Effects of lubricants on the mechanical efficiency of the pulleys.

Question

How does the type of the lubricant affect the mechanical efficiency of the pulleys?

Hypothesis

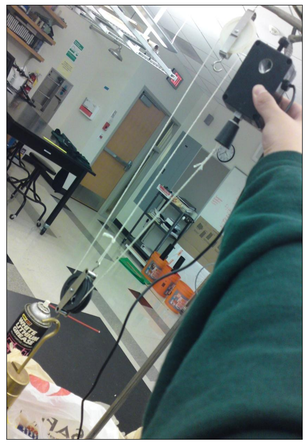
There is one or two types of the lubricants reducing the friction most and can increase the mechanical efficiency more than others.

Background

- **Pulley system** is consisting of a number of **fixed pulley** and the **movable pulley**.
- Since the tension in each rope length is *equal* to the force exerted on the free end of the rope, the mechanical advantage is simply *equal* to the number of ropes pulling on the load. (http://baike.baidu.com/view/34695.htm)
- When someone is using *any* machine, in addition to doing **work output**, the **extra work** will inevitably be done. (http://baike.baidu.com/view/148771.htm)
- I studied about the mechanical efficiency of the pulleys. I used " **η=（W_o ÷ W_i）×100%**" to get the mechanical efficiency. *So if I want to* ***increase the efficiency****, I should* ***reduce the friction*** *so that the W_o can increase and the η can increase.*
- "A **lubricant** is a *substance* introduced *between two moving surfaces to* ***reduce the friction*** between them, **improving efficiency** and reducing wear. (http://en.wikipedia.org/wiki/lubricant) In my project I decide to use lubricants to reduce friction.
- Simple machines are very ***useful*** in the life. Such as crane. There are **pulleys** on the crane arm. And it can reduce the force a lot and it is much easier to lift heavy things.
- Some of the simple machines can ***reduce the force***, others can ***reduce the distance***, but ***none of them can reduce the work***.
- I added **different lubricants** into the bearings of the pulleys during each experiment. Pulled the weights up, the raw data will be force measured by the force sensor.
- My *independent variable* was the different kinds of lubricant. My *dependent variable* was the mechanical efficiency of the pulleys.

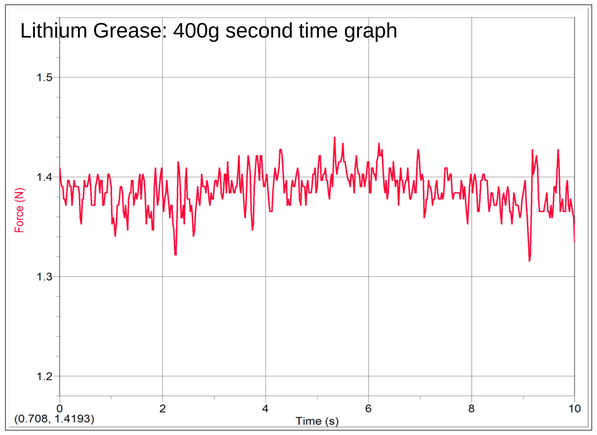
Methods

1) Prepared 1 pulley systems. It looked the same with the picture I took on the right.
2) I did the first experiment without any lubricant. I pulled the weights up, using a force. I kept pulling for 10s. And repeated this process 4 times and saved the file for later study. Then I added the weights, got the data after changing the weights into 400g, 800g and 1000g.
3) I repeated this process after adding SILICON lubricant into the pulleys. Then I cleaned up the silicon lubricant. I put all the pulleys with lubricant in the sink. I used cleaning agent to wash them. Let the water to rinse them, then used dryer to dry them.
4) I repeated the above process using –Lithium grease lubricant, wd-40 and light oil. I cleaned up the lubricant after I finished using each lubricant.
5) I put all the data in the different tables. And I saved one best graph when I did the experiment. I am going to graph the relationship between lubricants and the data by these tables.
6) After I finished, then I reviewed the data and determined the average force required for steady (constant velocity) lifting of the weights for each apparatus. The collected data would be analyzed by graphing and comparing.



This is my picture of the pulley system. I pulled up the string with a force sensor for 10s each time. And the force graph and data will appear on the computer screen.
"All photos taken by author."

Data



This was one of the graphs we did. We used the graph to find the force I used to pull the string. This graph was similar to others and it was a good one and I got it when I pulled up the 400g weights using the pulleys with lithium grease. It cost 10s.

This is my picture of three of the lubricants I used. They are WD-40, Lithium grease and Silicone.

200g

Type of Lub \ Trials / Force(N)	1	2	3	4	5	average
No lubricant	0.81	0.78	0.76	0.74	0.78	0.77
Silicon	0.76	0.74	0.75	0.74	0.73	0.74
WD-40	0.77	0.76	0.77	0.74	0.75	0.76
Lithium Grease	0.71	0.69	0.71	0.72	0.68	0.70
Light Oil	0.76	0.78	0.79	0.81	0.77	0.78

400g

Type of Lub \ Trials / Force(N)	1	2	3	4	5	average
No lubricant	1.44	1.45	1.52	1.50	1.48	1.48
Silicon	1.45	1.44	1.42	1.45	1.44	1.44
WD-40	1.46	1.45	1.44	1.43	1.45	1.45
Lithium Grease	1.39	1.36	1.38	1.41	1.40	1.39
Light Oil	1.50	1.47	1.45	1.48	1.44	1.47

800g

Type of Lub \ Trials / Force(N)	1	2	3	4	5	average
No lubricant	2.74	2.91	2.84	2.94	2.83	2.77
Silicon	2.73	2.76	2.75	2.78	2.81	2.77
WD-40	2.82	2.63	2.79	2.82	2.81	2.77
Lithium Grease	2.69	2.76	2.73	2.70	2.77	2.73
Light Oil	2.88	2.80	2.83	2.79	2.82	2.82

1000g

Type of Lub \ Trials / Force(N)	1	2	3	4	5	average
No lubricant	3.52	3.66	3.49	3.57	3.52	3.45
Silicon	3.49	3.42	3.43	3.44	3.46	3.45
WD-40	3.51	3.48	3.52	3.46	3.45	3.48
Lithium Grease	3.45	3.44	3.46	3.42	3.49	3.45
Light Oil	3.50	3.57	3.52	3.51	3.49	3.52

Discussion

- ***Lithium grease lubricated pulleys required slightly less force than those exposed to other lubricants. So it increases the mechanical efficiency more than others.***
- Lithium grease looks **thicker** than other lubricants. Lithium grease **was much more difficult to clean up** after using.
- The data looked very different between the data I got by using the original force sensor and the data by using another one. **I found different force sensor affects the data.**
- However, the unusual data that I got were the data after I used 400g weight, they were less than the data when we don't use lubricant with the same weights.
- I think the **clearance in the between the surface is big** because the greasy lubricants worked better than thin lubricants did.
- I only used two pulleys so that I can't get some very obvious differences after I used different lubricants. I found that it was hard to distinguish among most of them.
- I know how to improve my design in the future: *First of all, I may use more than 5 pulleys to make sure that I can get more obvious differences among all the data. And I will find a better way to clean up the lubricant more thoroughly.*
- If the lubricants mix, I think it will affect the data. Such as the light oil mixes with Lithium Grease, the greasy one and the thin one, the data might change a lot. I think this should be a part of my future study.
- I know in different conditions, the best working lubricants are different. If the machine is **dusty**, if the **humidity** is different, or if the lubricants are mixed, there may be different lubricants which can work best. I think this should be my future study.

Abstract

This project studied the mechanical efficiency of pulleys with different kinds of lubricants. Lubricants are important, as they are critical for any moving machine parts to reduce friction and wear; finding the best lubricant for each application is important in the effective operation of all machines. The independent variable was the different kinds of lubricants, and the dependent variable was the mechanical efficiency of the pulleys. Lithium grease lubricated pulleys required slightly less force than those exposed to other lubricants. I only used two pulleys so that I can't get some very obvious differences of the force after I used different lubricants. And I wasn't sure that I pulled the string in the same speed. From the data I got, I found that it was hard to distinguish among them. There was only about 6% difference between lithium grease and other lubricants. It was the top performer and might be the most appropriate lubricant for low-speed, plastic on metal interactions. Future studies should explore more exact measuring equipment and more trials with more lubricants.

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