Cage Wheels" in place of wheels. Rotation ring type Cage Wheels with retractable lugs for power Tillers were designed and developed to provide easy road transportation and to improve performance in wetland operations. A pair of cage wheels was constructed after testing the first wheel and implementing necessary modifications. The developed wheel consists of an inner ring and an outer cage. The 12 lugs were hinged on the inner ring resting on cross bars of outer cage those guide the lugs when the wheel was expanding or retracting. The 4 pulleys were provided on the inner side of the inner ring to rotate it smoothly when the wheel diameter was changed.

Two experiments were conducted in tow locations (dry and wet soil conditions) to compare the performance of the developed wheels with conventional cage wheels. Effective field capacity, time per hectare, traveling speed, travel reduction, the pull developed at 100% slip and wheel costs were considered in evaluation.

From the result, it was observed that the performance of designed cage wheels were significantly higher in both locations. Increase in pull and power of the developed cage wheel over conventional was about 1.5 and 1.6 in both soil conditions, respectively.

Background and Objectives

Agricultural tractors are normally operated under difficult soil conditions, especially in rice fields. The efficiency of field operations is limited due to very adverse traction performance of pneumatic wheels under wet soil conditions. Therefore Power Tillers that are operated in the saturated or flooded conditions often require special devices called "Cage Wheels" attached to the tyres (Datta and Ojha 1970, Devnani and Ojha 1970 and Bangali, 1976). Main objective of this study was to design and develop a suitable mechanism for a Cage Wheel with retractable Lugs for tow wheel tractor and to compare the performances of the above wheel with conventional cage wheel.

Materials and Methods

A pair of Cage Wheels was constructed after testing the first wheel and implementing necessary modifications. The developed wheel consists of an inner ring and an outer cage (Figures 1 and 2). The 12 lugs were hinged on the inner ring resting on cross bars of outer cage those guide the lugs when the wheel was expanding or retracting. The four pulleys were provided on the inner side of inner ring to rotate it smoothly when the wheel diameter was changed.

Tow experiments were conducted in two locations (dry and wet soil conditions) to compare the performance of the development wheels with conventional cage wheels. Effective field capacity, time per hectare, traveling speed, travel reduction, the pull developed at 100% slip and wheel cost were considered as criteria for the evaluation of cage wheels.

In order to evaluate the uniformity of the soil throughout the field, bulk density, true density, Atterberg limits, soil texture, soil compaction, cone index, cone depth and hardpan depth of paddy soil were tested.

Results

The field test performance of different traction aids was compared by obtaining number of parameters. Test results were obtained for two traction aids, each having three replicates. Mean values of these results are tabulated in Table 1.

Table 1: Comparative test result of Design Cage wheel and conventional Cage wheel for puddling.

Traction aids	Maximum pull (kg)	Theoretical forwarded speed (m/s)	Actual forwarded Speed (m/s)	Travel reduction (%)
Conventional Cage Wheel	164.70	1.52	1.25	17.70
Designed Cage Wheel	237.00	1.52	1.37	9.70

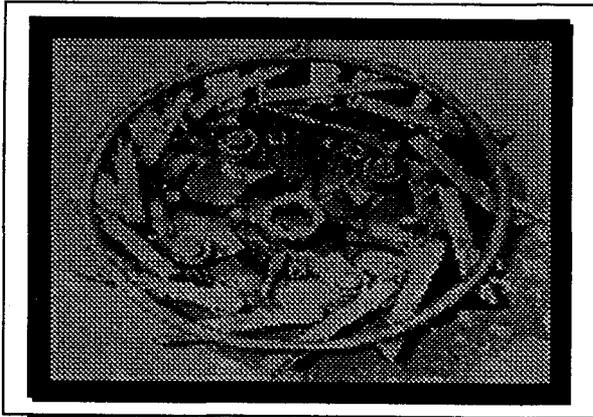


Photo 01 Designed Cage Wheel (Retracted)

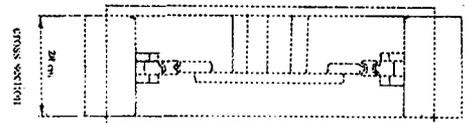
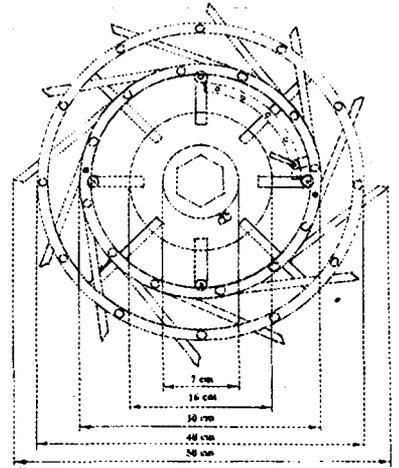


Figure 2: The designed cage wheels (Retracted position)

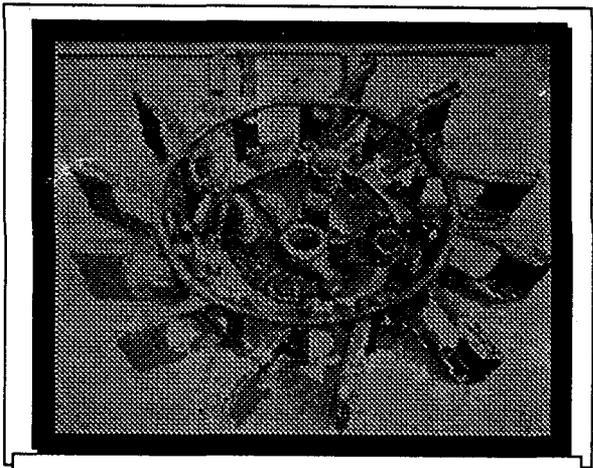


Photo.02 Designed Cage Wheel (Extended position)

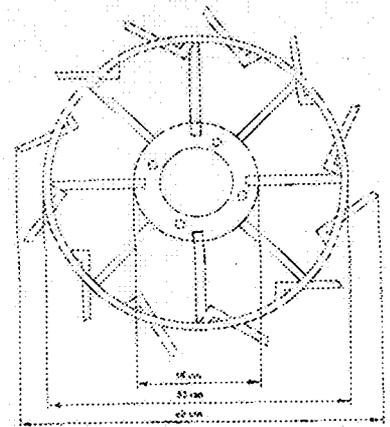


Figure 3: The part drawing of the conventional cage wheel.

According to the results of the tests conducted in the research station it was found that the travel reduction of the developed cage wheel has significantly reduced compared to the conventional cage wheel. This was proven by using F-tests (Duncan's multiple range test) at different precision levels. From the results, it was observed that the performance of designed cage wheels was significantly higher. Increase in pull and power of the developed cage wheel over conventional was about 40%, Following advantages of the developed cage wheel over the other traction aids can be identified:

1. It is capable of having a larger diameter than the tire in field operations and a smaller diameter for road transportation.
2. The hinged flat lugs penetrate to the hard pan properly compared to the triangular lugged mechanism and produce more traction
3. Retraction and extension of the lugs can be performed easily in wet or dry soil condition. Lug can be extended by driving the tractor in reverse direction with jerking action after disengaging a key in the retracted position.
4. Fabrication and maintenance of the cage wheel is simple. Maintenance of the wheel is easy since the lug bolts can be dismantled easily.
5. While reversing the tractor, angle of the lug changes from +30 to -30, due to swinging lug mechanism.

Conclusion

The performance of development cage wheel with retractable lugged was far better than other tested traction aids. It can be clearly observed that the performance of the developed Cage Wheel was significantly higher in each soil condition. The relative improvement in performance of the developed cage wheel over Conventional Cage wheel was about 1.5 for pull and around 1.6 power in both soil conditions.

Finally it can be conclude that the principle of swinging flat lug retractable cage mechanism functioned well on road as well as in field. One of its main advantages is the capability of traveling in the reverse direction, as well as in forward direction without bogging down. Using the retracting lug principle, the Cage Wheel can be developed further.

Acknowledgements

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References

- Bangali B. 1976. Effect of lug angle of cage wheel on traction and puddling performance of dual wheels. Unpublished M. Tech. thesis G.B. Pant Univ. of Agri. and Tech., Pantnagar, U.P., India.
- Datta, P. and Ojha, T.P.1970. Design of wheel parameters for puddle soils. *Journal of Agricultural Engineering (ISAE)*. 7(3): 60-65
- Devnani, R.S. and Ojha, T.P. 1970. Performance studies on small traction wheels in puddle soil conditions – A model study. *Journal of the Institution of Engineers (India), Mechanical Engineering Division*. 51(1): 36-42