RECLAMATION OF SHATTERED METAL USED IN SYNTHETIC FIBER PRODUCTION

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Abstract

Shattered metal can be used as a filtration medium in the production of polyester and nylon fiber used in industries such as textile & carpet manufacturing.

A reclamation process that successfully removes polyester and nylon from polymer-encapsulated shattered metal plugs provides the user improved product economics along with the creation of a sustainable process that eliminates landfill disposal.

A successful reclamation process effectively cleans and puts the reclaimed metal into the desired specification for the user without adversely affecting the metal particles. This paper discusses the benefits and process of metal reclamation.

Introduction

Each year, a typical polyester fiber plant may use as much as 50K lbs of shattered metal at a cost of ~$300K/yr. CMAI forecasts the global polyester fiber market to grow from 27mm tons in 2006 to 36mm tons in 2011 which is an increase of 33% [5]. Since the majority of polyester fiber producers use shattered metal in their processes, a similar growth will become apparent for shattered metal. Unless reclamation processes are put into place, the resulting polymer encapsulated plugs of shattered metal are then destined to be landfilled.

Shattered metal, glass beads, sand, and screens are typical filtration media [5] used in the production of synthetic fiber. Synthetic fibers are used in the production of textiles, carpets, tire cord, and a variety of other applications. The selected filtration medium or combination of media is put into a spin pack in some sort of configuration (Figure 1) depending on the pack design. [1].

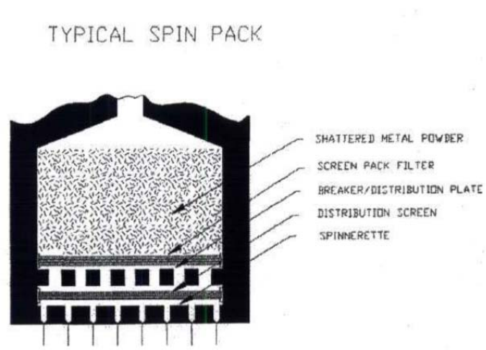

Figure 1. Typical Spin Pack showing shattered metal [1]

The spin pack is then put into the users' process lines where molten polymer is allowed to flow through the spin pack and produce fiber (Figure 2).

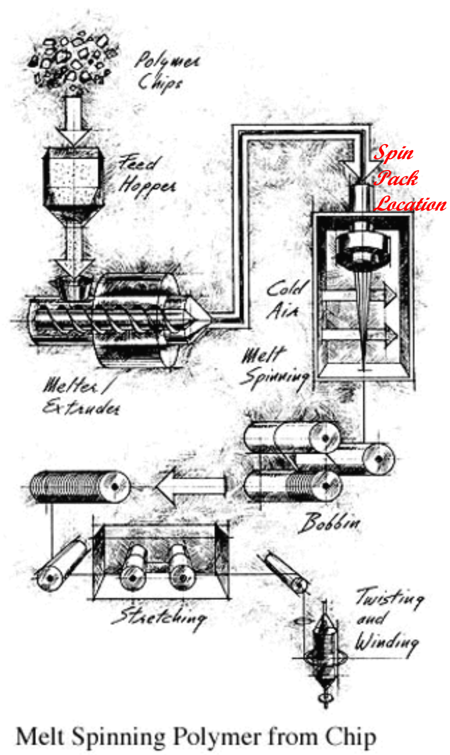

Figure 2: Location of spin pack in a process line [2].

After use, the spin pack is disassembled for cleaning, whereby; the polymer-encapsulated filtration medium is deposed of and replaced with virgin material (Figure 3)

	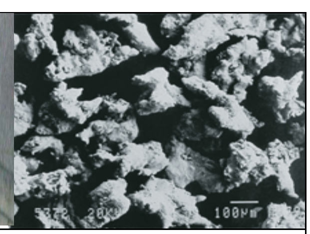
Polymer-Encapsulated Shattered Metal Plug	Shattered Metal Powder for Re-use

Figure 3. Shattered Metal [3]

Sources of shattered metal have historically been from global virgin metal suppliers who have proprietary processes, such as atomization, to convert base metal into metal powder. As the international market for mined metals fluctuates, so does the availability and pricing for the distribution and sale of shattered metal.

Global economics and environmental mandates have begun to push manufacturing sites toward greener processes and reclamation instead of disposal.

There are end-users who have in-house solvent and burnout processes to reclaim metal internal to their facility; however, reclamation using solvent chemistries produces waste water and waste solvent streams contaminated with metal that must be landfilled, incinerated, or treated. Burnout processes alone do not provide clean metal and can also offer air emission and waste metal fines problems.

Carolina Filters has developed a non-destructive, effective, and environmentally responsible reclamation process for shattered metal. In the following sections, the reclamation and testing processes are described, along with basic fundamentals of why shattered metal is the filtration of choice for many fiber producers.

Process Description & Layout

In the reclamation, process, polymer-encapsulated shattered metal plugs from spinning equipment are placed on racks in ovens equipped with specialty temperature controls and after-burner exhaust features. The racks are designed to separate components of the plug during the heating process. Afterwards, bulk metal from depolymerized plugs goes through a washing/drying process followed by separation of metallic & non-metallic components. Once a cleaned stream of shattered metal is produced, it goes through a sieving process to control particle size distribution per the users' specifications. When the sieved shattered metal has been collected, samples per lot are tested to produce a Certificate of Analysis (COA). The COA values must fall within the specifications for that grade of metal.

Tests used for reclaimed metal are the same as those used for virgin metal:

1. %Carbon,

To determine % carbon, the tared weight of sample of reclaimed metal is processed in an oven at 900F for 20 minutes. After cooling, the post-oven tared weight is determined and the % carbon calculated:

$$\% C = 100 \times (W_1 - W_2)/ W_1 \qquad (1)$$

where, C=carbon, W_1 = pre-oven metal weight (grams), W_2= post-oven metal weight (grams)

2. Apparent Density

Apparent density is an indicator of void volume in a sample of metal. The apparent density is the value determined by equation 2 when weighing a container of known volume that has been filled with metal powder. The device used to measure apparent density consists of a container of known volume and a special orifice that controls the flow of metal into the container so that "metal packing" is prevented.

$$AD = W/V \qquad (2)$$

Where AD= apparent density (g/cc), W=tared weight of metal, V=volume of the container.

3. Sieve Analysis (Table 1)

The sieve analysis is determined by using a rotap equipped with proper screens for the specific grade of metal and the user's specification. Once a sample of reclaimed metal has been processed through the rotap screens, the weight of metal captured on each screen is weighted and compared to the user's specification.

Specification: Grade30/60		**COA**	
Mesh	**% Metal**	**Mesh**	**% Metal**
+30	<10%	+30	4.59%
+60	Bal	+60	87.20%
-60	<15%	-60	8.12%
-100	<1%	-100	0.06%
-325	Trace	-325	0.03%
		Total	**100%**
AD	1.60-2.00	**AD**	1.72
%C	0%	**%C**	0%

Table 1: Sample Specification & COA [6]

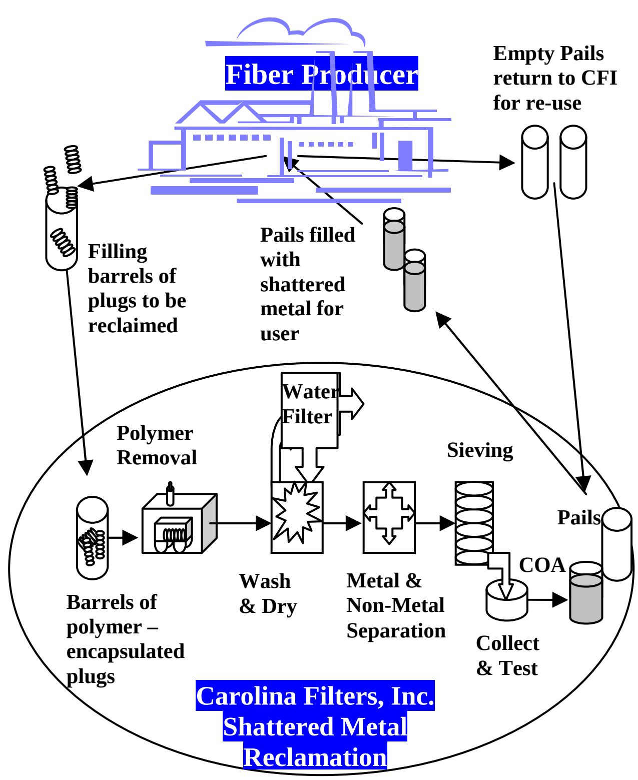

Figure 4: Lay-out of reclamation process [3]

Discussion

Metal reclamation provides ***'a sustainable option'*** for users greatly reducing concerns over the availability of virgin powder and the associated rising costs. Instead, the users can depend on the availability of metal and long-term pricing stability.

In terms of "re-usability" and ***sustainability***, users report

- the same or improved on-line performance
- elimination of disposal into landfills
- elimination of regulatory issues associated with land-filling
- competitive edge due to realized savings between the reclaimed & virgin metal

The reclamation process itself is environmentally friendly in terms of

- <u>Energy-use for reclamation</u>: Per pound of metal reclaimed, energy usage is less than 7 kilowatts/lb.
- <u>Solvent/chemical-free process:</u> No solvents or chemicals are used in the reclamation process. For rinsing, only water is used which can be filtered & recycled for future washing processes or other uses.
- <u>Recycling of shipping containers</u>: Users will return empty shipping containers to be used for future shipments. In general, approximately 5 shipments/container are possible before discarding the container or using it for other purposes. Recycling plastic shipping containers also reduces the amount of material going to landfills.
- <u>Minimization of wastes going to land-fill</u>: Reclaimed shattered metal yields are ~96% per batch of cleaned metal. As a result, reclamation eliminates land-filling 100% of polymer & 96% of the shattered metal. The residual 4% of metal that cannot be reclaimed is generally metal fines due to attrition; however, other uses for the fines are being researched.

For the users' process parameters, reclaimed metal must meet or exceed the on-line performance of virgin metal. To ensure a quality product, important characteristics of any grade of metal must be considered, such as:

1. <u>**Metallurgy**</u>**:** The users' process conditions determine the metallurgical needs of the metal. For example, a high nickel content P-270 grade is more resistant to oxidation that a standard DP1 grade.[5] As a result, when reclaiming a wide variety of in-coming metal streams, attention to metallurgy is important so as to not mix metals of similar grades but different metallurgies.
2. <u>**Characteristics of metal edges**</u>**:** The more irregularities and sharp edges on metal particles, the less packing that will result among the metal particles and the more void spacing will result. (Figure 5). The amount of sharp edges also relates to the ability of the metal to lock when loaded and pressed into the spin pack. In terms of filtration, the sharp edges are important in removing gels and other contaminants. [7]

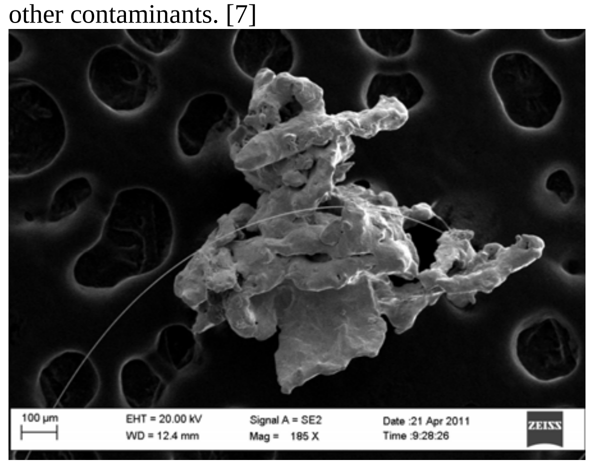

Figure 5: Sharp edges on reclaimed shattered metal particle

3. <u>**Metal fines:**</u> A quantifiable small amounts of metal particles outside of the specified grade can lead to plugged spinneret capillaries and a difference in the filtration level of the pack. During the sieving part of the process, it is extremely important to determine the proper combination of screens and screening techniques to ensure the metal powder is put into proper specification with minimal fines.
4. <u>**Cleanliness:**</u> Reclaimed metal should be free of carbon and organics. The removal of inorganic is important to reduce contamination issues when a user's incoming stream goes to a different user.
5. <u>**Specifications:**</u> A user desires metal that meets the specification of his filtration needs. When reclaiming shattered metal, it is extremely important to understand and use the proper sieving technology and techniques. Incorrect particle separation can produce quality and on-stream life process issues.

Case Study 1

A polyester fiber producer recently began using reclaimed shattered metal. Initial trials revealed no adverse process effects of reclaimed metal vs virgin metal. After 12 months of using reclaimed metal, the on-stream performance is the same as virgin; however, there has been a savings of ~$210K relative to metal purchase and an additional savings on landfill disposal of ~120K lbs of polymer-encapsulated metal plugs.

Case Study 2

A nylon producer noted the following:

> "We have been testing the reclaimed metal against the virgin metal that we use on a routine basis. All testing thus far confirms that the reclaimed metal meets all the standards for filtration and distribution as the virgin metal currently being used. The results of the carpets made with virgin and reclaimed metal will be the last test item to review before implementing the use of reclaimed metal on a routine basis. Everything looks good thus far and we fully expect to be able to take advantage of the cost savings and reducing our impact on the environment."

Case Study 3

A polyester producer was required to dispose of the polymer-encapsulated shattered metal plugs as hazardous waste because of the Cr and Ni content in the metal. As a result, not only did the disposal costs increase but the additional waste-stream threatened to change the user's waste generator status. Being able to reclaim the metal resulted in not only savings on disposal costs but kept the site from becoming a large quantity generator.

Conclusion

When operating an efficient and effective reclamation process, shattered metal can successfully be removed from polymer-encapsulated plugs for re-use without affecting the quality of the metal product.

Shattered Metal Powder can be reclaimed utilizing various methods of depolymerization, separating, and sieving. Reclamation process produces a product that:

- Has a lower concentration of fines as compared to virgin material
- Is more economical than virgin material
- Provides a relatively green and sustainable process [8]

Key Words: Shattered Metal, Apparent Density, Sieve Analysis, DP1

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