ENVIRO**Strip**® **Plus** WHEAT STARCH DRY STRIPPING MEDIA

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ABSTRACT

The importance of maintaining a wide mesh size range for optimum performance of ENVIRO**Strip**® wheat starch media has been well documented. ADM has recently developed a new mesh size range to enhance the performance of ENVIRO**Strip**® wheat starch media and simplify media management within a dry stripping facility. This new mesh size product, known as ENVIRO**Strip**® Plus, can be particularly useful in large-scale production situations. This product is the result of a new grinding procedure that creates an "all purpose" wide mesh size distribution that is more productive out of the barrel. The potential operational and economic advantages of ENVIRO**Strip**® Plus will be reviewed and discussed.

INTRODUCTION

In 1994, ADM/Ogilvie presented data[1] that characterized the evolution of three different media mesh sizes 12/30, 30/50 and 30/100. In this study, the media was recovered and blasted repeatedly to obtain strip rate data as a function of the number of blast cycles the product was used. These strip rate curves were then compared to a media mix replenished with 12/30 size wheat starch media. The results confirmed that optimum wheat starch media strip rates could be achieved by maintaining a broad particle size range. Constant replenishment of the working media with 12/30 size media was deemed to be the most economical method to achieve this.

Until now, the phenomena responsible for increased stripping efficiency of different product sizes could not be fully explained. One theory held that the creation of many small angular or "sharper" particles, through blasting of the wheat starch media, was responsible for the increase in efficiency. While this factor seemed to play a role, the ADM/Ogilvie study in 1994 also suggested that small particles on their own could not achieve optimum strip rates. It was evident that large particles needed to be present as well. And as suggested by others, changes in moisture content of the wheat starch media can affect the stripping efficiency, but it cannot fully account for the differences in stripping efficiency.

The mechanism of wheat starch coating removal needed to be better understood. The role of particle size, which had been explored in an earlier work, needed to be more clearly defined. In 1995 a graduate research program was undertaken at the University of Toronto to investigate the coating removal mechanism of wheat starch media. This program was led by Jan Spelt and funded by Industry partners ADM/Ogilvie, The Canadian Department of National Defence, and the Natural Sciences and Engineering Research Council of Canada. This recently published work[2] proposes new insights into the phenomena behind wheat starch coating removal. This work also helps to explain why the new ENVIRO**Strip**® Plus wheat starch media offers improved coating removal efficiency.

The objective of this paper is to compare the basic performance of ENVIRO**Strip**® Plus to 12/30 and 30/100 size media, and to elaborate on some aspects of the mechanism by which wheat starch media removes coatings.

DISCUSSION

EXPERIMENTAL PROCEDURES

1. Blasting Test Equipment

Testing was conducted in a modified Pauli Systems RAM 31 hand cabinet using a $^3/_8$-inch nozzle. In all tests conducted, blast pressures were continuously monitored at the pressure pot by a digital pressure gauge. Nozzle pressures were verified at the beginning of every blast cycle by two different needle gauges.

2. Product Breakdown/Consumption Rates

For media breakdown tests, thirty-pound batch quantities of ENVIRO**Strip**® 12/30 and Plus mesh sizes were evaluated in the hand-cabinet. A 0.250-inch thick plate of 7075 T-6 aluminum was used as the blast target. A six-blast cycle test was performed to determine the amount of media waste that would be produced, when tested under the parameters listed below.

ENVIRO**Strip**® Wheat Starch Media Parameters

Nozzle type	$^3/_8$-inch Double Venturi
Nozzle pressure	35 ± 1 psi
Media flow rate	8 - 9 lb/minute
Nozzle angle	45 degrees
Nozzle distance	6 inches

3. Coated Test Panels

An aerospace contractor, in accordance with USAF guidelines, prepared the coated test panels. The substrate material was 0.032-inch 2024 T-3 clad aluminum. The coating system applied was Mil-P-23377 epoxy polyamide primer followed by a Mil-C-83286 polyurethane top coat. All panels were artificially aged using a 7-day room temperature cure followed by a 210°F oven bake for 96 hours. All panels met or exceeded coating hardness (4H) and dry adhesion (4B) properties.

The coating thickness of the panels was measured with an Elcometer instrument. Coating thickness values ranged from 5.5 – 7.0 mils, which is higher than USAF specifications.

4. Strip Rate Tests

Each ENVIRO**Strip**® mesh size was tested for stripping efficiency on the coated test panels described above. The same blast parameters used during the breakdown tests were employed. The hand-cabinet cyclone was adjusted to remove media between 100 and 120 mesh in size.

DISCUSSION OF RESULTS

1. Product Breakdown/Consumption Rates

Using the parameters above, the breakdown rate of ENVIRO**Strip**® Plus was compared to ENVIRO**Strip**® 12/30 size media. After 6 cycles, both the working media and dust lost to the cyclone were recovered and weighed. A mesh size analysis was performed on the remaining media and the total waste generated (i.e. media <100 mesh US Std.) was calculated. The results indicated an average of 6.9%/cycle breakdown rate for ENVIRO**Strip**® 12/30 and an 8.0%/cycle breakdown rate for ENVIRO**Strip**® Plus.

2. Mesh Size Analysis/ Scanning Electron Micrography

The mesh size analysis of each product was carried out according to ASTM STP 447 B. Figures A-1, B-1, and C-1 in Appendix 1 present the mesh size distribution of ENVIRO**Strip**® 12/30, ENVIRO**Strip**® Plus, and a "typical production mix". The typical production mix, designated as "Pmix", is representative of a working media used by many ENVIRO**Strip**® users.

Scanning electron micrographs (SEM) were taken of each product and are presented in Figures A-2, B-2, and C-2 along side respective mesh distribution charts. The difference in these products is very apparent when viewing the charts and SEMs.

The 12/30size material has virtually 100% of particles greater than 30 mesh (US Std.) in size. The ENVIRO**Strip**® Plus size still has the majority (i.e. 65%) of particles greater than 30 mesh, with approximately 35% below 30 mesh. The "typical production mix" (Pmix), can have all but 10% of the particles under 30 mesh. Finally, if we were to show the mesh size distribution of 30/100, we would see that practically 100% of the particles would be found below 30 mesh.

Djurovic etal[2], in the University of Toronto Study, measured the particle size optically and reported average particle diameters (see Table 1).

Table 1. Average Particle Diameter of Different ENVIRO Strip**® Products.**

ENVIROStrip® Product Mesh Size	Below 30 Mesh Size (US Std)	Average Diameter (mm)
12/30	< 5 %	1.1
Plus	35 %	N/A
Pmix	90 %	0.4
30/100	> 99 %	0.4

Since past work has shown that a media mix with finer particles is more efficient, it suggests that the bulk of the coating removal work is accomplished by particles in the 30 to 100 mesh size range. However, as shown by Djurovic et al, improvements in wheat starch media stripping efficiency cannot be fully explained by the average particle size or average particle diameter. The stripping performance of 30/100 and Pmix has been compared in previous studies, and although the average particle size is approximately the same, Pmix achieves substantially higher stripping rates.

3. Strip Rate Results

The strip rate results obtained with ENVIROStrip® 12/30, 30/100 and Plus sizes are presented in Figure 1. When considering the strip rate levels, bear in mind that these rates were achieved on tenacious coating systems using a 3/8-inch nozzle in a hand-cabinet.

As each product was blasted or used, strip rates increased with use from blast cycles 1 through 5. The obvious trend is that as each product was used and became smaller in size, stripping efficiency improved. However, strip rates levels of each product differed substantially on first use, and stripping efficiencies did not improve to the same degree with each product.

The Plus size, with large (>30 mesh) and small particles present, started stripping on the first use, with strip rates increasing to the highest level (at cycle 5). The 30/100 size, which has virtually all particles below 30 mesh, started stripping at the same level as the Plus size, but only attained 60% of the Plus size strip rate (at cycle 5). By the fifth cycle, the 30/100-size product had been reduced to a very fine size, with particles mostly in the 60 to 100 mesh size range. The 12/30 size, as expected, achieved the lowest strip rates through cycles 1 to 5. The 12/30 strip rates increased to only 40% of the Plus size by cycle five.

Comparing 30/100 and the Plus sizes at the fifth cycle, the major difference between these products was that large particles were still present in the Plus size, whereas the 30/100 size had been reduced to quite a small particle size. On the fifth cycle, the Plus size was very similar to Pmix as presented in Figure B-1. The majority of particles were below 30 mesh, yet some large particles remained.

Thus, as can be seen from this strip rate comparison, the Plus size, which has a broader size range, achieves the best stripping efficiencies overall. The Plus size begins with modest stripping efficiency when new, and achieves optimum performance similar to Pmix, within 5 cycles of use.

4. Wheat Starch Media Coating Removal Mechanism

The above data supports the theory that both large and small particles need to be present to achieve optimum stripping efficiency. The study by Djurovic et al also identified this factor as key, and proposed a mechanism for wheat starch coating removal. Particle velocity measurements were used to build a simple model that indicated the following:

(1) "Small particles are accelerated to much higher velocities. For example, 200 µm particles were predicted to travel twice as fast as 1mm particles."

(2) "The kinetic energy of individual particles increases significantly with particle diameter even though the velocity decreases with increasing diameter. For example, a 1mm particle was predicted to have 5 times the kinetic energy of a 500 µm particle."

(3) "The total kinetic energy conveyed by a given mass of particles increases as the average particle diameter decreases."

This velocity model suggested that, while small particles can be accelerated to higher velocities, the larger ones carry individually much more kinetic energy, possessing enough energy to initiate coating removal. Djurovic et al proposed that during the initiation of topcoat removal, the relatively few larger particles in Pmix have sufficient energy to penetrate the hard glossy finish of the polyurethane topcoat. The smaller particles, which actually carry most of the kinetic energy in the flow, then enlarge these initial sites where the coating has been penetrated. Consequently, a balance of small and large particles or wide size distribution, as found in Pmix and ENVIRO**Strip**® Plus, would result in higher coating removal rates.

Djurovic et al also suggested that a particular mesh size distribution - and not average particle diameter or particle shape - played a key role in determining stripping efficiency. Their work showed that although ENVIRO**Strip**® 30/100 and Pmix were very similar in terms of average particle diameter, particle shape, and average particle velocity, the Pmix had a much better stripping efficiency.

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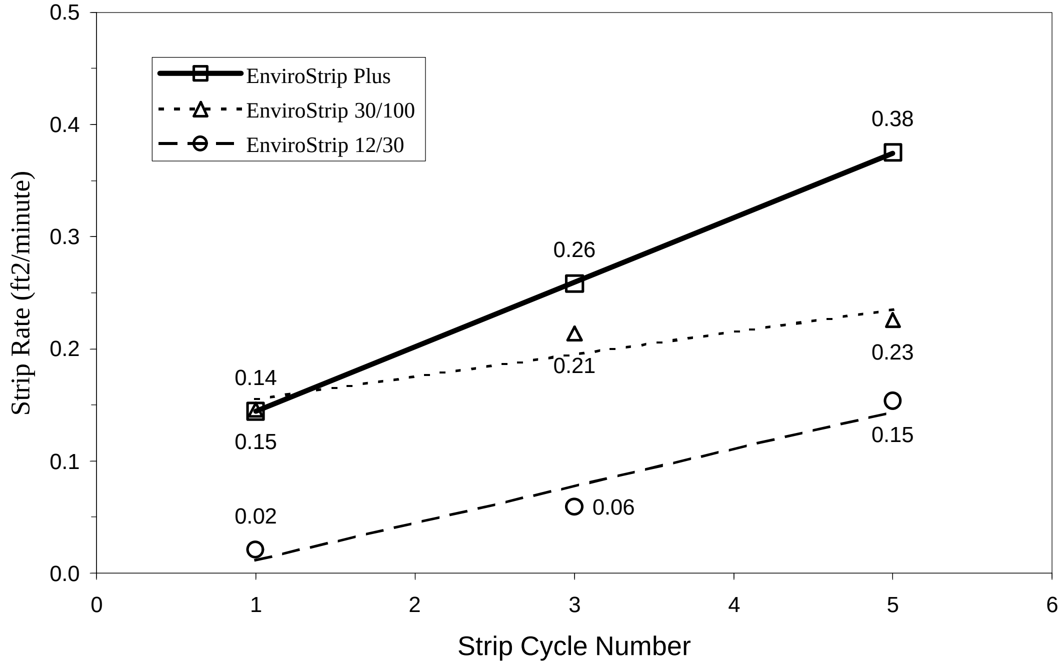

Figure 1. **Plot of Strip Rate versus Strip Cycle Number for ENVIROStrip® 12/30, ENVIROStrip® 30/100 and ENVIROStrip® Plus Mesh Sizes**

CONCLUSION

From this study we can conclude the following:

1. The particle size distribution of wheat starch media plays a key role in determining the removal efficiency on aerospace coatings. A broad particle size - comprised largely of particles in a 30 to 100 mesh size range combined with some larger particles (>30 mesh) - provides the optimum stripping efficiency for ENVIROStrip® wheat starch media.

2. ENVIROStrip® Plus removes coatings when used new and quickly attains optimal stripping efficiency. Using wheat starch media in the Plus size can simplify media management and better maintain optimum stripping efficiency without significant changes in breakdown rates compared to 12/30.

REFERENCES

1. J. Oestreich, D. J. L. Monette, “An Investigation of EnviroStrip Starch Media Coating Removal from 2024 T-3 Aluminum Alloys, 1994 DoD/Industry Advanced Coating Removal Conference Proc., New Orleans, LA, May 1994, pp. 113 – 152.

2. B. Djurovic, E. Jean., M. Papini, P. Tangestanian, J. K. Spelt, “Coating removal from fiber-composites and aluminum using starch media blasting”, Wear 224 (1999), pp. 22–37.

Appendix 1

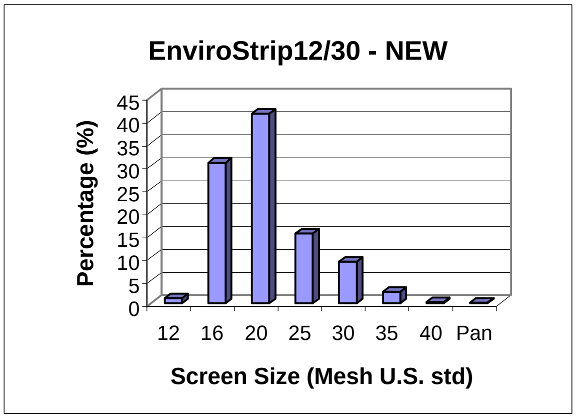

Figure A-1 Mesh Size of EnviroStrip 12/30 (New)

Figure A-2 SEM of EnviroStrip 12/30

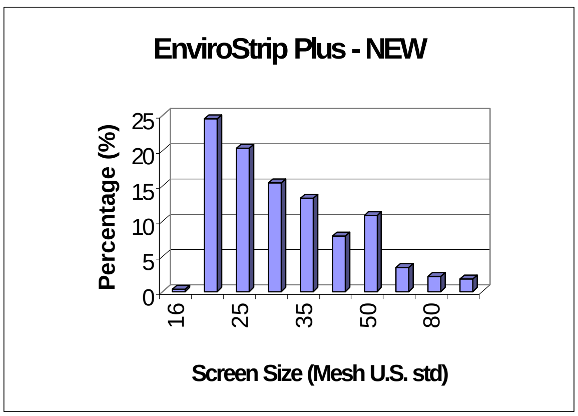

Figure B-1 Mesh Size of EnviroStrip Plus (New)

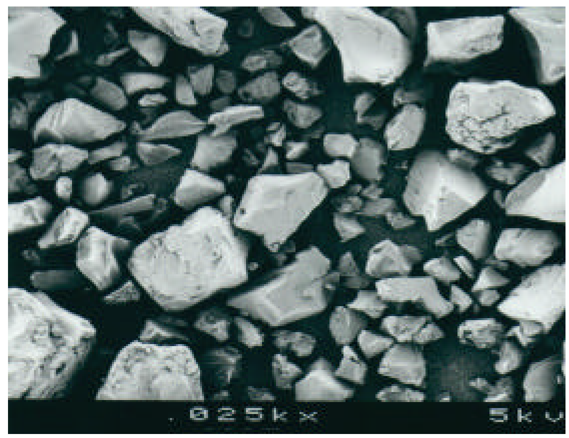

Figure B-2 SEM of EnviroStrip Plus

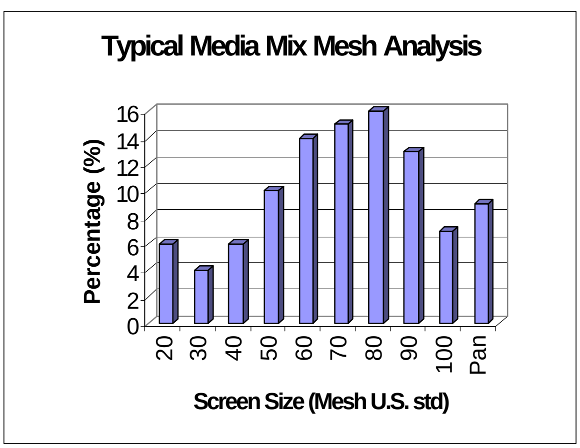

Figure C-1 Mesh Size of Typical Production Mix

Figure C-2 SEM of Typical Production Mix