Jet Fuel Particulate Removal

Magnetic Separation as a Method to Improve Product Quality

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3 minute read

"We have already noticed a significant reduction in traditional filter use compared to last year based on 2 months of operation."

- Darrel Johnson, GM, Menzies Aviation

Problem

Hydrocarbon liquids, gasses and refined products often collect significant amounts of black powder contamination (or rouge) in pipeline systems. This black powder contamination consists mainly of iron oxide and iron sulfide compounds; these compounds are typically under 10 microns in size and often in significant quantities down below 1 micron. Unfortunately, it can be costly to clean jet fuel and other refined products with single-use depth media membrane filters.

Issues with black powder in these systems include:

- Degradation of product quality;
- Erosion and abrasion of pipelines that results in black powder contamination;
- Damage to pipeline pump and meter components;
- Costly filter replacement and hazardous waste disposal; and
- Potential for black powder under 1 micron to enter the aircraft reservoirs.
- Continuous hazard exposure by personnel.

The Nashville airport receives ~80% of its jet fuel from a large US refined products pipeline system. Black powder contamination introduced during transportation requires 5-micron disposable filters, clay packs, 3-micron pre-filters and finally 0.5-micron filters to ensure high product quality when entering the jet fuel storage tanks. The high cost of traditional filtration driven by a need for improved product quality drove the Nashville airport to consider alternative cost-effective methods for black powder contamination removal.

Figure 1. Magnetic separator installed upstream of tankage at airport fuel facility.

Solution

In 2018, the Nashville airport ran a test with a Black Powder Solutions' (BPS) test magnetic separator on a jet-fuel slipstream. Based on the success of the test, the airport purchased and installed a full-size magnetic separator to process its ~4,400 barrel batches that are typically delivered over 3.5 hours from the connected pipeline system. The magnetic separator is the first line of defense for removing black powder as it is upstream of the various other conventional filtration systems. This unit has a magnetic array capable of holding up to 425 pounds of contamination before cleaning is required and is currently on a 4 month cleaning cycle.

Results

The contamination removed from the magnetic separator during the 1st cleaning was sent out for lab analysis. That analysis indicated that (i) 20% of the contamination was at or under 1 micron in size with the median particle size at 37 microns **(Table 1)** and (ii) much of the black powder contamination consisted of iron-based compounds typical of pipe scale **(Table 2)**. In excess of 10% of the black powder was under 0.5 microns, which would have passed the last stage of conventional filters and accumulated in the jet fuel tankage and further downstream. Subsequent 0.8 micron Millipore patch tests done both upstream and downstream of the magnetic separator identified a marked improvement in fuel quality and cleanliness **(Figure 3)**.

Figure 2. Contamination collected on magnetic elements from one 4,400 barrel batch of jet fuel over 3.5 hours.

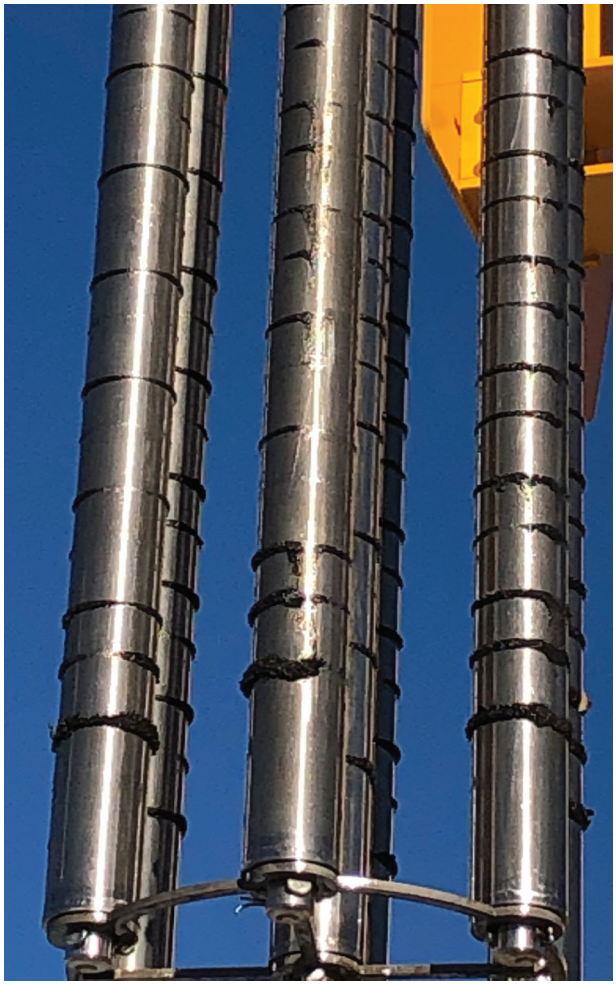
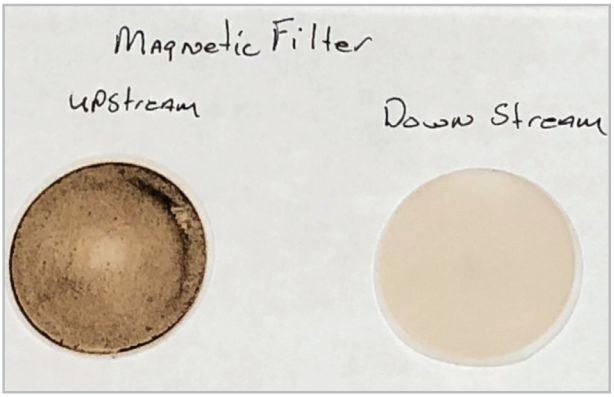


Figure 3. 0.8 micron Millipore Patch Test Results from fuel samples taken upstream and downstream of magnetic separator.



SEM ANALYSIS RESULTS

Table 1. Particle size distribution stats.

SIZE (μm)	
Maximum	14000.00
Minimum	0.14
Mean	143.02
Median	36.67
Range	13999.86
Quartile1	1.42
Quartile3	180.00

Figure 4. SEM microscopic image of particulate contamination.

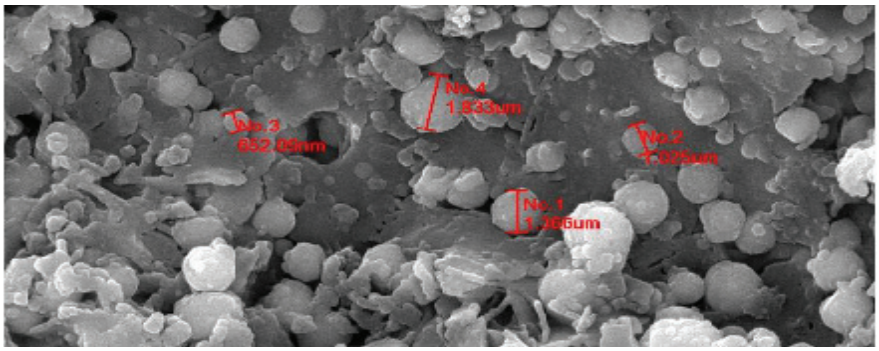
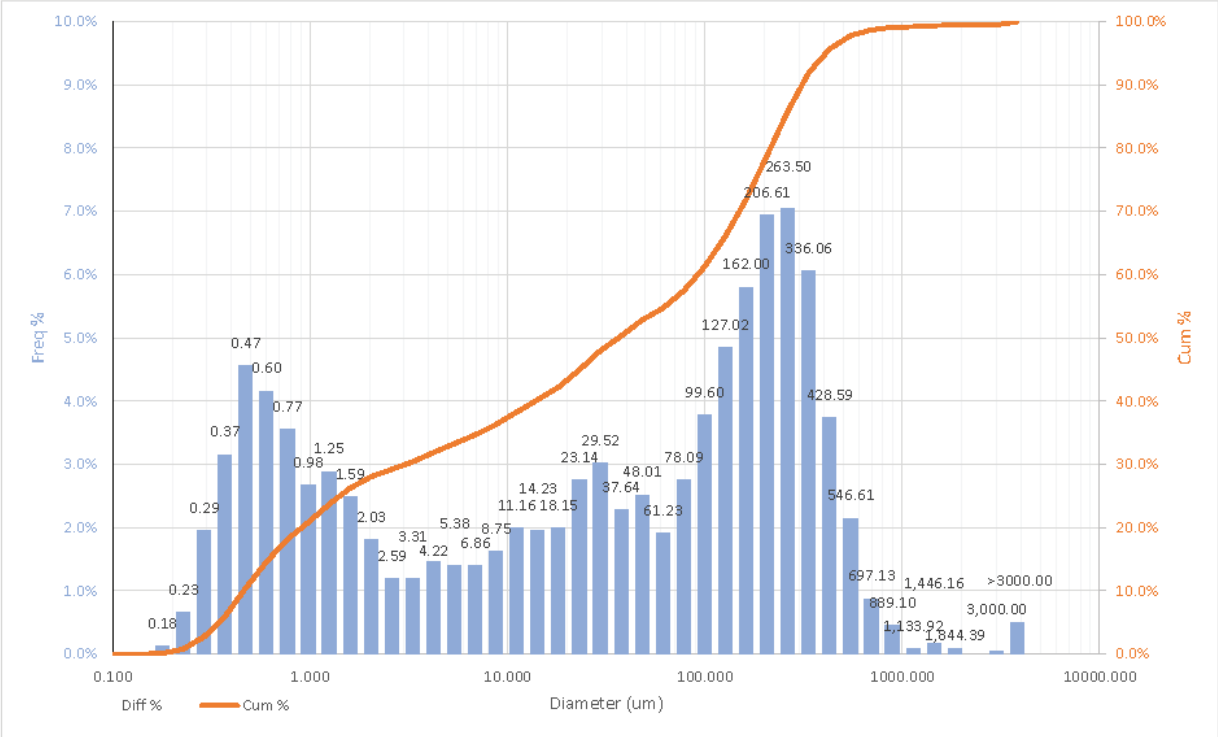


Figure 5. Histogram that illustrates particle size distribution.



XRD/EDS ANALYSIS RESULTS

Table 2. XRD quantitative analysis results stating composition of jet fuel contamination.

Mineral Name	Compound Name	Chemical Formula	Weight
Magnetite	Iron Oxide	Fe3O4	34.06
Goethite	Iron Oxide Hydroxide	FeO(OH)	42.8
Ledipocrocite	Iron Oxide Hydroxide	FeO(OH)	1.2
Rutile	Titanium Oxide	TiO2	0.5
Quartz	Silicon Oxide	SiO2	3.7
Wustite	Iron Oxide	FeO	7.3
Other	--	--	10.44
		Total	100