DoubleSShot

Sieve Analysis of "*C & H*" Pure Cane Sugar

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Objective

The purpose of this analysis is to determine the particle size distribution of C & H brand sucrose sugars found in stores. Though sucrose can and is used as a rocket fuel in sugar motors, this analysis is being done to compare the particle size of both granular and powder sucrose sugars to that of the commonly obtained sizes of KNO_3 . The particle size distribution of the oxidizer, in this case KNO_3 , effects the slurry viscosity during the heating and pouring of the propellant into the grain casting tubes. Any reduction of the slurry viscosity that does not affect cure time and burn rate is advantageous to the casting process. Slurry viscosity, propellant caramelizing, cures time, burn rate and fracture toughness are all important for the Sugar Shot to Space project.

Testing

The property being tested in this analysis is particle size distribution.

Apparatus Required

- Stack of five screen sieves including pan and cover
- Digital scale (300 gram capacity with 0.01 gram resolution)
- Mortar and Pestle (for crushing the sample if lumped)
- Timing device

Additional materials

- Gloves
- Safety glasses
- Camera or video recorder

Notice: The balance should be sensitive to 0.1% of total weight of sample taken.

Procedure

The only current requirement for grain size is that it be “granular”. This may need to be looked into at a further date when our automated casting system is completed and tests conducted for the required size of particle. Four sieve sizes were used; US Standard #35, 60, 120, and 230 from Hubbard Scientific. Size #10 was not used to help break up any clumps in this analysis because no clumps or large particle sizes were seen in the sample.
The sieves were cleaned, washed, and thoroughly dried for twenty four hours in thirty-nine percent humidity air. The sieves were then weighed with the weights recorded. A 20.00 gram dried sample of C & H granular table sugar was measured and placed in the #35 sieve of the stack and covered. The stacked sieves were then roto-tapped for a period of five minutes.
Each sieve, cover and pan was then carefully weighed including the amount of KNO_3 retained.

Results

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The cover showed only a trace of sugar but was weighed. Visually, sieve #60 showed the majority of the sample collected with varying amounts retained by the other sieves. See data table.

Sieve #	Sieve size micron	Mass of sieve grams	Mass of sieve and sample retained grams	Mass of sample Retained grams	Percentage On each sieve	Cumulative % retained
cover	NA	55.24	55.26	0.00	0.00	0.00
10	NA	-	-	-	-	-
35	500	158.52	160.06	1.54	7.70	7.70
60	250	152.85	167.92	15.07	75.35	83.05
120	125	143.35	146.63	3.28	16.40	99.45
230	63	139.67	139.77	0.10	0.50	99.95
pan	< 63	127.26	127.28	0.02	0.10	100.05

Table 1 “C & H brand pure cane table sugar (sucrose) particle size distribution

Figure 2 Sieves and pan with sugar retained.

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sieve #	size range	Wentworth range	Wentworth name	other names
	256-∞ mm	10.1-∞ in	boulder	boulder
	64–256 mm	2.5–10.1 in	cobble	cobble
	32–64 mm	1.26–2.5 in	pebble	gravel
	16–32 mm	0.63–1.26 in	pebble	gravel
	8–16 mm	0.31–0.63 in	pebble	gravel
	4–8 mm	0.157–0.31 in	pebble	gravel
5	2–4 mm	0.079–0.157 in	granule	gravel
10	1–2 mm	0.039–0.079 in	very coarse sand	sand
35	0.5–1 mm	0.020–0.039 in	coarse sand	sand
60	0.25–0.5 mm	0.010–0.020 in	medium sand	sand
120	125–250 µm	0.0049–0.010 in	fine sand	sand
230	62.5–125 µm	0.0025–0.0049 in	very fine sand	sand
	31.25–62.5 µm	0.00015–0.0025 in	silt	mud
	1/∞-3.9 µm	1/∞ –0.00015 in	clay	mud
	1/∞-0.97 µm	1/∞–0.000039 in	colloid	mud

Chart 1 Wentworth Scale (adapted from Wikipedia)

The majority of the particles (> 75%) are -35/+60 sieve size or between 250-500 micron and could be characterized as medium sand particle size. This would indicate a very uniform particle size distribution

Conclusion

The “table sugar” sample of C & H pure cane sugar has a very uniform particle size and would be categorized as a medium sand. Though having an average particle size that is generally larger than what could be said was optimal for our purposes based on previous propellant castings, this particle distribution size would be suitable for the Sugar Shot to Space project. Currently, no specifications with regard to grain size distribution exists for KNO_3. This may be an area where a study could be undertaken to determine the optimal particle size for a viscosity needed to be “pourable” and for other desirable characteristics such as Isp, cure time, burn rate, and fracture toughness as needed for Sugar Shot to Space.

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