The production of a paraffin based fuel grain for use in a hybrid rocket

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When talking about fuels for a rocket there are usually three categories that come to mind, Solid, liquid and hybrid. The type of fuel that was chosen for uOttawa rocket club was a paraffin based fuel, this makes the rocket fall under the category of a hybrid rocket because paraffin is considered a solid fuel that needs a liquid oxidizer.

Why paraffin? There are many different reasons why paraffin was chosen as the solid fuel grain for this rocket. To begin, it commonly known as candle wax. That being said this makes it extremely easy to purchase and also inexpensive to buy in large quantities for the final fuel grains. Besides being easily accessible and cheap, paraffin is an extremely stable fuel. Traditional solid fuels such as ammonium perchlorate, NH4ClO4, contains perchlorate, a powerful oxidizer, and ammonium, a good fuel source. The problem is that this fuel is reactive, which makes it much more dangerous to work with and transport. A good example of the dangers of producing these types of fuels would be the PEPCON disaster, where a plant that produces ammonium perchlorate caught fire and caused a large explosion. On the contrary, when working with paraffin there is a minimum amount of danger. Paraffin has a melting point of around 68 degrees Celsius which means the process of mixing and molding for the fuel grain can be done at relatively low heat, also paraffin will not explode or combust under normal conditions; when exposed to a flame it will simply melt. After hearing how stable paraffin is, it’s easy to start to question why paraffin would be a good option for a fuel grain if its not very explosive or combustible. The cool thing about paraffin is that when we use a liquid oxidizer, in this case nitrous oxide, we can ionize the liquid and combust the oxygen at high heat which is unique property with paraffin as the fuel. Once the oxidizer begins to combust and comes in contact with the paraffin, the paraffin will begin to melt and form a low viscosity layer, because this layer has a low viscosity the flow rate of the nitrous oxide is enough to lift droplets of paraffin into stream of nitrous oxide and increase the fuel mass transfer rate. This is similar to having an injection system in the combustion chamber. This property of paraffin also leads to a better regression rate, which is the rate at which the fuel grain disappears due to the combustion reaction in the chamber. In summary, because paraffin is so chemically stable and has these properties it makes it the ideal fuel for our hybrid rocket.

Finally, the process we use to make our fuel grain involves melting our paraffin in a water bath and then slowly pouring paraffin into an ABS pipe while keeping a smaller pipe rotating in the center. The smaller pipe enables the grain to have the inner diameter it needs allow the oxidizer to flow through. In the future making a permanent mount where the paraffin could be poured in slowly over a time span of 24 hours would be ideal, allowing us to form a perfect fuel grain and not have issues due to shrinking of the fuel grain as it cools and also be able to make mixes involving metallic powders or other compounds that would increase regression rate or reduce the chunking of the fuel itself as it burns