



DoubleSShot

pH and Sieve Analysis of *pkunlimited* KNO₃

Rev. 2011/03/28

Objective

The purpose of this analysis is to determine the KNO_3 pH and particle size distribution. The pH of the oxidizer appears to have an effect on the caramelizing of the sugar propellant when heat/melting in the casting process. 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. The pH result and data obtained from this grain size distribution is used to determine suitability of the KNO_3 sample for propellant grain casting that requires the propellant to be “pourable” and respond to vibration table settling technique presently used to reduce voids and increase propellant density.

Testing

Two properties are being tested in this analysis; pH and particle size distribution. The pH of the sample was tested and a particle size determination of the relative proportions of grain sizes.

Apparatus Required

- pH strips or pH meter
- 100 ml graduated cylinder
- Thermometer
- Glass cup
- Distilled water
- 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

PART ONE pH

The potassium nitrate (KNO_3) needs to have a nearly neutral or slightly acidic pH. The pH test is done by dissolving a 20.0 gram sample of the oxidizer into 100.0 ml of distilled water. The solution needs to be at a temperature of 20 °C prior to the pH testing. This can be done with a pH meter or suitable pH testing strips. The testing strips used in this investigation were *pHydrion* 1-12 pH paper strips.

Results

The pH paper strips indicated a pH very close to 7.0 as illustrated in the following picture. It may be 6.5 as it stings like an acid on cuts (from personal experience). This pH is within the required range of 5.5 – 7.0 and is within the acceptable range with regards to the required pH.



Figure 1 pHydrion pH strip test of "pkunlimited" KNO_3

Procedure

PART TWO particle size

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. Five sieve sizes were used, US Standard #10, 35, 60, 120, and 230 from Hubbard Scientific. Size #10 was used to help break up any clumps though very little was seen in the sample.

The sieves were cleaned, washed, and thoroughly dried for twenty four hours in twenty-eight percent humidity air. The sieves were then weighed with the weights recorded. A 20.00 gram dried sample of KNO_3 was measured and placed in the #10 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

The cover showed no signs of KNO_3 but was weighed. Visually, the pan showed the most KNO_3 collected with varying amounts retained by the 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	55.26	55.26	0.00	0.00	0.00
10	2,000	167.56	167.56	0.00	0.00	0.00
35	500	158.51	161.42	2.91	14.55	14.55
60	250	152.85	161.49	8.64	43.20	57.75
120	125	143.37	149.38	6.01	30.05	87.80
230	63	139.70	141.66	1.96	9.80	97.60
pan	< 63	127.29	127.76	0.47	2.35	99.95

Table 1 “pkunlimited” KNO_3 particle size distribution



Figure 2 Sieves and pan with KNO_3 retained.

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 are -35/+120 sieve size or between 125-500 micron and could be characterized as sand like. As such, this KNO₃ particle size distribution should be acceptable in regards to propellant casting viscosity.

Conclusion

The sample of KNO₃ Obtained from ebay seller “pkunlimited” in Oceanside, California was found to have a pH that is acceptable for our propellant casting process without the need of additives. It was also found that the particle distribution size is suitable for the Sugar Shot to Space project though no specifications with regard to grain size distribution currently exists for KNO₃. 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 cure time, burn rate, and fracture toughness as needed for Sugar Shot to Space.

March 28, 2011 update:

KNO₃ obtained from “pkunlimited” has been used successfully for ProtoSShot-III, several finocyl and star unigrain motor tests and was used in the MiniSShot-I flight. While there is nearly 200 pounds remaining, this is only enough for the DoublesShot boiler plate motor. Contact with pkunlimited is no longer possible as the phone has been disconnected and is no longer at the last location of pick up and has also been delisted as a seller on ebay with the last transaction listed as January, 2011.

A new source KNO₃ is now necessary.

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