

DEVELOPMENT OF MICRO SPARK COATING

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Abstract

Many kinds of surface modification method have been developed to lengthen life of parts or molds or to repair parts, and they have great effects. However, there are many problems to be solved. For example, as for welding, pre-process such as cleaning of workpiece is indispensable. Besides, because workpieces is heated by concentrated heat, there is a problem of distortion. In order to solve such problems, authors propose a new method of coating and cladding with small discharge pulses (from now on it is called "Micro Spark Coating" or shortened to "MSC"). Because it is quite an easy process and can make a good quality layer, it can be an substitute for welding or metal spray.

Micro Spark Coating was developed jointly by IHI and Mitsubishi Electric. It was released to the press last July.

In this paper, outline of this technology is explained, and then application examples and technical data are discussed.

1 Conventional Method

Conventionally, in manufacturing or repair process of airplane engines, special surface modification methods such as plating, welding or metal spray are used, and they have great effect on many purposes. However, they still have problems to be solved as mentioned below;

- 1) They require expensive hardware.
- 2) They depend on hands not hardware.
- 3) They require men of skill.
- 4) They re not good for the environment

"Micro Spark Coating" is one of answers for those problems.

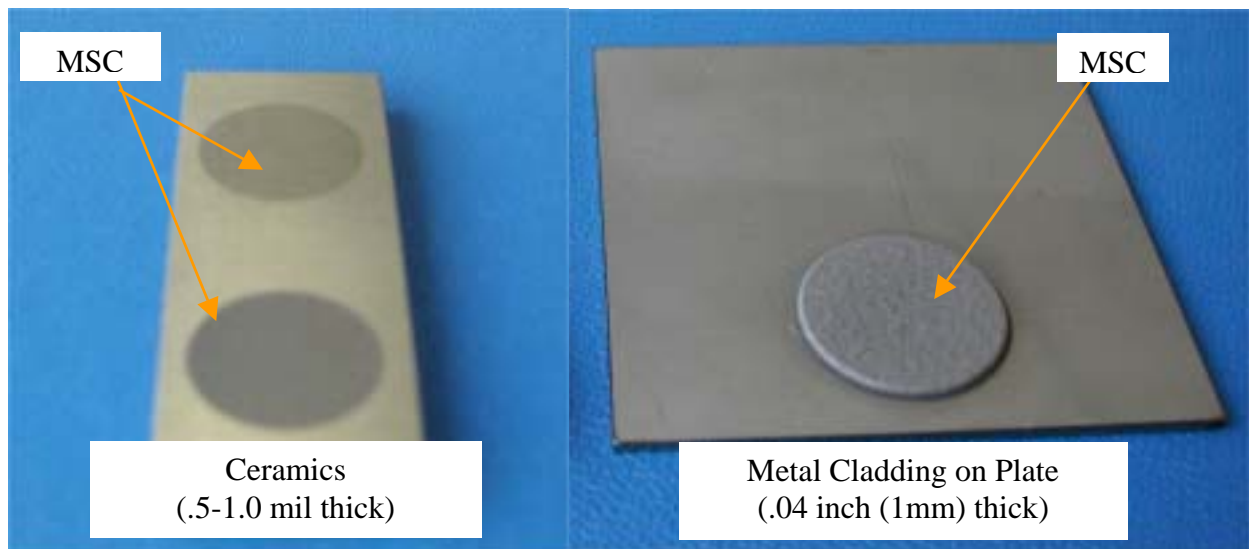


Fig. 1. Examples of Micro Spark Coating layer

2 What is Micro Spark Coating

2.1 Samples of Micro Spark Coating

Micro Spark Coating makes it possible to form a hard surface or metal cladding on the metallic material using an electrical discharge in dielectric fluid, which has two large constituents.

- 1) Ceramics coating layer[1][2]
- 2) Metal thick cladding

Left picture of Fig. 1 is an example of ceramics coating layer. It is composed of carbide such as TiC or WC. Right one is an example of metal cladding and it can be an alternating technology for metal spray or welding.

2.2 Principle of Micro Spark Coating

The description of Micro Spark Coating is as follows (Fig. 2);

- 1) Micro pulse electric discharge is generated between electrode and part surface in dielectric fluid. The Electrode is made of semi-sintered powder.

- 2) The discharge energy melts electrode and part surface. Melted powder moves onto the pool of melted metal on the surface. And it causes strong bonding between part and coating. Thick cladding is created with repeated discharge.

- 3) Distance from electrode to surface is several micro meter, controlled by servo system. Pool size of melted metal on surface is about

also several micro meter. Electrical discharges are generated about 10 thousands per second. In Micro Spark Coating, the metallic powder material is used as the electrode. The electrode material worn by heat of micro-discharge pulse moves to a workpiece and becomes a layer. Compressed powder material is good for a Micro Spark Coating electrode to increase electrode wear.

2.3 Characteristics of Micro Spark Coating layer

The excellent characteristics of Micro Spark Coating is as followed;

- 1) No deformation, no crack like welding because of no concentration of heat energy. And no peeling, like plasma spray, because the electrode material is melted on to the part material.

- 2) No bench work is needed such as Masking, because coating area is limited to discharge area that is determined by electrode shape.

- 3) No finish machining such as grinding is needed, because thickness can be controlled accurately.

- 4) Quality is steady. It dose not depend on skill. All conditions are controlled by machine.

- 5) The machine is very compact. This makes it easy to integrate this process into the flow line of part production.

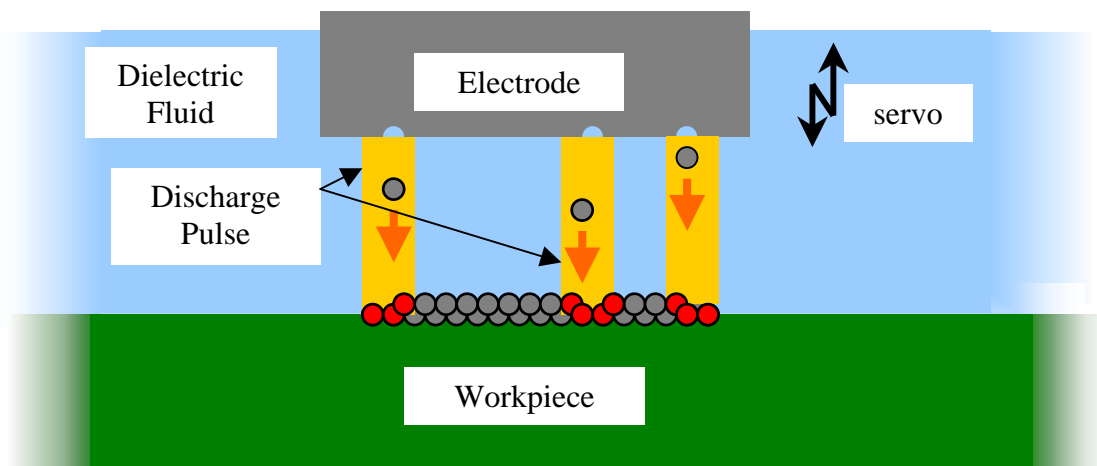
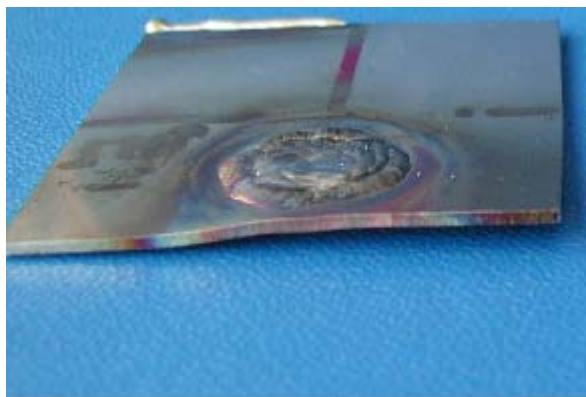


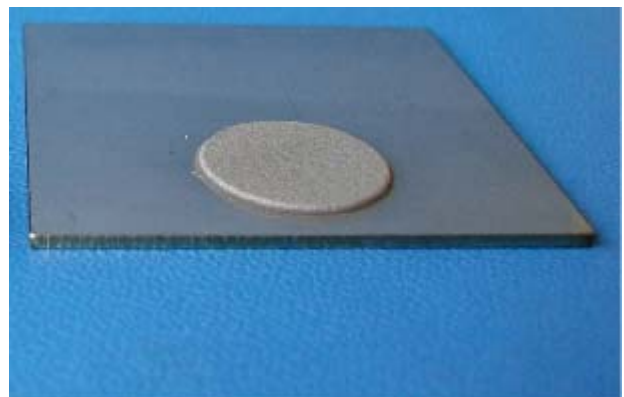
Fig. 2. Principle of Micro Spark Coating

Table 1. Comparison of MSC with other methods

	Micro Spark Coating	Plating	Welding	Plasma Spray
In- Line	Easy	Difficult	Difficult	Difficult
Cost	Low	High	High	High
Bench Work	No Need	masking	Machining	Masking
Quality	Steady	Peeling	Crack	Peeling
Deformation	Small	Nothing	Big	Small
Cladding Material	Ceramics, Metal	Metal	Metal	Ceramics, Metal

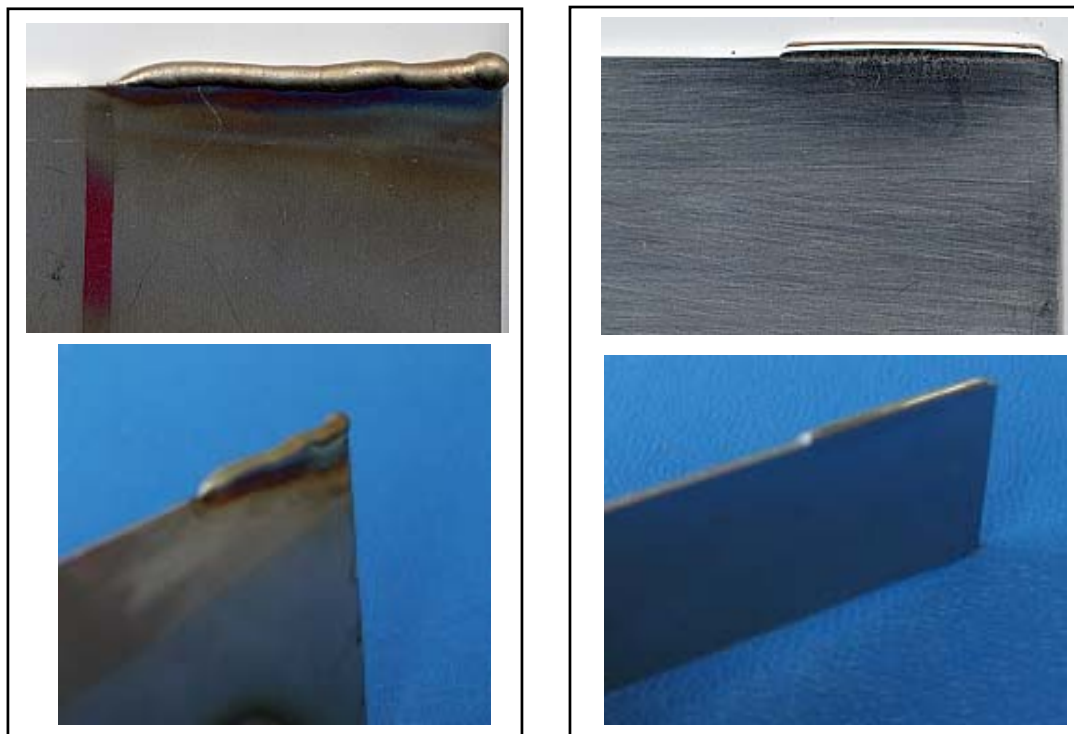


(a) Welding



(b) Micro Spark Coating

Fig. 3. Comparison between welding and Micro Spark Coating



(a) Welding

(b) Micro Spark Coating

Fig. 4. Comparison between welding and Micro Spark Coating (cladding to thin plate edge)

Table 1 is the comparative table of Micro spark coating, with plating, welding and plasma splay.

Fig. 3 and Fig. 4 shows the comparison between welding and Micro Spark Coating. Even if skilled workers weld up cladding on a thin plate, deformation is observed as shown in Fig. 3(a). While Micro Spark Coating process is used, no deformation is observed, or little if anything as shown in Fig. 3(b).

Fig. 4 is comparison of samples clad to thin board edge. Although excess is seen greatly and needs to make form correction at a post-treat in

welding, it is not necessary to do a post-treat with Micro Spark Coating.

2.4 Microstructure of Micro Spark Coating layer

Fig. 5 is a microstructure photograph of a Micro Spark Coating layer. In this photograph, the basemetal is nickel alloy and the layer material is cobalt alloy. It is confirmed that a dense thick layer is built on the workpiece, and that no defects are seen in the basemetal under the Micro Spark Coating layer.

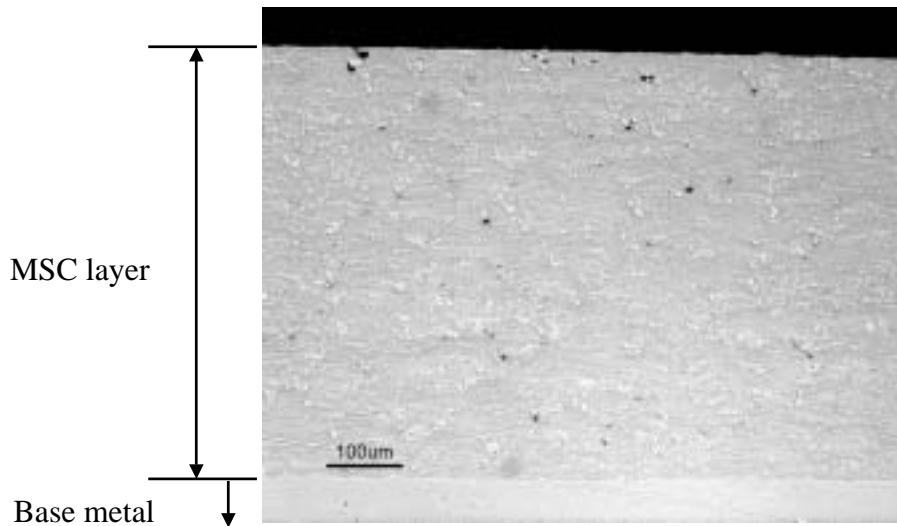


Fig. 5. Example of MSC dense layer

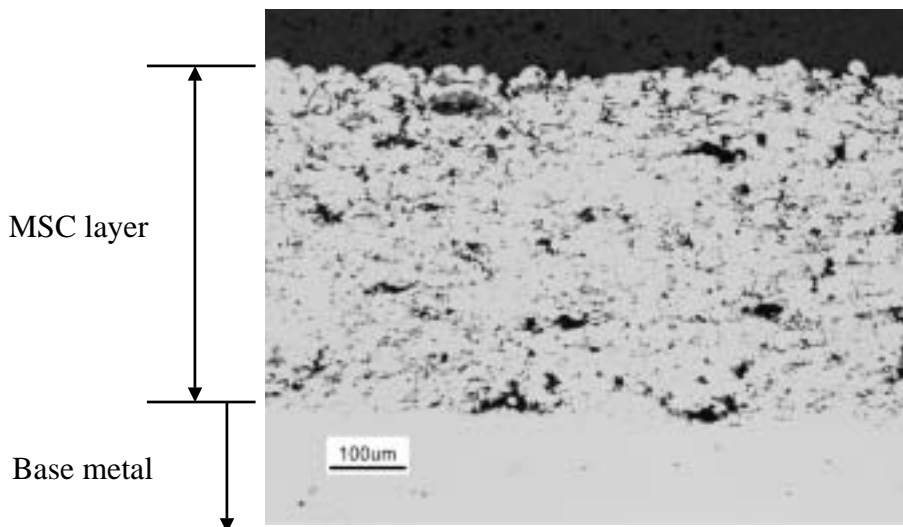


Fig. 6. Example of MSC porous layer

Fig. 6 shows another Micro Spark Coating layer. It is an example of a porous layer. In this photograph, the basemetal is nickel alloy and the layer material is cobalt alloy. Micro Spark Coating can make various layers. Appearance of the layer depends mainly on the electrical conditions of discharge pulses and the characteristics of the electrode.

2.5 Photographs and illustrations

Fig. 7 is an appearance figure of the processing equipment of Micro Spark Coating. It is designed for the manufacturing flow line. This machine is designed to have narrow frontage. It is due to be released in November, 2004.



Fig. 7. Appearance of Apparatus

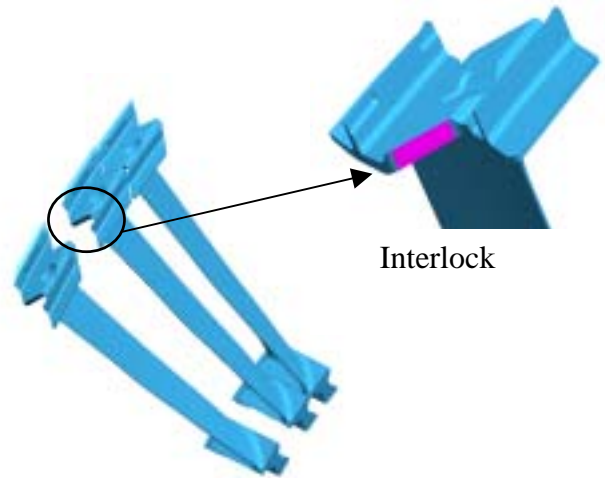


Fig. 8. Interlock of LPT blade

3 Application Example

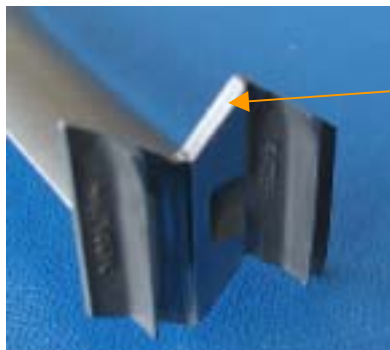
3.1 Application to LPT blades of an airplane engine

Conventionally, in manufacturing or repair process of airplane engines, surface modification or cladding methods such as plating, welding or metal spray are used.

As an application example of Micro Spark Coating, we will show the sample of LPT (Low pressure turbine) blade interlock of the airplane engine. The interlock is an area where low-pressure turbine blades contact mutually. Usually welding is used to clad anti-wear



(a) Welding



(b) Micro Spark Coating

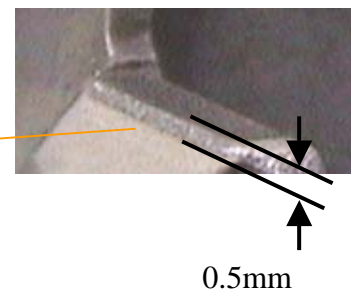


Fig. 9. Application Example

material on this area. (Fig. 8)

Figure 9 shows the comparison of cladding technology between the conventional method welding and Micro Spark Coating. There is big excess in fig. 9 (a), while Micro Spark Coating makes it easy to clad locally in required area and to required dimension without masking. No Finish grinding is thought to be necessary after cladding. (Fig. 9 (b))

3.2 Lead time advantage for LPT blade interlock

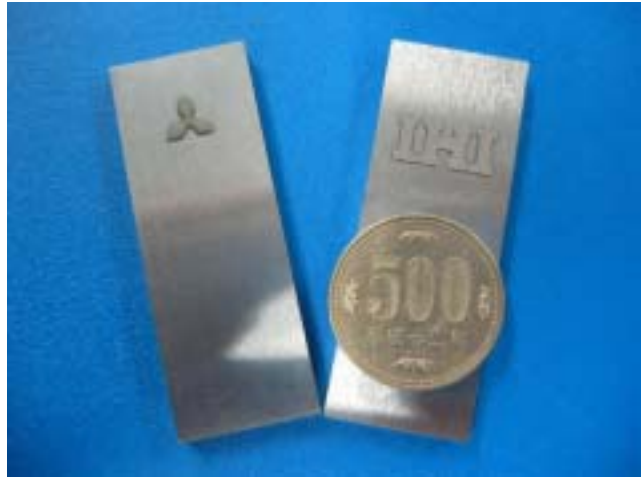
Fig. 10 shows the comparison of manufacturing process between the conventional welding process and the new process with Micro Spark Coating.

In the current process, anti wear metal is welded up on the interlock surfaces in advance. And after the excess is removed, the blade is machined in the flow line. While Micro Spark Coating needs almost no pre-treat or post-treat, and it is easy to integrate into the flow line. The lead time and the cost of part machining will be reduced drastically.

3.2 Another example of Micro Spark Coating

Fig. 11 shows another example of

You can see even the edges of marks can be stamped clearly without masking.



4 Conclusions

In this papers, new coating and cladding technology Micro Spark Coating was introduced. It is a unique technology. It does not depend on skill, it depends on machine, and makes good layer. It can be an alternating technology for metal spray, welding, or plating.

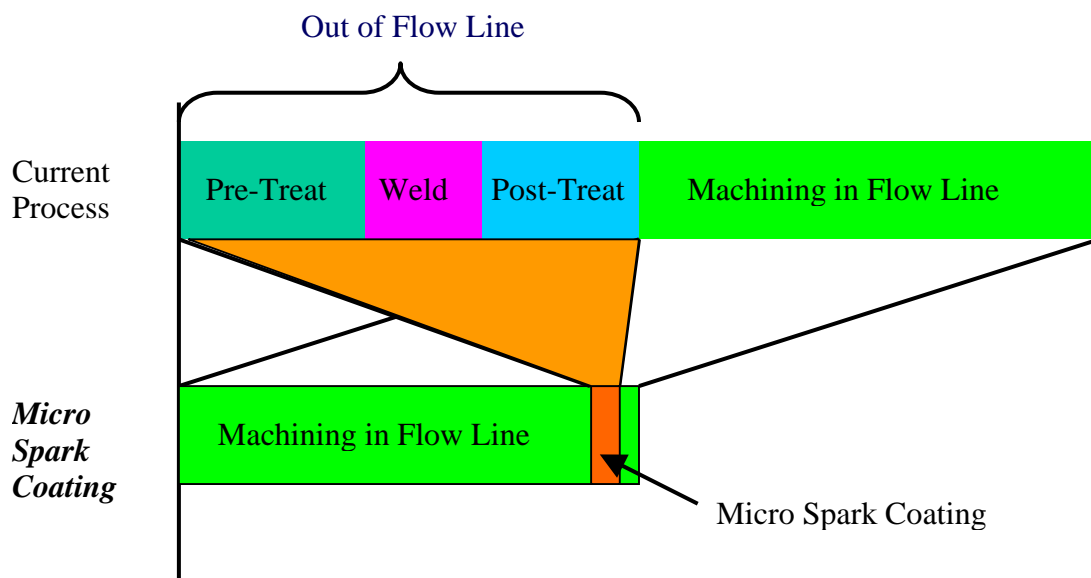


Fig. 10. Adoption of Micro Spark Coating to the flow line of turbine blades

Micro Spark Coating. The marks of two companies are stamped with Micro Spark Coating. It takes about 5 minutes for each stamp.

References

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