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An Evaluation of "Pyro-Flake" Titanium for Use in Fireworks

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Several months ago, our company was approached by the Suisman Titanium Corporation. They told us that they were considering introducing some new titanium products specifically intended for the fireworks trade, and that their materials would be priced below that of titanium sponge. They asked whether we would perform an evaluation of their "Pyro-Flake" titanium and make recommendations concerning the introduction of their products to the fireworks trade. We performed that study, and one of our recommendations was that a condensed report of our study be published. This article is that condensed report and was in part subsidized by Suisman Titanium. However, Suisman Titanium has asked us to be completely candid, and they have not exerted any editorial control over the content of this article.

Material Description

As its name suggests, Pyro-Flake titanium materials are flakes of titanium metal; this is in contrast with traditionally used titanium sponge which is granular. The flaked material has two dimensions (length and width) that are roughly equal, but its third dimension (thickness) is substantially less. The first Photo is of 20–40 mesh Pyro-Flake titanium. We were asked to evaluate both pure titanium flakes as well as flakes made of a common aerospace alloy (90% titanium, 6% aluminum, and 4% vanadium).

Ignition and Burn Characteristics Test

Some of the first tests we performed were intended to discover how easily the two types of flaked titanium ignited in comparison with sponge. Also, during these tests, observations were made of relative spark color, intensity, and duration as well as the sound produced during burning. In these tests, 16 small tubes (½" ID × 1½" long) were loaded with ¼ tsp. of 4 Fg Black Powder and ¼ teaspoon of various types and mesh sizes of titanium. The tubes were individually raised to a height of 15 feet, fired with the aid of an electric match, photographed (time exposure), and personal observations of the effects were recorded. The test results are summarized below:

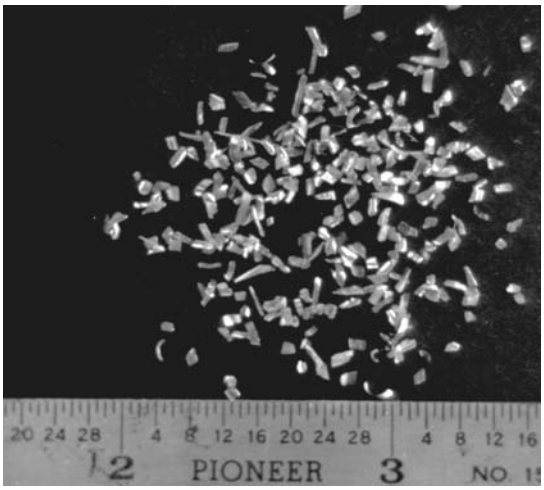

Photo 1. 20–40 mesh Pyro-Flake titanium.

1) In all tests, both the pure and 90-6-4 flakes produced roughly an equivalent number of sparks, with probably a slight advantage to the 90-6-4 flakes. More significantly, however, both types of flakes produced considerably more sparks than did the same mesh size of sponge. The difference was most clearly seen for the 10–20 mesh materials which are shown in Photos 2, 3 and 4.

Photo 2. Ignition test, 10–20 mesh sponge.

2) There were no discernible differences in spark color or intensity for any of the types of titanium. Similarly, there were no discernible differences in the crackling sound produced by the splitting of the burning particles near the end of their paths.

3) Judging from the percentage of sparks hitting the ground, it was felt that sponge and pure flakes (of the same mesh size) had durations that were equivalent. However, the 90-6-4 flakes had durations approximately 10 to 20 percent longer than the pure material.

4) In these tests, it is not known for certain why the flake materials generated abundantly more sparks than did the sponge. Two possibilities came to mind, perhaps the flake material is more easily ignited, or more likely, there are an increased number of titanium particles per unit weight in the flake material.

Clearly the flake material significantly out performed the sponge and, to a lesser extent, the 90-6-4 flakes out performed the pure titanium flakes.

Salute Performance Test

The next series of tests were performed to discover the relative effectiveness of flake and sponge material when used in salutes. The tests employed 32 salutes made with somewhat larger tubes (1" ID × 3" long). Each tube was loaded with 1 tablespoon of flash powder (70% potassium perchlorate and 30% German dark aluminum) and ¼ teaspoon of titanium. In the first half of the tests, the salutes were suspended 5 feet above the ground, fired with the aid of an electric match, and photographed (time exposure). The second half of the tests employed salutes of similar construction; however, in this case, a subjective rating of performance was sought from two observers. In these tests, in order to assure objectivity, no one involved knew which salutes contained the various types of titanium. In order

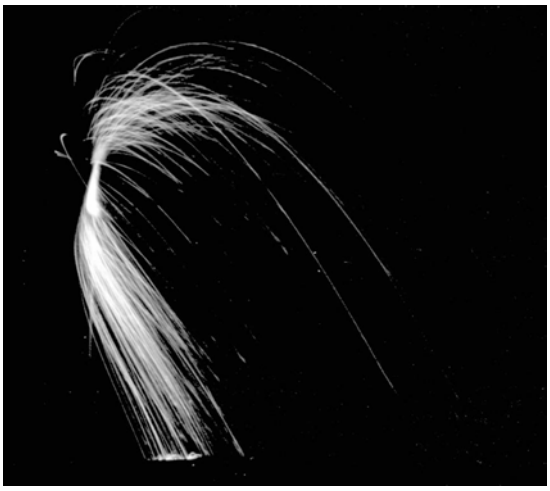

Photo 3. Ignition test, 10–20 mesh Pyro-Flake (pure).

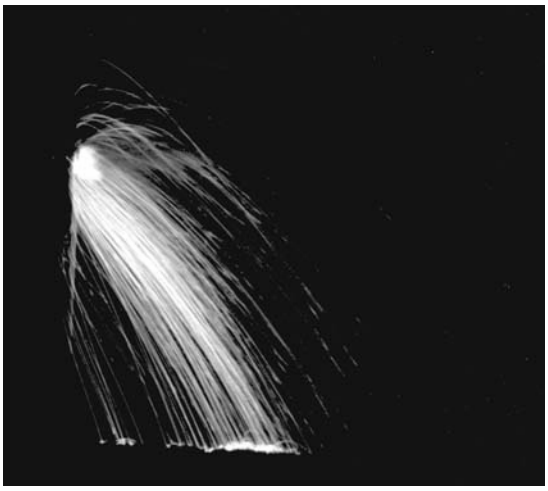

Photo 4. Ignition test, 10–20 mesh Pyro-Flake (90-6-4).

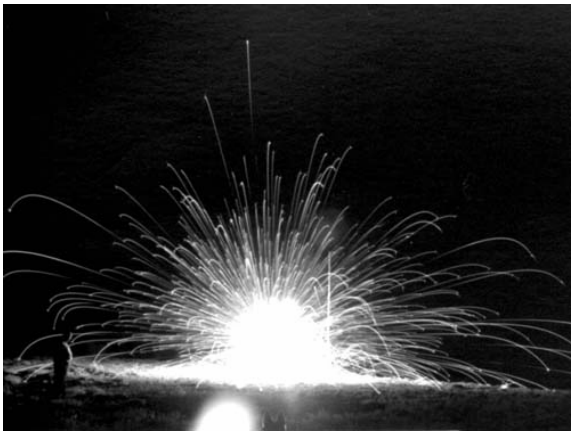

Photo 5. Salute, 20–40mesh sponge.

to aid the observers in evaluating the sparks produced, a small shadow shield was erected in order to block the bright flash of the exploding salutes. The results of both test series are summarized below:

1) In all tests, the salutes containing sponge spread sparks farther than did those containing flaked titanium. As an example, see Photos 5 and 6, which are of salutes containing 20–40 mesh material.

2) Even though it was felt that it was possible that the flaked titanium salutes containing the 90-6-4 titanium had sparks that persisted slightly longer than did those from sponge, the sponge titanium salutes were consistently rated by the observers as being more impressive.

3) The distance traveled by typical sparks was largely independent of whether the salutes used sponge or flakes. It is primarily in the distance traveled by the longest sparks where the difference occurred. For flaked titanium the typical length of travel was about the same as the maximum distance traveled. Further, the travel distance for sparks from salutes with 10–20 mesh flakes is very nearly the same as for those containing 20–40 mesh flakes.

It is felt that the shape of the flaked titanium results in their limited spark travel distances. It would be expected that the low mass flakes would suffer large aerodynamic drag, in comparison to sponge, when propelled at high velocities.

Photo 6. Salute, 20–40 mesh Pyro-Flake (90-6-4).

The result was clear that sponge significantly out performed flaked material when used in salutes. (Note: We have been told by Suisman Titanium that they hope to add thicker flake titanium to their product line, and expect it will compete favorably with sponge in salutes.) There is, however, an area where the more predictable, though more limited, spark travel distances for the flaked titanium may be a definite advantage. That is in producing stage and special effects where it is the stray long traveling spark that can cause serious problems.

Fountain Performance Test

The next series of tests were performed to evaluate the relative effectiveness of sponge and flaked titanium when used in fountains. Ten test fountains were rammed in fairly large tubes (1" ID × 5" long) and were choked with a 3/8" hole. The fountain composition was 88% handmade meal prime (75% potassium nitrate, 15% air float charcoal, 10% sulfur and + 5% dextrin) and 12% titanium. (Prime composition containing dextrin was used because it was already on hand, and it was felt that the presence of a small amount of dextrin would not affect the test results.) One at a time and in pairs, the fountains were burned at a height of four feet and photographed (1/60 sec.). The test results are summarized below:

1) In all tests the flaked titanium significantly out performed sponge in terms of the number of sparks produced. This was particularly

Photo 7. Fountain test, 10–20 mesh sponge.

evident for the 10–20 mesh materials, see Photos 7 and 8.

5) As in the ignition tests discussed earlier, there is some question as to why these results were obtained. However, the reason is probably less important than the result.

6) From these tests, it was concluded that flaked titanium significantly out performs sponge when used in fountains.

Comet Performance Test

The last series of tests were performed to evaluate the relative effectiveness of flaked and sponge titanium when used in comets. For these tests, 16 large box comets were prepared by pressing composition into tubes (1" ID × 1" long). Dry-pressed box comets were used in order to save time by eliminating the need to dry conventionally made comets. The composition used for the comets was the same as used in the fountain tests above. The comets were test fired and photographed (time exposure). The test results are summarized below:

1) For the comets made with 10–20 mesh material, those made with sponge had a rather sparse tail in comparison to those made with flaked titanium.

2) For the comets made with 20–40 mesh material, the increase in the number of sparks produced by the flake titanium was less obvious. However, the flaked titanium did produce a slightly denser tail, and the

Photo 8. Fountain test, 10–20 mesh Pyro-Flake (90-6-4).

produce a slightly denser tail, and the tail persisted longer, see Photos 9 and 10.

From these tests, it was concluded that flaked titanium noticeably out performed sponge of the same mesh size when used to make comets.

Conclusion

From the tests performed it was concluded that the Pyro-Flake titanium products supplied by Suisman Titanium Corporation significantly out performed titanium sponge in all applications except in salutes. It was further concluded that between the two types of flaked titanium the 90-6-4 alloy's performance consistently equaled or marginally surpassed that of the pure titanium flakes.

Based on the performance advantage (in addition to the cost advantage mentioned above), we recommended that Suisman Titanium proceed with their introduction of their 10–20 and 20–40 mesh Pyro-Flake titanium (90-6-4 alloy) to the fireworks trade. In addition, we recommended that they consider producing two other products. The first is a thicker 10–20 mesh flake that might equal or surpass the performance of sponge when used in salutes. The second is a –40 mesh material for use in small comet stars.

We were recently told by Suisman Titanium that they would begin marketing their 10–20 and 20–40 mesh Pyro-Flake products (90-6-4 alloy) about November 1, 1987. They also indicated

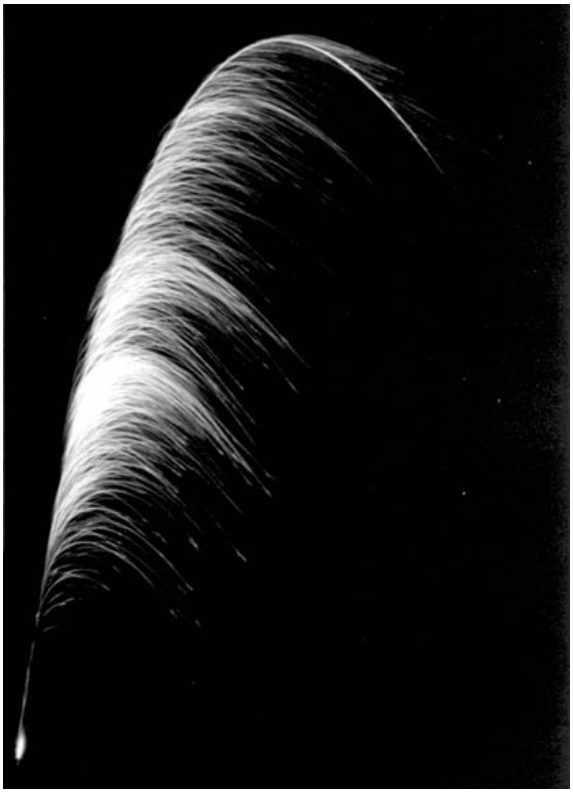

Photo 9. Comet test, 20–40 mesh sponge.

Photo 10. Comet test, 20–40 mesh Pyro-Flake (90-6-4).

that they were considering making some additions to their Pyro-Flake product line in 1988.

Postscript

Since these tests were performed, Suisman Titanium has modified their Pyro-Flake materials slightly. They are now somewhat thinner flakes than were originally tested. As was confirmed in a brief series of tests, this has the effect of further increasing the number of sparks produced per unit weight, but at the cost of producing sparks with a shorter duration. It is felt that this is an effective compromise for a number of reasons. Sparks from fountains of such long duration that they fall to the ground and continue to burn is a waste of material and represents an added safety concern. For comets, it is true that their attractiveness is enhanced when the duration of sparks is sufficient that a long tail is produced. However, when burning times are excessive, the lingering death of an ever more emaciated tail is quit unattractive. The thinner Pyro-Flake material does seem to generate sparks of sufficient duration. Thus, because more sparks are produced, the cost effectiveness of Pyro-Flake titanium should be even greater.