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P2_6 “It’s the wrong trousers Gromit!” Part 1

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Abstract

In the classic film *The Wrong Trousers* Gromit receives some ex-NASA robotic “Techno Trousers” from Wallace for his birthday. This paper investigates whether the vacuum generator in the boots of the trousers would work when walking upside down on a ceiling as shown in the film. The vacuum generator required would need to be powerful enough to reduce the pressure in the boot by 18.5kPa. This suction is consistent with a low vacuum, and hence is feasible; however its operating time would be very short. Whether the trousers would work in space is also briefly discussed, concluding that it is unlikely with their current design.

Introduction

In Nick Park’s 1993 clay animation film *The Wrong Trousers*, featuring the famous characters Wallace and Gromit, Wallace buys Gromit some ex-NASA robotic “Techno Trousers” for his birthday so that Wallace would not have to take Gromit for walks anymore [1]. One of the many features of these trousers is that they can walk up vertical walls and walk upside down using switchable vacuum and magnetic field generators located in the soles of the boots [2].

This paper will consider whether the techno trousers could work in real life conditions. We will examine what suction is required to allow the trousers and a man to walk on the ceiling without losing contact. The magnetic feature will not be considered in this paper.

Theory

In order for the vacuum generator in the sole of the boots to work, it will be assumed that there is a slightly raised rubber insulator surrounding the boot (as shown in figure 1). This will create a cavity which will have a lower pressure than the surroundings when the vacuum is applied. The difference in pressure between the atmosphere and the cavity is what we will be calculating.

To walk it will be necessary for the trousers to be able function with only one of the boots in contact with the ceiling as well as both. Therefore calculations will be made with one boot supporting all of the weight.

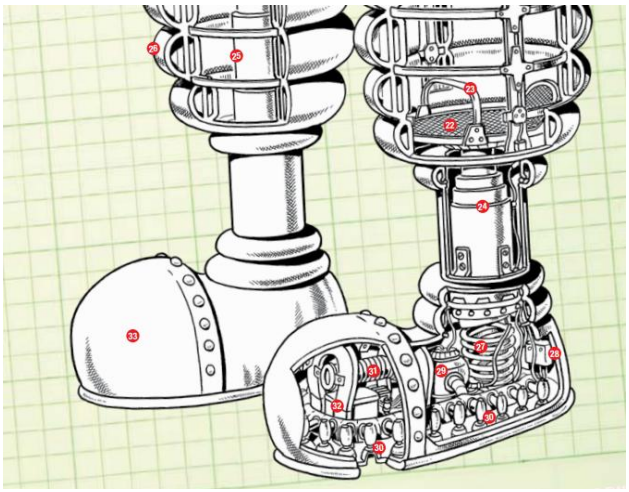

Figure 1 Detailed drawing from the Haynes manual of the boot part of the trousers. 30 indicates the vacuum tubes

To calculate the pressure difference the following equation is used

$$P_{atm} - P_{boot} = \frac{F}{A} \qquad (1)$$

where P_{atm} is the pressure of the atmosphere, P_{boot} is the pressure in the cavity, F is the force due to gravity and A is the area of the boot [3].

Its force due to gravity is calculated by applying Newton’s second law

$$F = mg, \qquad (2)$$

where *m* is the combined mass of the trousers and Wallace and *g* is the acceleration due to gravity, 9.81ms^{-2} on Earth's surface.

Discussion

The boot will be approximated as a rectangle with dimensions 0.3m x 0.2m and two semi-circles with a radius 0.1m. This gives a total surface area A of 0.09m^2. Taking the average mass of a man to be 70kg, the mass of the trousers to be approximately 100kg and using equation (2) gives a force of 1667.7N. Using these numbers in equation (1) gives a required pressure difference of 18.5kPa.

If atmospheric pressure is 101.325kPa [3] then the pressure in the boot needs to be 82.8kPa. This means the vacuum generator needs to be powerful enough to reduce the atmospheric pressure inside the boot cavity by approximately 18% in order to create a vacuum capable of supporting Wallace and the trousers. This corresponds to a low vacuum [4], which has a similar strength to a vacuum cleaner.

Although this is a feasible vacuum required, the main issue that arises is that the trousers operate from a rechargeable battery [2]. So by making a quick comparison with a wireless vacuum cleaner with a similar strength, the operating time would be around 20 minutes [5]. In the film Gromit uses the trousers to help him paint the ceiling. In this scenario the trousers could be connected to a mains electricity supply and would function well. However, the trousers are also used to scale a building and rob a diamond. This would probably take considerably longer than 20 minutes in a real life situation.

Originally the trousers were designed for use by astronauts for spacecraft repairs and other extra-vehicular activities [6]. As the spacecraft would be in freefall at this altitude, there will be no acceleration relative to the spacecraft. The pressure in outer space varies between 1x10^{-4}Pa to 1x10^{-15}Pa [4] which is very close to a perfect vacuum. In order for the trousers to work, the pressure that needs to be created in the boot needs to be less than this. Achieving a pressure which would be lower than the local environment would be very complex and beyond the capability of the vacuum generator in the trousers [7].

However, it is likely that the magnetic generators would be able to function in outer space and hence the techno trousers could work on Earth and in space.

Conclusion

To conclude, the techno trousers would be able to walk upside down on Earth when scaled up to a realistic human size. The trouser's shortfall is that they would need a very powerful battery or to be connected to the mains to have a reasonable operating time.

Since the pressure in outer space is already nearly a vacuum, it would not be possible to create a vacuum better than the local environment and hence the techno trouser's vacuum generator system would not work in this region.

We intend to investigate the magnetic field generator feature of the trousers in a future paper.

References

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