*Elliott R. Sampson, TAFA, Concord, NH*

This issue's job shop is different than originally promised. This shop is KLM's aircraft engine overhaul shop at Schipol airport in the Netherlands. Marcel van Wonderen, Process Engineer at KLM, has been a pioneer in introducing thermal spray and related technologies into the engine maintenance shop. He was interviewed by myself and Mark Bakker, a regional Sales Manager for TAFA Europe Ltd. van Wonderen has been among a group that has introduced (1) arc spray as an alternate to the plasma spray process and (2) waterjet stripping as an alternative to chemical and mechanical stripping.

van Wonderen was introduced to arc spray during a visit to Northwest Airlines in Atlanta, GA, for a demonstration of a coating removal system. At this time he witnessed arc spraying of NiAl on a PWA JT-8D engine part for dimensional restoration. van Wonderen ascertained that General Electric Aircraft Engines had not accepted this process yet, and he then proceeded to petition General Electric for approval. This resulted in an arc spray demonstration at the facilities of KLM. Initial test results were very positive, so a third to ninth stage spool was sprayed with NiAl bond coat and Al topcoat. The part was then machined with great success and put in an engine for fuel testing. This too yielded excellent test results. At that time other parts were sprayed as well, including a fan exit frame and compressor case (Fig. 1). The successful testing resulted in approvals for arc spray coatings to replace plasma spray coatings one year later.

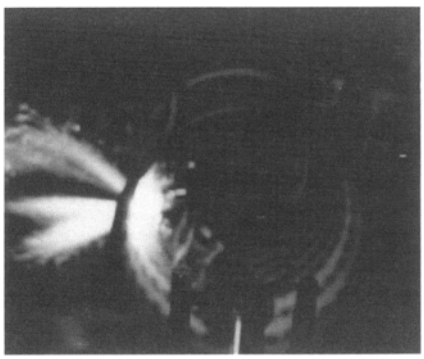

**Fig. 1** Arc sprayed fan exit frame and compressor case

van Wonderen was asked *"Why Arc Spray?"* He replied, "The answer is quite easy—because of its simplicity, economics, machinability, and the quality of the coatings produced." He went on to say that simplicity is shown by the fact that the arc spray operator has to control only four parameters compared to at least 16 parameters in plasma spraying. The more the parameters, the more time it takes to prepare for spraying and the more problems may arise. The arc spray process is less sensitive and may be used at spray angles ranging from 30 to 90°. This is in contrast to the plasma spray process that requires, optimally, an angle of 70 to 90°. The materials for arc spray require no special treatment, whereas plasma spray powders often need to be stored in a humidity-controlled environment. As well, the arc system's portability allows it to be moved from booth to booth, whereas the plasma process in many installations requires a dedicated booth.

Other advantages of arc spray over plasma spray are:

- Spray time savings—up to five times higher spray rates, thus less labor time, lower coating material cost, lower spare parts cost
- Initial purchase savings because arc spray systems generally cost one-third of a plasma spray system
- The instant startup (no "startup" delays) of this process
- Higher bond strength. This reduces the redos, that is, reapplication of the coating because of rejects caused by chipping of coating during machining
- Better machinability that permits a deeper depth of cut may be used

## Applications for Arc Spray Coatings

KLM is using arc spray coatings on aircraft engine parts for both stationary and rotating parts. Most of the applications are related to various wear phenomena and include:

- Bond coats—used to ensure the best possible adherence to the substrate for the top coatings, such as aluminum top coats for spools
- Dimensional buildup coatings (NiCrAl, Alloy 718 and 75)—used to restore dimensions to original serviceable limits
- Abradable coatings (materials such as CuZnAg and Al)—used to allow controlled abrasion by turbine blades
- Antifretting coatings (e.g., CuNiIn) on the pressure faces of compressor blades. During engine-run those blades suffer from vibrations; therefore, antifretting coatings are used to extend the product lifetime

## Cooperation between Supplier and Customer

In van Wonderen's opinion, a good relationship between the supplier and the customer is of major importance. Upon request of KLM, their arc spray supplier has developed a material (CuNiIn) in wire form that previously was only available in powder form. Research and development have lead to the production of CuNiIn wire, which KLM has assessed by metallography for in-house use. As the results were positive, subsequent testing by means of fatigue bars have been performed at General Electric (USA). The aircraft industry is one of the most demanding industries, and it may be seen as a great success that the coating sprayed by KLM with wire has been approved in May 1998. The cooperation resulted in a new wire for the coatings industry and in the purchase of the first dedicated arc spray system, which will only be used for blades and vanes. This is their third arc spray system.

At present the major aircraft engine manufactures (such as General Electric, Pratt & Whitney, Rolls Royce, CFMI, Garret) have approved many wires to be used for the maintenance of their engines.

KLM and their arc spray supplier are now working together on other projects, including coatings to replace hard chrome plating. Another example of the cooperation is in the field of maintenance and calibration. KLM has developed maintenance contracts and calibration services, which is very important for the Quality Assurance department of KLM. Furthermore, the maintenance contracts (preventive maintenance) result in less repairs and downtime.

## Thermal Spray Technologies Used by KLM

Besides arc spray coatings, KLM uses coatings of flame wire spray process, flame powder spray process, plasma spray process and the latest technology HP/HVOF spray process. All of these coatings are used because of the different intrinsic properties that they involve.

Other pioneering work performed by van Wonderen at KLM is in the field of surface treatment and coating removal. Surface treatment is performed by means of shot peening. This process, which can be described as propelling small metal balls to the workpiece surface, is used to produce compressive stresses in the base material in order to avoid cracking caused by tensile stresses of the applied thermal spray coatings.

Since 1994, KLM has used a process called "Ultra High Pressure Waterjet Stripping." This coating removal process is used to remove worn coatings from various aircraft engine parts before recoating. Before this system was installed, KLM used mechanical and chemical processes to remove the coating. This coating removal system uses, as the name indicates, ultrahigh-pressure (around 3800 bar) waterjets, which "blow off" the coating. The implementation of this system by van Wonderen resulted in not only an important reduction of the stripping process times (in some cases up to 4000%), but also in less chemical waste. Instead of paying for the disposal of the chemical stripping waste, KLM can now send the "waste" to a merchant to recycle the Ni and Co particles. Due to the environmental friendliness of this process, in 1994 KLM was awarded with the "LIFE"-project (development of innovative clean technology) of the European Union, and in 1996 KLM received the biannual Industry Environmental Award for Clean Technologies from the Dutch Government.

van Wonderen's vision and willingness to promote technology has benefited KLM economically, technically, and environmentally. His vision is important to the constant advancement of the industry.

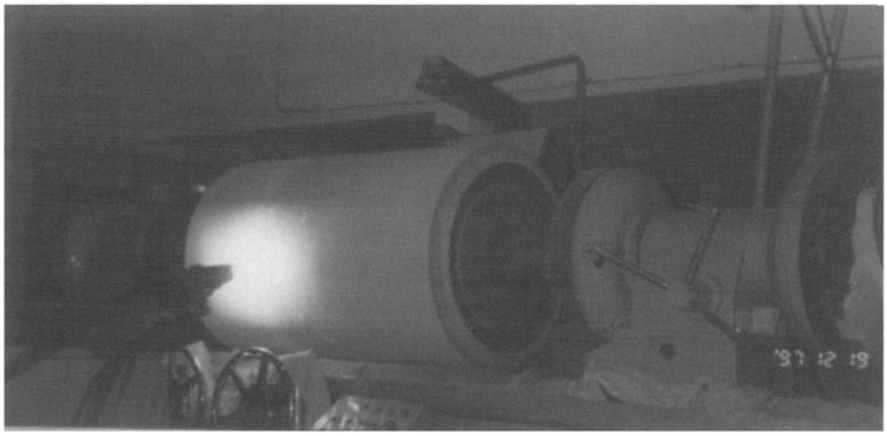

**Fig. 2** Ice flake roll sprayed with a NiCr bond coat and AlSi topcoat

**Fig. 3** Aluminum being sprayed on a submarine for the Brazilian Navy

## Applications from Other Countries

Wherever possible this forum will include applications from other countries. In this issue the following applications came from Guilherme Bungner of VGK Engenharia & Power Service Technologies of Brazil. Figure 2 is an ice flake roll sprayed with a NiCr bond coat and AlSi topcoat. Ammonia inside the roll and water spray ice makes ice in the form of flakes, which are used to cool a chemical process.

Figure 3 shows aluminum being sprayed on a submarine for the Brazilian Navy using a 4 in. fan cap and then sealed with an epoxy sealer and painted.

Next issue will cover a commercial job shop and more applications from South America.