Advances in Natural Science
Vol. **3**, No. **2**, **2010**, pp. 213-217
www.cscanada.net
ISSN 1715-7862 [PRINT]
ISSN 1715-7870 [ONLINE]
www.cscanada.org

The 3rd International Conference of Bionic Engineering

Abrasive Wear of Geometrical Surface Structures of Scapharca Subcrenata and Burnt-end Ark Against Soil[1]

ZHANG Rui[2]

LU Zhi-li[3]

LI Jian-qiao[4]

Abstract: Scapharca subcrenata(*Arca subcrenala Lischke*）and Burnt-end Ark (*Arca inflata Reeve*) were selected as the research object. The abrasive wear experiments of three types of surface structures against soil were performed in the abrasive tester. These surface structures include the Scapharca subcrenata node rib pattern shell, Scapharca subcrenata rib pattern shell and Burnt-end Ark. The test results showed that the wear-resistant function of the surface structures of the Scapharca subcrenata node rib pattern shell and the Burnt-end Ark shell was better than that of the surface structure of the Scapharca subcrenata rib pattern shell when the relative sliding velocity was 2.41m/s. When abrasive size was range from 0.380mm to 0.830mm, the wear loss of these three types of surface structures were increased with the relative sliding velocity increasing.
Keywords: Scapharca subcrenata; Burnt-end Ark; geometrical surface structure; abrasive wear; wear resistance

1. INTRODUCTION

The different surface morphology of creatures used to enhance the wear resistance is very common in nature. The surface structure of creature becomes a perfect and special structure by nature selection. Many creatures, Such as Beetle, pangolin, lizard, intertidal shellfish, and sand snake, whose surface structures show the excellent wear resistance (TONG et al., 2007; Hazel et al., 1999; RONG, 2008; GAO, 2008; TONG et al., 2005; TONG et al., 2004; TONG et al., 2005; Rechenberg & Khyari, 2006; Barthlott & Neinhuis, 2004; Peressadko & Gorb, 2004). The wear resistance of creatures is related to their surface

---

[1] **The authors would like to thank the financial support by National Natural Science Foundations of China (Grant No. 50635030; 50805064), Scientific Forefront and Interdisciplinary Innovation Project of Jilin University (Grant No. 200903266), Key Technologies R & D Programme of Jilin Province (Grant No. 09ZDGG001).**
[2] Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University, Changchun 130022, China
[3] Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University, Changchun 130022, China
[4] Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University, Changchun 130022, China
*Received 10 May 2010; accepted 19 July 2010

morphologies and their structures directly. In this paper, we have studied the shell surface geometric morphologies of the Scapharca subcrenata and the Burnt-end Ark as well as their abrasive wear properties.

2. EXPERIMENT PROCEDURE

Scapharca subcrenata shell and Burnt-end Ark shell belong to Bivalvia Mollusca shellfish, as shown in Fig. 1 and Fig. 2. Scapharca subcrenata and Burnt-end Ark live in the shallow soft mud flats or buried in the shallow water habitats mud sand bottom, especially like to live near the outfall where fresh water flows in. They experience the severe abrasive wear in motion. At the same time, they are affected by sediment erosion in the process of living. The outer surfaces of Scapharca subcrenata shell and Burnt-end Ark shell are observed by using a stereomicroscope. The outer surface of Scapharca subcrenata shell has two kind of surface morphology. The left shell of Scapharca subcrenata has the surface radiation ribs and small nodules, as shown in Fig. 3. The right shell of Scapharca subcrenata shell only has the surface radiation ribs, as shown in Fig. 4. The left and the right shells of Burnt-end Ark have the same structures and only have the surface radiation ribs, as shown in Fig. 5.

Fig. 1: Scapharca subcrenata shell

Fig. 2: Burnt-end Ark shell

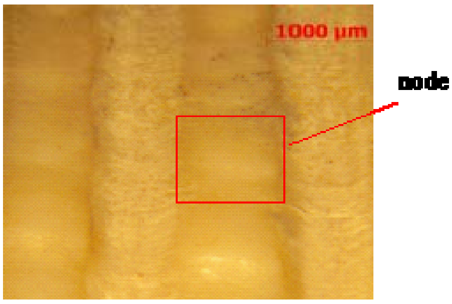

Fig. 3: Scapharca subcrenata node rib pattern shell

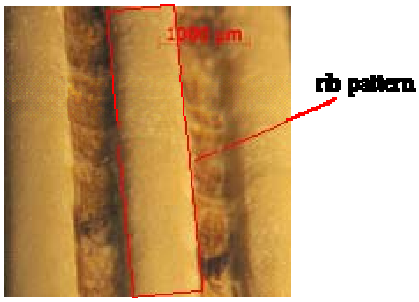

Fig. 4: Scapharca subcrenata rib pattern shell

Fig. 5: Burnt-end Ark rib pattern shell

The typical parts of Scapharca subcrenata shell and Burnt-end Ark shell are selected. These parts are sliced by a precision cutting machine. The slice Size is 16mm×16mm. The slices are worn by using a JMM-abrasive tester. Fig. 6 shows JMM-abrasive tester principle diagram, including compaction wheels, turntable, installing fixtures and loosing material samples shovel (RONG, 2008). In the test, the samples are fixed in the depth of abrasive about 70mm. the relative sliding between the sample and the abrasive is driven by the rotating wheel. The direction of the relative sliding velocity and the rib pattern meets at the same angle. The mixture of 96.5% quartz sand (abrasive size 0.380-1.700mm) and 3.5% bentonite is selected as the abrasive, and the water content of the abrasive is from 3% to 5% (*Group of effects of soil abrasive characteristics*, 1986). Fixtures can be installed four samples of Intermittent transposition, followed by conversion to wear sample. The transposition itinerary of a sample is 410m. A single specimen transposition is recorded as a grinding way. The grinding process automatically change the sample fixed on the fixture after one test. Each sample grinding process takes 15 cycles, and the total trip is 42.15km. The test ambient temperature is 20-23℃. The electronic analytical balance (precision of 0.01mg) is used to measure the mass of sample before and after wear.

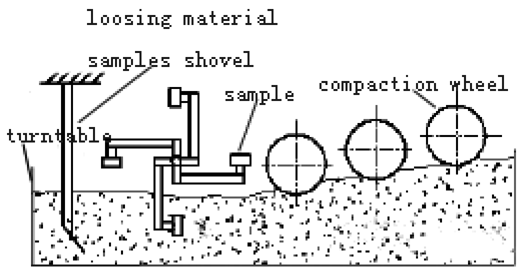

Fig.6: JMM abrasive tester principle diagram (RONG, 2008)

3. RESULTS AND DISCUSSION

Fig. 7 and Fig. 8 show the abrasive wear mass loss of Scapharca subcrenata rib pattern shell, Scapharca subcrenata node rib pattern shell and Burnt-end Ark shell. In Fig. 7 and Fig. 8, the sizes of the abrasive particles are from 0.380mm to 0.830mm, and the relative sliding velocities between the samples and the abrasives are 2.41m/s, 2.93m/s and 3.45m/s respectively. Seen from Fig. 7, the wear masses of the Scapharca subcrenata rib pattern shell and the Scapharca subcrenata node rib pattern shell increase with the relative sliding velocity being added. However, the wear-resistant function of the Scapharca subcrenata node rib pattern shell is better than that of the Scapharca subcrenata rib pattern shell. Seen from Fig. 8, the wear masses of the Scapharca subcrenata rib pattern shell and the Burnt-end Ark shell increase with the relative sliding velocity being added. The wear-resistant function of the Burnt-end Ark shell is better than that of the Scapharca subcrenata rib pattern shell. From the above Figures, The wear resistance of the structure surfaces of Scapharca subcrenata shell and Burnt-end Ark shell is related to the relative sliding velocities. Their wear masses increase with the relative sliding wear velocity being added. With the relative sliding velocity between the abrasive and the specimen increasing, the abrasive wear on the sample surface increases the impact opportunities, and the wear losses increase during the wear process.

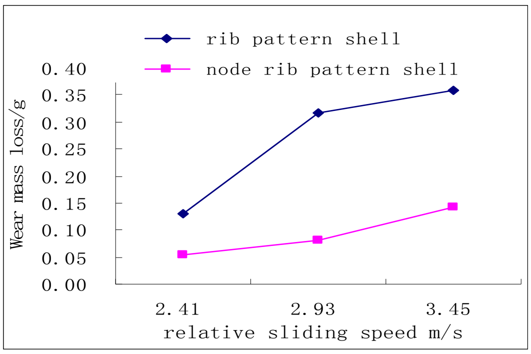

Fig. 7: The wear mass losses of Scapharca subcrenata shells

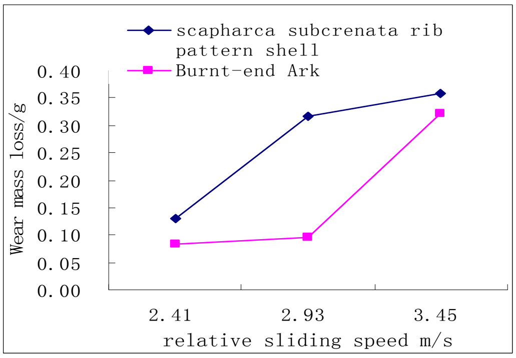

Fig. 8: The wear mass losses of Scapharca subcrenata node rib pattern shell and Burnt-end Arkshell

Fig. 9 and Fig. 10 show the abrasive wear mass losses of the Scapharca subcrenata shell, the Scapharca subcrenata node rib pattern shell and the Burnt-end Ark shell. In Fig. 9 and Fig. 10, the relative sliding velocity between the samples and the abrasives is 2.41m/s, the sizes of the abrasive particles are from 0.380mm to 0.830mm, and from 0.830 to1.700mm. Seen from Fig. 9, though the abrasive size is changed, The wear resistance of the Scapharca subcrenata node rib pattern shell is better than that of the Scapharca subcrenata rib pattern shell under the relative sliding velocity of 2.41m/s. Seen from Fig. 10, the wear resistance of the Burnt-end Ark shell is better than that of the Scapharca subcrenata rib pattern shell. The reason is that the radiation pattern and the rib groove width of Burnt-end Ark are wider than those of Scapharca subcrenata rib pattern shell. During the wear process, the contact area between the abrasive and Burnt-end Ark shell radiation rib pattern is less than that between the abrasive and Scapharca subcrenata rib pattern shell. Therefore, the wear-resistant function of Burnt-end Ark is better than that of Scapharca subcrenata rib pattern shell.

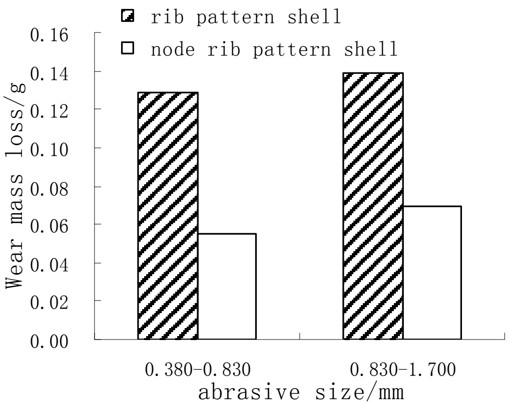

Fig. 9: The wear mass change of Scapharca subcrenata shells

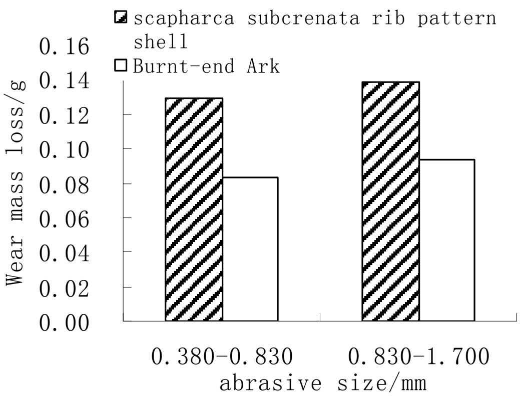

Fig. 10: The wear mass change of Scapharca subcrenata rib pattern shell and Burnt-end Ark shell

CONCLUSION

The wear resistance of Burnt-end Ark shell and Scapharca subcrenata node rib pattern shell is better than that of Scapharca subcrenata rib pattern shell under the relative sliding velocity of 2.41m/s. When the sizes of the abrasive particles are from 0.380mm to 0.830mm, the abrasive wear masses of three surface structures of the Scapharca subcrenata shells and the Burnt-end Ark shell increase with the relative sliding velocities being added.

REFERENCE

Barthlott W, Neinhuis C. (2004). The lotus-effect: non-adhesive biological and biomimetic technical surfaces. P*roceedings of the First InternationalIndustrial Conference Bionik*, 211-214.

GAO F. (2008). *Research on the Coupling Characteristics of Anti-Erosive Wear of Desert Lizard.* PhD Dissertation, School of Biological & Agricultural Engineering, Jilin University, Changchun, China.

Group of effects of soil abrasive characteristics. Effects of soil abrasive characteristics on wear behaviors of agricultural machine materials. *Transactions of the Chinese Society of Agricultural Machinery*, 1986, *17(3)*: 53-62.

Hazel J, Stone M, Grace M S, Tsukruk V V. (1999). Nanoscale design of snake skin for reptation locomotions via friction anisotropy. *Journal of Biomechanics, 32*: 477-484.

Peressadko A G, Gorb S N. (2004). Surface profile and friction force generated by insect. *Proceedings of the First International Industrial ConferenceBionik.* 257-263.

Rechenberg I, Khyari A R E. (2006). The sandskink of the sahara-A model for friction and wear reduction. *Proceedings of the International Conference of Bionic Engineering-ICBE'06*, Changchun, P R China, 213-216.

RONG B J. (2008). *Biomimetic Geometrical Structure Surfaces with Anti-abrasion Function and Their Abrasive Wear against Soil.* PhD Dissertation, School of Biological & Agricultural Engineering, Jilin University, Changchun, China.

TONG J, LU T B, MA Y H, et al. (2007). Two-body abrasive wear features of surfaces of pangolin scales. *Journal of Bionic Engineering, 4(2)*: 77-84.

TONG J, WANG H K, MA Y H, et al. (2005). Free-abrasive wear of three mollusk shells (Lamprotula fibrosa heude, rapana venosa valenci-ennes and dosinia anus philippi). *Tribology Letters, 19(4)*: 331-338.

TONG J, Moayad B Z, REN L Q, et a1. (2004). Biomimetics in soft terrain machines: A review. *International Agricultural Engineering Journal, 13(1-2)*: 71-86.

TONG J, SUN J Y, CHEN D H, et a1. (2005). Geometrical features and wettability of dung beetles and potential biomimetic engineering applications in tillage implements. *Soil＆Tillage Research, 80(1)*: 1-12.