8.6.3: Cultural Connections- Rockets

For millennia the skies have fascinated humans. It seemed to be an unreachable place that was filled with mystery. Finally, in the heart of the Cold War we finally made it into space. The Russians were the first to do it, with the spaceship Vostok 1, piloted by Yuri Gagarin in 1961. The booster that brought him into space was called the Vostok-K, and held over 10,400 pounds of fuel. That is a huge amount of fuel for a simple mission that lasted only a little under 2 hours. The rocket fuel was comprised of ammonium perchlorate, aluminum powder, and a polymer of butadiene and was a solid. This fuel was powerful, but it was not renewable, limiting flight time. The fact that Russia got a man in space first scared the United States. This was the heart of the cold war, and the US believed that if the Russians "owned"space then they could fire missiles down on them from anywhere. Therefore, the United States needed to be the first on the moon to counteract the Soviet actions.

Figure 1. Saturn V Rocket

The United States put the mission of reaching the moon into the hands of the Apollo 11 astronauts. They rode the Saturn V rocket into space and to the moon. This rocket held 262,000 pounds of fuel for liftoff and another 100,000 pounds of fuel to reach the moon. That is a huge amount of fuel, almost 30 times the amount of fuel that was aboard the Vostok-K rocket. The Saturn V rocket uses an LOX fuel. LOX is a liquid fuel comprised of liquid oxygen and liquid hydrogen. It is extremely powerful, and also very unstable when ignited. This is why many accidents have occurred while using this type of fuel. LOX fuel is also used on the current day space shuttle missions.

The space race was in full swing in the 60's and 70's. It has died down since, but in the near future it will heat up again. This time however, the race will be to put man and machine on farther and more out of reach planets like mars or even planets out of our solar system. In order to do this a reliable and renewable source of fuel must be used. This fuel source could come in the form of the alkane methane.

Methane is a readily renewable source in space. It is common on Mars, and very abundant on Saturn's Moon Titan. It is also known to be on some other planets outside of our solar system. When the spacecraft reaches its destination, or in some cases on the way (methane is available in space too, not just on planets), it could refuel. This way the spaceship only has to carry enough fuel to get to the destination, or until more can be made. This is a huge step. The rockets previously required the over 300,000 pounds of fuel because it needed a lot for a return trip. With methane as a fuel source the starting fuel amount could be cut down immensely. Also, the LOX fuel is very unstable. Methane however is very stable, and actually hard to ignite unless the right conditions are met. Since methane is so abundant, and easily made from the following reaction called the **Sabatier Process**:

$$CO_2 + 4\,H_2 \xrightarrow[\text{pressure}]{400\,^\circ C} CH_4 + 2\,H_2O$$

It is also a lot less expensive than the LOX fuel. This would leave NASA the ability to research many other things with the extra money, instead of having to spend it on rocket fuel. Another advantage to methane is that it can be stored at -161 degrees Celsius. This is a lot lower than the -252 degrees that hydrogen has to be stored at. Therefore there would not be as much need to cool the tanks, or insulate them, saving space, weight, and money. Also, methane is denser than hydrogen, so a smaller space could be used to store the material, again saving space and weight. Methane's abundance in the outer solar system is crucial to its possible effectiveness. Methane is not toxic like LOX fuel, and is called the "green fuel" because it is environmentally friendly as well.

Having the ability to grab elements to form methane, or methane itself from space can expand the realms of space travel immensely in the future.

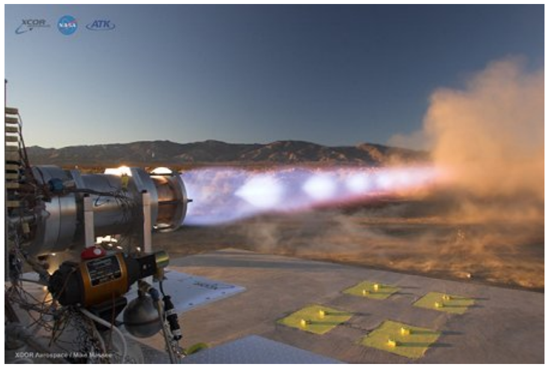

Figure 2. Methane Rocket Engine

An example of a methane engine, with thrust of 7,500 pounds (needs 3,000,000 eventually, but its a start) shown on the NASA website science.nasa.gov/media/medial...testfiring.wmv

A disadvantage of using methane is that it is hard to ignite. The previous LOX fuel was extremely easy to ignite, which is a good and a bad. To ignite methane you need an ignition source, not just an oxidizer that could ignite LOX. This ignition source could be very hard to find in space, especially because of the extremely low temperatures of space. The ignition source is a problem that NASA is tackling, and can be solved. With the only major disadvantage being that methane is hard to ignite, this fuel type will be extremely useful and efficient once the few issues are figured out.

More on Methane

Methane has four C—H bonds arranged tetrahedrally around a single carbon atom. It's boiling point is -161.6 °C and it has a melting point of -182.5 °C. Methane is related to other straight chain alkanes such as ethane (2 carbons), and propane (3 carbons). The properties (table) are shown below.

Table 1. The First 10 Members of the Family of Straight-Chain or Normal Alkanes.

Name	Molecular Formula	Projection Formula	Condensed Structural Formula	Boiling Point (in °C)
Methane	CH_4		CH_4	−162
Ethane	C_2H_6		CH_3CH_3	−89
Propane	C_3H_8		$CH_3CH_2CH_3$	−42
n-Butane*	C_4H_{10}		$CH_3CH_2CH_2CH_3$ or $CH_3(CH_2)_2CH_3$	−0.5
n-Pentane*	C_5H_{12}		$CH_3CH_2CH_2CH_2CH_3$ or $CH_3(CH_2)_3CH_3$	36
n-Hexane*	C_6H_{14}		$CH_3CH_2CH_2CH_2CH_2CH_3$ or $CH_3(CH_2)_4CH_3$	69
n-Heptane*	C_7H_{16}		$CH_3(CH_2)_5CH_3$	98
n-Octane*	C_8H_{18}		$CH_3(CH_2)_6CH_3$	126
n-Nonane*	C_9H_{20}		$CH_3(CH_2)_7CH_3$	151
n-Decane*	$C_{10}H_{22}$		$CH_3(CH_2)_8CH_3$	174

References

1. Methane Rocket [www.space.com]
2. Methane Blast [science.nasa.gov]
