CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)

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Project Number

S0211

Project Title

Keeping the Rover Rolling

Abstract

Objectives/Goals

Planetary rovers utilize machined metal wheels with treads called grousers. The drive wheels must provide traction and resist side-slip on loose soils such as sand. The objective of this experiment was to answer the question: With a chevron-shaped grouser, what is the optimum internal chevron angle to provide both the required traction and to resist slipping while traversing a sand slope?

Methods/Materials

The materials needed for the project were a wheel test vehicle, wheels with chevron-shaped grousers with internal angles varying by 30 degrees, clean dry sand, and a spring scale. The rover wheel test vehicle with interchangeable front wheels was driven across smooth dry play sand. While the vehicle is moving, measure the traction load in grams to the point of wheel slip and measure the load in grams needed to pull the vehicle off a straight line while driving forward (side-slip measurement).

Results

A range of rover wheels with chevron grouser treads (chevron angle 0º-180º in 30º increments) was tested for its ability to provide driving traction and side-slip resistance in dry sand. Clearly a flat paddle-like tread would pull forward best and a ridge all around the wheel would resist side-slip best. This experiment was designed to determine the shape which would both reliably climb and traverse dunes. The results showed a 90º chevron grouser performed best.

Conclusions/Discussion

A mathematical relationship between traction and slip resistance was determined experimentally. This result can be incorporated into computer models of rover wheels to develop new designs that are efficient for planetary exploration. It was found that both traction and side-slip resistance were related to the projected length of the grouser blade. This relationship was a cosine or sine function respectively. From analysis of the sine and cosine relationship plots, it is clear that the optimum angle is 90º for the chevron grouser. The cosine plot for traction load showed a traction of 159 g, which was greater than the median. The sine plot showed a side-slip resistance of 47 g, which is close to the maximum. In profile, the 90º chevron grouser pattern forms a closed disc, thus acting like a ridge around the wheel.
Future work should explore the relationships between grouser spacing and depth to traction and side-slip resistance.

Summary Statement

An experiment to optimize the tread design (maximizing traction and minimizing side slip) for a planetary rover navigating on sand.

Help Received

Father helped build and test wheels; JPL Engineers Donald Bickler and Chris Vorhees helped define measurement technique.