The dirt on sulfur remelting

Izza Humayun, Enersul Limited Partnership, Canada, outlines a recommended approach to managing contaminated sulfur.

Contaminated sulfur cleanup can be a daunting task. It is natural to seek the cheapest and quickest methods of removal. Unfortunately, the nature of sulfur can pose a hazard to the environment and requires appropriate and sometimes costly methods for handling, treatment or disposal. To make a well informed decision on a method, it is vital to understand the plausibility, process, and potential complications of these options in relation to the specific situation, as well as their associated costs.

Dealing with contaminants

Due to stricter environmental regulations in recent years, a need exists for the reduction of sulfur pad usage. As a result, many producers are required to remove existing sulfur blocks, including their sulfur base pads. Contaminated sulfur in the base pad of a storage block usually results from poured liquid sulfur intermingling and solidifying in the soil and bonding with impurities existing there, unless a proper base pad lining was employed. Further contamination can occur during reclamation when the remaining layer of sulfur is being scraped from the ground and the equipment picks up surrounding organic and inorganic materials. Contaminated sulfur may also be gathered during site cleanup and requires similar treatment to base pad sulfur.

Remelting contaminated sulfur poses many difficulties for obtaining consistent results as every case of contamination is different. Results obtained from clean sulfur remelting are incomparable since the success of sulfur remelting depends largely on the level or characteristics of the contaminants. The highest concentration of contaminants in a sulfur block is in the lowest layers.

Every site deals with a unique blend of contaminants. Both organic and inorganic contaminants may be present and though organic contaminants are present in a lesser proportion to inorganic, they can cause greater performance issues. Inorganic contaminants are insoluble materials such as rocks, gravel, shale, clay, silt and sand. Fines such as silt may take an excessive amount of time to settle in the melting tank or may

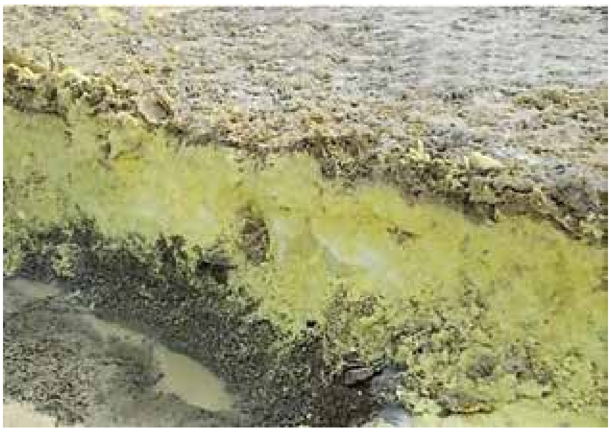

Figure 1. Intersectional view of a sulfur base pad during reclamation.

Figure 2. Remelting pit heating coils covered with contaminant.

not settle at all; instead staying in the flow of liquid sulfur. Likewise, ash content may remain in the final sulfur product.

Organic contaminants dissolve or react to an extent in liquid sulfur, which can generate H_2S, cause discolouration of the sulfur and foul the equipment. One example is car-sul, a polymer formed by the reaction between carbon and sulfur, which can foul the process equipment and plug filter surfaces if it is found in excess quantities. Grass, pine needles, cones, leaves and topsoil were found to discolour sulfur after being heated for a few minutes at 250°C or after an extended period at 140°C, which is within the range of normal remelt sulfur temperatures. Upstream plant upsets could also be a cause for high concentrations of alkanolamine or hydrocarbons, which would be retained in the sulfur as it is poured into a sulfur block.

Unnecessary mixing of soil and sulfur can occur during reclamation. Organics such as soil and biomass are dug up during base pad reclamation if a concrete or asphalt base was not used. The care that is used in extracting the base sulfur can significantly affect the level of contamination that needs to be dealt with. A poorly prepared sulfur pad and inadequate paving for reclamation equipment will only escalate the contamination. If this occurs, the refuse soil may have high entrained sulfur content when it is removed from the remelter, thus requiring treatment with an acid neutralising agent, such as limestone, before disposal.

High moisture content in the raw material greatly affects melting efficiency. Every 1% of moisture adds approximately 15% of extra useful heat required for remelting. Higher moisture content also leads to more acidic conditions inside the remelter. Likewise, rain water entering a remelter creates higher acidity when mixed with liquid sulfur, which then corrodes the equipment. For this reason, high acidity dramatically affects the equipment life span. Moisture content also creates foam on the surface of the liquid sulfur, which is at risk of overflowing from the remelter if the appropriate head space was not incorporated in the design. In one example of a pit remelter, 4% moisture was found to create as much as 22 in. of foam.

The higher the level of contamination in the remelter feed stock, the more frequently a remelter needs to be cleaned; particularly if it doesn't have continual refuse removal. As contaminants collect in the bottom of the remelter, the heat transfer from the heating coils is impeded which negatively affects the performance. If the sulfur is extremely contaminated (over 50%), remelting and filtration may still be possible, but may not be practical because the material will not become mobile enough when heated above the melting temperature of sulfur. The size distribution of contamination (coarse versus fine) has a significant impact on the separation efficiency through remelting.

Remelters may be in either a pit or tank form and may use periodic or continual refuse removal. Tank remelters have much more room for variation in design and potential improvements, compared to a pit remelter.

Table 1. Performance test results of the HCSR

		Test 1	Test 2
Raw Material	Sulfur content	79.5%	70.8%
	Contaminant content	14.5%	22.3%
	Contaminant fines (<106 µm)	36.9% (of total contamination)	21.9% (of total contamination)
	Moisture content	6.0%	6.9%
Liquid Sulfur	Sulfur content	92.5%	94.6%
	Contaminant content	7.5%	5.4%
	Contaminant fines (<106 µm)	81.7% (of total contamination)	98.3% (of total contamination)
Auger Refuse	Sulfur content	6.8%	26.9%
	Contaminant content	93.2%	73.1%
Sulfur capture		99.3%	90.3%
Contaminant capture		55.7%	83.6%

Note: Units are scalable to meet required throughput capacity

However, environmental regulations are the main driving factor for remelting technology selection.

The reality is that disposing of base pad sulfur may be a necessary and unavoidable expense. This is why it is important to have a realistic understanding of what work and resources need to go into a reclamation project, and how to properly plan to avoid escalated costs due to poor handling and improper evaluation of the situation. The first step is to determine if remelting to extract the sulfur is even feasible. By first investing in an analysis of the contaminated sulfur, the best course of action can be determined.

Sulfur analysis

Enersul offers services to perform analyses on sulfur samples. The samples need to be representative of the entire contaminated sulfur source. If significant variation exists in the sulfur source and collecting a representative sample is challenging, multiple samples can be submitted. Tests are conducted on the samples to determine properties such as:

- H_2S content.
- Moisture content.
- Sulfur content.
- Acidity.
- Recoverable sulfur.
- Particle size distribution.
- Fines settling velocity.
- Carbon and ash content.
- Refuse sulfur content.
- Landfill classification.

It is possible to then determine whether the contaminated sulfur is capable of being processed and detect potential safety hazards. At this point, client input is required to begin the design basis for information such as:

- What is the minimum purity requirement of the output sulfur? What composition standards will the sulfur be marketed or sold to? This is directly linked to the design of the settling tanks, residence times, throughput and filtration.
- What is the target throughput? Once the determination of recoverable sulfur is complete, a system throughput requirement (per day) can then be determined. A higher throughput requirement inherently changes the design and cost accordingly.
- What standards does one design to? Are there national, regional, or company regulatory requirements, standards and practices to comply with?

Solutions

If remelting is found to be feasible, one can determine a range and throughput that the remelter can achieve based on input conditions. If the inputs to the remelter change, the purity level and throughput of the project will also change. The target will be to minimise sulfur content in the refuse soil and contaminant content in the sulfur product. Once these clarifications have been made and the raw material analysis completed, equipment design can begin and the associated costs can be determined.

It is important to understand the possibilities of what can be realistically achieved. Enersul's experience includes remelting over 270 000 t of sulfur with mild to major contamination at various sites in Alberta, Canada, and conducting performance tests for Enersul's Highly Contaminated Sulfur Remelter (HCSR). The HCSR is a tank type remelter, which utilises an auger conveyor for continuous refuse extraction and liquid sulfur circulation to improve heat

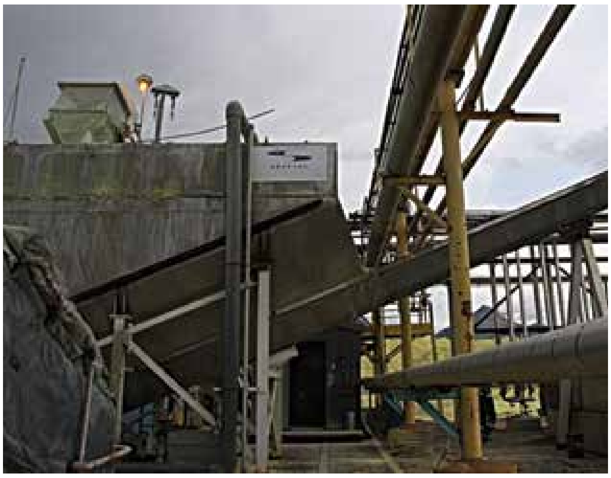

Figure 3. Enersul's HCSR remelter.

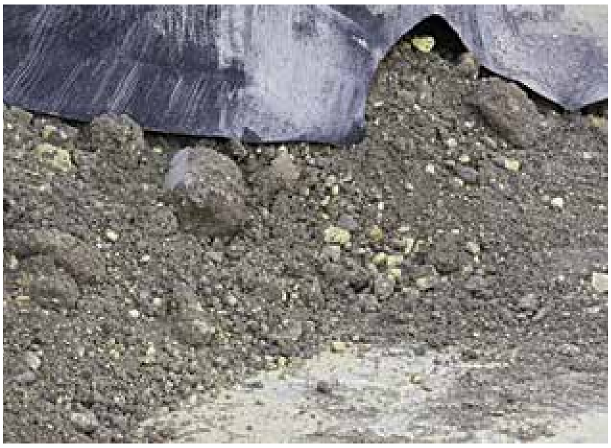

Figure 4. Test 1 raw material (approximately 80% sulfur content).

Figure 5. Test 1 refuse material.

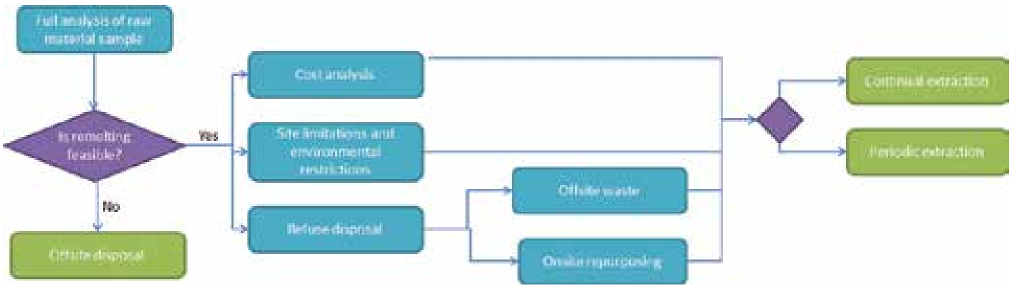

Figure 6. Decision tree for contaminated sulfur disposal.

distribution and temperature control. The performance test results are shown in Table 1.

The extraction of high purity sulfur from contaminated base pads requires more than one stage of processing and Table 1 reflects only the first stage of separation. However, the raw material was successfully processed in both tests despite higher moisture content and significant fine contaminant content. Note that the vast majority of the remaining contaminants in the liquid sulfur were solid fines, indicating that fines are more difficult to remove. In these cases, the refuse was neutralised, blended with gravel and used as used as road filler on site and the costs of future treatment and land filling were completely avoided.

Ultimately, the decision process for contaminated sulfur disposal comes down to a cost analysis after determining the viability of all possible options. The available options depend on the sample analysis results. If remelting is not found to be feasible, the contaminated sulfur would need to undergo treatment and be sent to a landfill designated for hazardous waste disposal. If remelting is found to be feasible, the equipment design will depend on the cost analysis, environmental restrictions, and available methods of refuse disposal. Naturally, the cost of the remelting equipment varies significantly depending on the design. Offsite disposal costs can be substantial given that the material would need to be transported to a landfill which may be a significant distance from site. Ideally, a user should be able to reduce the tonnage that needs to be landfilled and recover clean sulfur that can render a profit.

Conclusion

A front end investment in sample analysis, careful planning and proper equipment selection can prepare an owner for any scenario and save them money in the long run, thus reducing the chances of additional costs due to unforeseen complications. In addition, more energy should be invested in utilising proper reclamation methods to reduce the level of contaminant a user may have to deal with in the first place. Through every phase of contaminated sulfur handling, Enersul can offer its services so that customers can make informed decisions.

References:

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