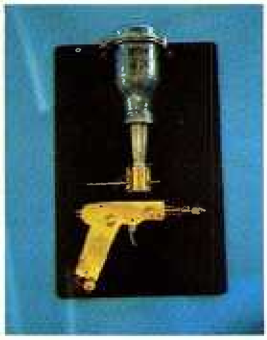


The "Betsy" prototype Spraywelder (1945)

The Development of Thermal Spray Hard Surfacing

By W.P. CLARK

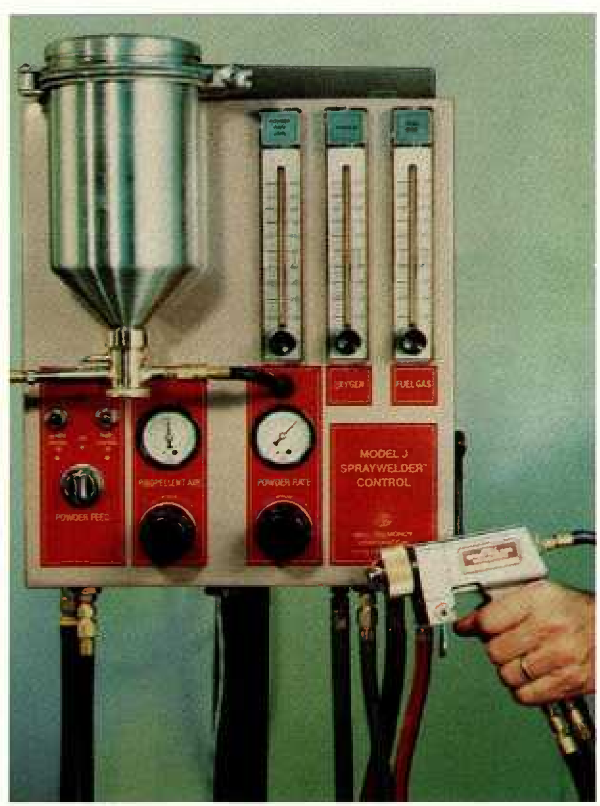
Reprinted by Wall Colmonoy Corporation,
19345 John R St., Detroit, MI 48203

Model A Spraywelder (1946)

Shown here some of the steps along the way in the development of today's Spraywelder unit.

Model C Spraywelder (1954)

Model D Spraywelder (1960)



Model J Spraywelder (1980)

The Development of Thermal Spray Hard Surfacing and Protective Coatings

Techniques and Equipment developed since 1940 make it possible to spray-apply welded surfaces or wear-resistant nickel- and cobalt-based alloys

By William P. Clark Sr.

What is today "thermal spray" process has, in the past been termed "metal spraying" is also referred to as "flame spraying" and "metallizing." The literature shows the process was known in Europe during the days just before World War I and that its invention has generally been credited to a "Dr. Schoop".

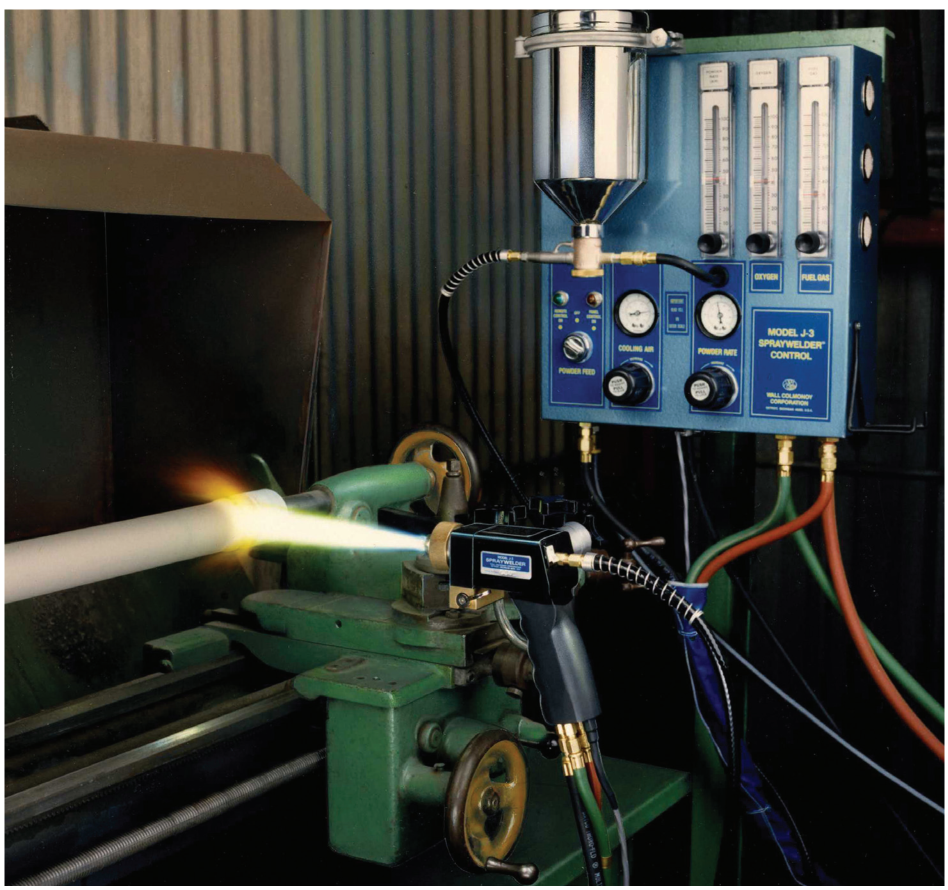
During its early days, thermal spraying, according to today's terminology, was used mainly for depositing coatings on metals for corrosion or heat resistance, for decorative purposes, and the repair of surface defects. Also, as the literature states, no claim was made that "sprayed molten metal coating are either welded or brazed to the metal." As defined by the American Welding Society, with thermal spraying "finely divided metallic or non-metallic particles are deposited in a molten or semi-molten condition to form a spray deposit" (coating).

Hard surfacing – or hard facing as it is officially known – also dates back to earlier days in the history of welding. It involved the use of oxyacetylene fusion welding procedures to deposit alloy layers on base metals to provide specific properties not possessed by the base metals – namely, good impact properties or a desired degree of corrosion or abrasion resistance. By the mid-1930's arc welding procedures were being utilized in hard facing operations, and, in 1939, it was noted that tungsten carbides with their very high hardness and very high resistance to wear by abrasion and erosion were unlike other alloys used for hard facing in that the tungsten carbides, simply stated, are "wetted by the molten metals and thus become fused in place – much as a lump of tinned steel might be soldered to a piece of copper."

Hard facing has been defined by the American Welding Society

Wall Colmonoy's Spraywelder™ System

The culmination of more than 50 years of technical innovation



as a "particular form surfacing in which a coating or cladding is applied to a substrate for reducing wear or loss of material by abrasion, impact, erosion, galling, and cavitation." Surfacing is also the "deposition of filler metal (material) on a base metal (substrate) to obtain desired properties or dimensions."

A New Alloy – A New Company

Thermal spray hard surfacing, as discussed in this paper, combines the attributes of both "thermal spraying" and "hard facing." Its development began in the year 1940, shortly after Mr. A. F. Wall purchased a California company, Colmonoy, Inc., from Mr. Norman Cole and Mr. Walter Edmonds. These two men had patented a nickel-chrome-boron hard surfacing alloy and had named it "Colmonoy" (from their own names, and that of the product; "Col" from Cole, "mon" from Edmonds, and "oy" from alloy.) They sold it in oxyacetylene welding rod form, primarily to those engaged in rebuilding pumps and valves for the petroleum industry.

This new alloy contained certain chromium boride crystals that were nearly as hard as diamonds, which provided excellent abrasion resistance. The nickel-chromium matrix alloy supplied the ability to survive in very corrosive media.

The alloy had one more quality that was intriguing – it was "self-fluxing." The boron (and silicon) content acted to remove surface oxides on metal surfaces to which the alloy was being applied. This meant the base metal surface did not have to be made molten to get overlays to bond. It also meant lower application temperatures.

Colmonoy®

This new alloy contains certain chromium boride crystals that are nearly as hard as diamonds, which provide excellent abrasion resistance.

Mr. Wall had an interest in metal spraying since the 1920's. He reasoned that the self-fluxing characteristics of the new alloy should make it possible to use metallizing techniques to spray-apply the material, followed by the use of a torch to weld it to the base metal. This would be faster than rod application; it would also reduce the amount of material required, because spraying could be done to fairly close limits. There would also be a great reduction in finishing costs as the sprayed overlays would be closer to finish dimensions, and much more evenly distributed than hand welding with rod and torch.

Wire Development Difficulties...And Solutions

Metallizing technology was in its infancy at the time, but there were already a number of wire metallizing guns on the market. In an effort to form the alloy into wire diameter small enough so that it could be applied with one of these early guns, Mr. Wall and his staff joined 3/16 in. (4.8mm) diameter cast rods into 3 ft (0.91m) lengths and grounded them down to a diameter of 1/8 in. was prohibitive, and the brittle nature of the product made it impractical to cast it in diameters less than 3/16 in.

Although work on the idea slowed during World War II, it was during this time that the idea was conceived to reduce the alloy to powder form, which could then be formed into a rod or wire of usable diameter.

The first attempts combined the alloy with a Lucite material, which was extruded into 3 ft long rods. When sprayed though the wire metallizing gun, the plastic in the rods would volatize in the flame, while the molten alloy deposited on the part. This was a reasonably practical approach, except that the rods made with Lucite were quite brittle and difficult to handle.

Other types of plastic were tested. It was found that by using polyethylene as the bonding agent, a flexible wire was produced, and this proved to be a marketable product.

While this plastic bonded wire enjoyed some success in the marketplace, the developers felt the alloy could be even more economically applied if it could be sprayed directly in the form of a powder. This would eliminate not only the cost of making the wire, but also the inefficiency inherent in burning up its 15% plastic content.

Torch Development

The world market was investigated to find a suitable powder spray gun. An English-made unit showed promise, and extensive experiments with it were begun. This gun incorporated a turbine wheel to keep the powder in suspension so that it could be pulled into the gas flow by venture action. The gun soon proved impractical, however, because the hard particles in the alloy quickly tore up the turbine wheel.

It was discovered that a new type of powder spray gun was being developed by the Powder Weld Company of Brooklyn, New York. Through a cooperative effort with Powder Weld engineers, the gun was refined so that it could be used to thermal spray Colmonoy powder fairly successfully. However, it did have some drawbacks. It was over-designed, with 16 independent controls, about eight dials and regulators that had to be checked constantly, and a prohibitive price tag. While it was a good laboratory tool if used by properly trained people, it was not practical to be used in a shop.

A Prototype Named "Betsy"

Mr. Wall and his staff decided that they had gained enough background and knowledge of powder spraying to develop their own spray gun. Their aim was to produce a unit that would be simple, yet rugged enough to withstand the abuse encountered in a typical repair shop.

A prototype, christened the "Betsy," was built and was quickly followed by a production model capable of spraying four pounds per hour at approximately 60% deposit efficiency.

Designated the "Model A," this was the first practical powder spray gun designed and built in the United States, and its introduction during the 1946 AWS Annual Meeting in Atlantic City, New Jersey, created quite a stir. Orders for four units were taken at the show. The Glen L. Martin Co. (predecessor of the Martin-Marietta Co.) and the Atlantic Refinery Company (predecessor of Atlantic Richfield Oil Co.) were among the first customers.

The gun soon established itself as a useful device for industry. Improvements and refinements to the original design evolved and were marketed over the years.

The current model in this evolution is a complete powder spraying system. The gun, which

Betsy

A prototype, christened the "Betsy," was built and was quickly followed by a production model capable of spraying four pounds per hour at approximately 60% deposit efficiency.

has convenient fingertip controls to start and stop the powder and gas flows, is connected directly to a control panel. This houses precision meters and controls that allow the operator to adjust gas mixtures and powder flows so that the spray rate can be varied between 7 and 18 pounds per hour, while deposit efficiency over 90% is achieved.

With today's advanced alloys and equipment, the thermal spray hard surfacing of almost any metal having a melting point above 1950°F (1065°C) is practical.

Four basic steps are involved:

1. *Preparation.*

The base metal is blasted with angular chilled iron grit so that the sprayed overlay can achieve the mechanical bond with the part necessary until after fusing.

2. *Spraying.*

Most cylindrical work is done on a lathe where it is rotated while the pistol, mounted on the tool post, moves the length of the overlay. Parts of other shapes may be sprayed by a handheld pistol.

3. *Fusing.*

This changes the mechanical bond of the sprayed particles into the metallurgical bond of a fused or welded overlay. An oxyacetylene torch is the preferred method of fusing. Controlled atmosphere furnaces or induction heating coils may also be used.

4. Finishing.

All sprayed-and-fused overlays can be ground. This is best done wet, using light, fast cuts. Many can also be machined with tungsten carbide tools.

"Puddle Torch" Now Named Fusewelder™

Consists of a small oxyacetylene torch with a powder-holding hopper attached between the nozzle and butt.

The "Puddle Torch"

During the 1950's a simpler kind of powder spraying torch was introduced by several manufacturers. Generally known now as a "puddle torch," it consists of a small oxyacetylene torch with a powder-holding hopper attached between the nozzle and butt. The powdered alloy is added to the gas stream before it leaves the tip. Spraying and welding are accomplished alternatively, using an on-off powder flow valve; the spray pattern is quite precise.

The Scene Today...

Development of the "puddle torch" and improvements in powder manufacturing methods opened up new applications for powder thermal spray hard surfacing. Development of the plasma transferred arc (PTA) welding process, plasma (non-transferred arc) thermal spray process, and the high velocity oxygen fuel (HVOF) thermal spray process have opened up fields of application that offer large improvements in part performance. Today, many tons of self-fluxing nickel and cobalt hard surfacing alloys are being applied every month by thermal spray coating processes to hold back the costly effects of industrial wear. Applications are no longer limited to coatings which must be welded (fused). Thermal spray coatings can protect and ever wider range of base metals. In addition to those industrial wear applications, coatings now provide benefits that are designed into aerospace parts providing enhanced performance. Those early experiments with a single promising alloy and the makeshift use of metallizing guns led the way to a remarkable growth in this interesting and important technology.