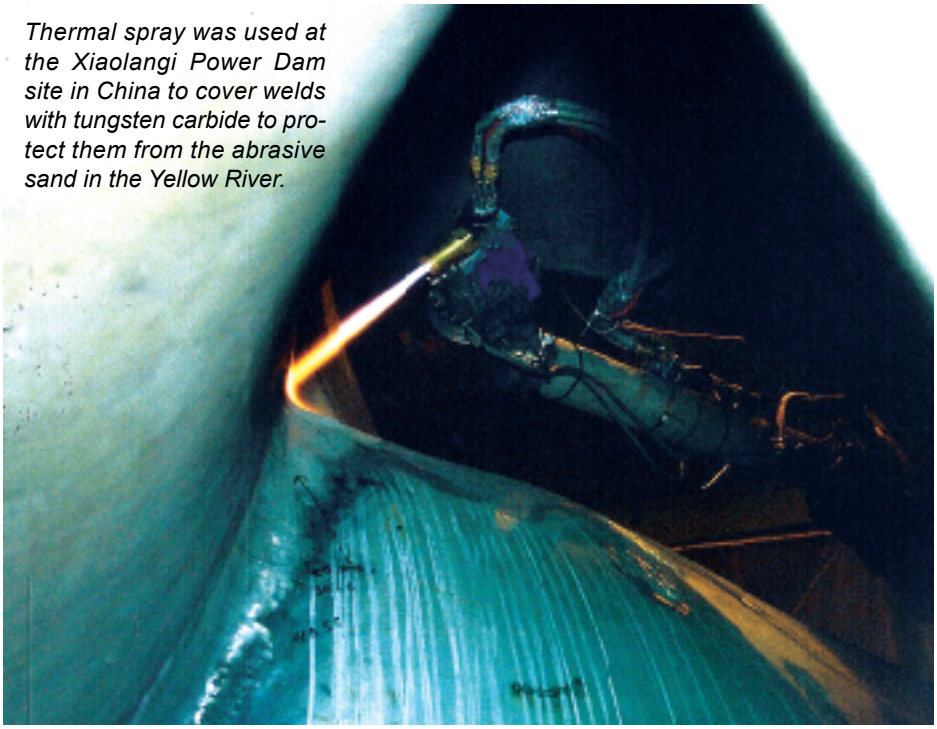

Thermal spray was used at the Xiaolangi Power Dam site in China to cover welds with tungsten carbide to protect them from the abrasive sand in the Yellow River.

Remanufacturing worn parts using thermal spray technologies can be a lucrative business that can conserve materials, energy, and time

BY RICHARD S. BRUNHOUSE, PETER FOY, AND DALE R. MOODY

Thermal Spray Wins as a Green Technology

Thermal spraying is not usually regarded as a "green technology" that helps to conserve the environment and natural resources. Yet, the process has been at the forefront of conservation of materials and energy since it was first developed in the early 1900s. For example, thermal spray has provided a second or "green" life to products by restoring or remanufacturing damaged parts associated with everything from aerospace to zoos.

Thermal spraying is defined (Ref. 1) as "a group of processes in which finely divided metallic or nonmetallic surfacing materials are deposited in a molten or semimolten condition on a substrate to form a thermal spray deposit. The surfacing material may be in the form of powder, rod, cord, or wire."

Remanufacturing is defined (Ref. 2) as, "an industrial process in which worn-out products are restored to like-new condition. In contrast, a repaired product normally retains its identity, and only those parts that have failed or are badly worn are replaced or serviced."

When to Remanufacture

There are several "green" reasons to consider remanufacturing, including the following:

1. The reuse of the core or base materials conserves natural resources.
2. A significant portion of the energy consumed to configure the original part is conserved.
3. Reduced cycle time. For thermal spray operations, the time to remanufacture a part is significantly less than the

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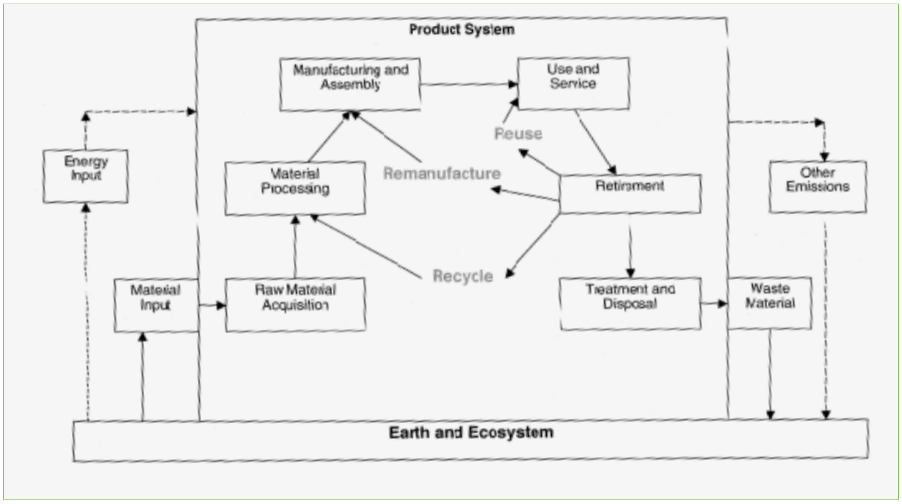

Fig. 1 — Diagram of a product life cycle.

time needed to order and receive a replacement part.

Remanufacturing can be considered a win-win-win situation compared with manufacturing: the customer pays less, the remanufacturer earns more, and the environment is protected (Ref. 3). These points are illustrated in Fig. 1 (Ref. 4).

For thermal spray operations, there is an additional element to the life-cycle diagram. That has to do with specialized machinery for thermal spray; for example, chambered or controlled-atmosphere thermal spray systems. Often, these specialized systems are "recycled" to the remanufacturer for a second life.

In Fig. 1, note that remanufacturing is the most labor-intensive operation of the three Rs (Reuse, Remanufacture, Recycle). It has been estimated that the remanufacturing process is, in general, three to five times more labor-intensive than manufacturing of the same product. The stripping, cleaning, inspection, and sorting are activities that are not present in manufacturing. Also, the batch sizes are much smaller and the degree of automation is lower than in manufacturing. Therefore, the core value has to be high for remanufacturing to be cost-effective.

Typical Thermal Spray Cycle

A typical thermal spray remanufacturing cycle is diagrammed in Fig. 2. The steps shown in the figure may differ from the those associated with other remanufacturing operations. In many remanufacturing procedures, cleaning is done prior to inspection in order to reveal defects. For thermal spray, cleaning typically follows inspection since faults that would cause rejection of the core are usually apparent before cleaning, and the thermal spraying is usually performed on a freshly cleaned (grit-blasted) part to ensure coating integrity.

A number of studies have been carried out to gain a better understanding of remanufacturing and its implementation (Refs. 5–8). An objective of this article is to apply and expand some of those findings to the thermal spray industry, specifically, what is needed to put into practice the recommendations from these studies.

Types of Remanufacturers

These studies considered three types of remanufacturers: original equipment manufacturers, contracted remanufacturers, and independent remanufacturers.

Original Equipment Manufacturers (OEMs) may remanufacture their own components. Many diesel engine and gas turbine manufacturers (such as Caterpillar and GE) perform their own remanufacturing. The OEM remanufacturer has the advantage of having detailed information regarding the thermal spray process needed for the component. The OEM may also have access to specialized machinery such as controlled-atmosphere thermal spray systems. In addition, by carrying out their own remanufacturing, the OEM maintains control of any proprietary materials and processes. The distribution is also easier since, in many cases, the OEM has a direct relationship with the end user. The disadvantage that the OEM remanufacturer has is usually higher overhead resulting in higher prices for the remanufactured product. One engine manufacturer indicated that, despite its higher overhead, it attributed its competitiveness to factory methods carried over from the OEM, resulting in higher worker productivity. This company also claimed higher efficiencies regarding use of equipment, facilities, and energy (Ref. 6).

Contracted remanufacturers include companies that have an established contract to remanufacture components for an OEM. Some gas turbine manufacturers have set up separate companies for this purpose in order to maintain control of the remanufacturing without conflicting with their own OEM operations. The OEM-owned or controlled remanufacturer usually has less restrictive business requirements compared to the OEM and, therefore, can hold the costs down.

Independent remanufacturers for thermal spray operations are typically job shops that remanufacture components supplied to them by their customers. In a few cases, the thermal spray job shop may purchase the cores from one party and

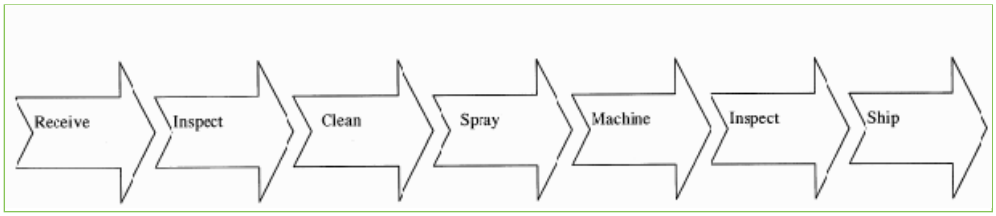

Fig. 2 — Diagram of the remanufacturing steps for thermal spray.

then sell the remanufactured component to another company. The operations usually have very limited association with the OEM but a close relationship with the customer. A good example of this type of remanufacture is the thermal spray operation serving the pulp and paper industry. It is often preferable to thermal spray and machine large calendar rolls, boilers, and digesters in situ to avoid the time and expense of removing and shipping them. The independent thermal spray operators serving the pulp and paper industry are able to provide this service since they have the portable equipment required to make the repairs.

End-User Operations

In addition, thermal spray has a fourth type of remanufacturer not discussed in these studies, the owner or end user. The owner or end user, including many airlines such as American, Delta, and United, have their own thermal spray shops for remanufacturing aircraft components. This arrangement is feasible because the airlines are closely associated with the aircraft manufacturer from the conception of an aircraft, and therefore can plan on and control the remanufacturing requirements (design for remanufacturing). Airlines often need a quick turnaround of parts and must avoid the delays associated with shipping the parts to another shop. Airlines need to be familiar with the equipment for maintenance and safety, and therefore are positioned to remanufacture the parts. Airlines have a significant number of aircraft to justify maintaining a stock of remanufactured parts.

This airline-aircraft association has been beneficial to the ecosystem in another respect. It was this association that led to the Hard Chrome Alternatives Team (HCAT) program that developed (green) alternatives for using hard-chrome coatings on landing gear struts and other components. This environmentally friendly process also allows for rapid turnaround of these critical parts.

Use by Power Companies

Some land-based power companies attempted to follow this same business model but ran into many problems when they tried to bring the remanufacturing of turbine engine components in-house. For example, the company had relatively few gas turbines from a number of different manufacturers (see point 4 in the following list). The company had limited knowledge of the manufacturing methods, many of which were proprietary (see point 3 in the following list). The company did not have the specialized equipment needed for a number of the remanufacturing operations (see point 3 in the following list).

Conditions for Success

The following is a list of conditions that are necessary to ensure the success of any remanufacturing operation.

1. Availability of a core that has value and can be reused.
2. The cost to remanufacture the core must be significantly less than the value of the end product.
3. The technology is available to restore the core to as-new condition.
4. The part can be mass-produced in a factory environment (unless it is a high-value part such as a calendar roll).
5. The value of the remanufactured part is close to the value of a new part.
6. The part is not prone to obsolescence.

The studies also noted several obstacles encountered by independent remanufacturers, including the following.

1. The OEM usually has to deal with only a few models at any given time. On the other hand, the remanufacturer often has to deal with numerous models or variations extending over a period of time.
2. Special components or materials may not be available to the independent remanufacturer.
3. The need for long-lead-time or custom materials imposes delays.

Other problems encountered in remanufacturing are poorly defined accessibility to used products to be remanufactured, and a poorly defined, variable remanufacturing process.

Advantages of Using Thermal Spray

Remanufacturing using thermal spray has several advantages compared to other remanufacturing operations. Most components to be remanufactured using thermal spray operations generally do not experience rapid obsolescence. Moreover, thermal spray is a mature process that does not experience a high rate of technical innovations. In fact, some thermal spray operators successfully use equipment that is 50 years old. Therefore, some level of technical forecasting is possible.

The Three Main Concerns

The three main challenges that a thermal spray remanufacturer faces are core collection, the labor-intensive process, and redistribution.

Core collection for thermal spray operations is often voluntarily performed by the end user due to the high value of the core. The main problem for the remanufacturer is to identify the end users and develop a relationship for acquiring the cores. A remanufacturing firm typically has a large number of core sources, meaning they have to bring together a large number of small-volume flows that increases the collection complexity. Controlling the quality, quantity, and timing of the returned products is key for creating a profitable remanufacturing operation.

The labor-intensive thermal spray process is exacerbated by the stripping and special cleaning (grit blasting) operations normally not present in other manufacturing processes. In addition, special quality assurance requirements, such as spraying, preparing, and evaluating test coupons, may be necessary.

The uncertainty in core quality also adds challenges to the thermal spray remanufacturing process. Two returned products that are identical except for quality might require two different sets of remanufacture programs, which make planning and control more difficult. Also, when looking at one type of product within the same remanufacturing facility, the processing steps are, to a large degree, dependent on the condition of the product. Unlike manufacturing, remanufacturing does not have a fixed sequence of production steps.

Redistribution. A typical remanufacturing firm serves a number of small markets and uses a variety of products and strategies to serve these markets. These are often different from each other. Also, the recovered products often are distributed to a large number of customers. Complications can be caused by many different products being in the same supply chain and in different phases of the product life-cycle. In one study (Ref. 4), Cummings OER, a Toronto remanufacturer of gasoline engines, was evaluated.

With its association with the OEM operations, Cummings OER was able to provide flexibility to market demands with a quality product.

Entering the Business

Anyone thinking about entering or expanding into the remanufacturing business should start with a detailed business finance model. This model can start with a business plan overview and then be developed over the three remanufacturing divisions previously discussed. When considering entering several different markets, it would be well to develop a separate plan for each market.

Begin with a mission statement as to which market to pursue (i.e., remanufacturing of printing rollers). Include a statement as to where you plan on positioning your organization in the market (price, responsiveness, quality demonstrated by offering a warranty, etc.). This would be a place to identify the competition along with estimates regarding quantities, market share, and pricing. Include the OEM as a competitor.

The plan should also include a statement regarding business readiness; are any permits needed, is the required thermal spray equipment available, are qualified operators in place, are any special quality control or lab services needed? Other considerations include the following areas listed below.

Collection. How do you plan to collect the cores (printing rollers is being used as an example). This would include the following: Where are the cores when retired? How many, how often? Who owns the cores following retirement? If you own them, how will they be inventoried, stored, etc? Is there anything your organization can do to encourage collection of the cores? For example, provide a prepaid shipping container. What are the conditions of the cores when shipped? For example, are the bearings in place on the rollers? What protection is needed for the cores during shipment? Is there a need to maintain the identity of each core?

Process. The process steps must be detailed and correlated to the machines and the operators. The process starts with the receipt of the cores through the delivery of remanufactured cores. It needs to include stripping of the old coating, examination of the part prior to coating, postcoating machining or polishing, and replacing other elements, such as the bearings on a printing roll.

Redistribution. How will the remanufactured part be distributed: placed in stock for later sale, or sent directly to the customer? Will there be any follow-up items such as commissioning or running in the part?

Once developed, the business model should be reviewed, revised, and kept up to date as a true reflection of the business.

Conclusions

Remanufacturing can be a win-win-win situation. It can make your customer happy, the environment cleaner, and your bank balance healthier. This article references several studies that include interviews with successful remanufacturers who present ideas that should be considered by everyone contemplating entering the remanufacturing business.

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