Fusion Powder Alloys

Weld Tech News

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WELD TECH NEWS is a newsletter for welders working primarily in maintenance and repair. Each issue contains useful information on materials (cast iron, steels, aluminum, copper alloys, etc.), welding products and welding techniques. By collecting each issue, the reader will soon have a handy reference manual covering all aspects of welding, brazing and soldering for maintenance and repair.

FUSION POWDER ALLOYS

Advantages of Powder Processes

There are several established processes for applying filler metal to metal surfaces. Some, such as the arc welding processes, require melting of the base metal and diluting with the filler metal. Those processes that do not require melting of the base metal (such as brazing, braze-welding) have obvious advantages over the fusion processes. Unitherm is a powder process offering the many advantages of "surface bonding" without melting the base metal together with several additional advantages.

Filler metal in the form of spheroidal powder offers a tremendous surface area to the source of heat, resulting in very rapid temperature rise prior to melting. A specific alloy used as a filler metal has a calculated solidus temperature (the highest temperature at which the alloy is still solid) and a liquidus — the lowest temperature at which the filler is completely liquid. The amount of heat required to raise the temperature of the filler metal to the solidus or liquidus, depends upon many factors including the surface area of the filler and the cleanliness of the surface. Therefore, clean spheroidal powder represents the best conditions for rapid melting. Injected into the torch flame, such powder bombards the heated workpiece in a state of surface liquefaction and upon continued heating melts completely forming a discrete molten pool. Powder continually fed into this molten pool dissolves instantaneously. The operator can deposit thin or thick, wide or narrow overlays by simply varying the amount of powder injected into the flame and the speed with which he moves the torch.

The Unitherm Torch provides ideal powder control by virtue of its unique design and manufacturing workmanship. Different tips are available to further aid the operator in establishing optimum parameters for a given application.

The Unitherm Process is cost efficient in many ways. Not only can the torch be adjusted to overlay precise areas with a minimum of overspray, but the deposition efficiency of the powder — the amount of usable
deposit recovered per unit of powder applied — can exceed 98%. Build-ups can be held to close tolerances, so that only minor machining or grinding to size is required. Since there is never melting of the base metal, no loss of alloy content is experienced.

Choosing the proper Unitherm Powder Alloy for a given application is easily accomplished. The service requirements dictate the general hardness range of the deposit.

The nickel-base Unitherm Powders are suitable for all steels including stainless, nickel alloys and cast iron. Venus-P should be used only on copper and copper alloys.

**Typical Applications**

Field applications best utilizing the Fusion Powder Process can run the gamut from a five gram overlay on a sewing machine part to hundreds of pounds used to repair basic oxygen furnace heat shields. In between are literally thousands of individualized applications wherein the Fusion Powder Process has been preferred over the more conventional joining and surfacing as well as other powder processes.

Looking into the tool room, we find repairs to both cast iron and steel gears and sprockets with chipped or missing teeth, shafts with damaged keyways and ends, cams, dogs, latches, profiles, racks and pinions and a variety of specialized tools used for fixturing and jigging.

The ability to closely control the amount of material allows the application of extremely thin overlays. Therefore heating fixtures, rails, guides, chains and similar parts can be overlayed with minimum increase in dimension. Such parts are often put into service without machining or grinding.

Industrial knives and cutting blades of all types are ideal applications for this process as well. In the paper and pulp field, knives and tools used to debark logs can be overlayed by the Original Equipment Manufacturer (OEM) prior to sale to the user and the end user can extend tool life by continuing to surface the cutting edges. For example, hard facing the teeth on 4-5 foot diameter circular saw blades is an excellent use for fusion powders.

A myriad of copper tubing-fitting parts and components such as condensers, evaporators, radiators, heat exchangers, finned diffusers are typical applications.

In the automotive field, cast iron engine blocks having chip-outs, voids, porosity and other cosmetic defects are repaired by powder spraying without preheat and without subsequent furnace cooling.

Industrial chain saw bars have been powder overlayed on the nose, using narrow gap fusible powders which has resulted in tremendous savings of material and labor as compared to the old process of finish grinding.

The glass industry in particular are large users of the powder processes. Cast iron split bottle molds require routine buildup of worn and chipped edges.
Natural limestone is quarried and slabbed using gang saw blades overlayed with powder. Cutting efficiency is tripled.

In mining, particularly strip mining, tools used to process oil sand are wearfaced with extremely abrasion-resistant powder deposits. This application in particular would not be economically feasible were it not for the powder spray process.

Earth moving equipment presents many opportunities to use this process. Plow shares, cultivator sweeps, bucket teeth, discs, shovels, trenchers, rock bits and other drilling gear are but a few of the many uses.

The oil fields, coal mines, road building industries all use the process and enjoy savings in time and expenditure. The applications exist in every maintenance operation and only have to be identified.

**How Powders Are Manufactured — Atomization**

There are many techniques and processes designed to reduce a metal or alloy system to powder form. Choosing one method over the other can be influenced by many factors. Of prime importance is the required end use. If the powder is to be used to manufacture small metal parts normally cast or machined, a crushing procedure might be chosen since this would produce the desired angular shape.

For virtually all flame-spray applications, atomization is ideal since this process best produces the spherical or spheroidal shape that promotes smooth flow in powder feeding devices. Atomization begins with a crucible or melting pot and a source of heat. Ideally, induction heating and its stirring effect in the pot is chosen.

The "charge" or the material to be melted is put into the crucible after careful weighing. The charge varies with the alloy being manufactured. It can consist of completely alloyed ingots of the desired chemistry or separate raw materials. To manufacture a binary nickel-chromium alloy such as Inconel, for example, one can use any form of alloyed Inconel or charge the pot with electrolytic nickel brickettes and chromium metal in lump form. Additional elements are added to suit, taking into consideration normal oxidation and reduction.

Raw materials are both melted and dissolved in the crucible until complete liquefaction is achieved, employing some degree of superheat. The ideal temperature to tap the heat is one of the variables of the process. Further, the surface of the molten mass in the crucible is protected from the ambient atmosphere by some form of "flux" or by using a layer of protective gas.

At the proper time, the crucible is mechanically tipped so that the molten metal will pour in the tundish — a funnel-shaped containment vessel that is also heated. This allows a stream of molten metal to flow through the atomizing chamber where it is broken up into droplets. These droplets are then collected in a large tank.

The atomizing chamber is, of course, the heart of the operation. The atomizing medium, which can be a gas such as nitrogen or argon or a liquid such as water, is pumped through a nozzle of complex design. The
pressure of the medium is another variable of the process, since this greatly determines the size and shape of the powder that forms.

Illustrations #1 and #2 show the extreme differences in powder quality that are currently being produced by the atomizing process.

#1

This Unitherm Powder is clean, uniform and oxide-free, making it easy to use and produce excellent quality deposits.

#2
This powder is heavily oxidized, irregular in shape, and very difficult to use, resulting in poor bonding characteristics and poor deposit quality.

There are other somewhat proprietary procedures that may or may not be involved such as hydrogen atmosphere scrubbing and annealing, magnetic separation, etc. Since the Unitherm Process is classified as narrow gap — simultaneous melting and fusing, the desired particle size distribution of the Unitherm Powders is shifted downward. This means that the -325 fraction ("fines") will be somewhat higher than the Cryotherm wide gap — "cold" process, which requires coarser powder. It also suggests that the fluidity of a given Unitherm Powder system can be altered by careful control of the sieve analysis. So "all powder is the same," a statement one hears from time to time is not true.

Hence, the manufacturing process utilized, the use of proprietary atomizing procedures, nozzle design, the atomizing medium (gas or water), and the pressures of the atomizing medium striking the molten metal will determine the final quality of the powder produced.

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**The Welding Shop**

**THE UNITHERM POWDERS - CHARACTERISTICS AND PROPERTIES**

The Unitherm Process is a narrow gap "hot" powder spray process wherein complete melting of the powder occurs, together with true coalescence with the base metal. All Unitherm Powders are self-fluxing and all are designed to apply without melting the base metal. All except Venus-P are nickel alloys.

The microstructure of these complex alloy deposits reveals a network of metalloids and intermetallics formed by the activator group of carbon, silicon, boron and phosphorus. It is this compact structure of different combinations of carbides, silicides, borides and phosphides that classify these as superalloys.

Coefficient of friction values in particular are unusual and account for reports of unusually long service life in metal-to-metal applications. Although we differentiate one alloy from the other mainly on the basis of Rockwell C hardness, these values are merely relative. True hardness readings are taken using the microhardness Knoop and Vickers scales and extrapolated into Rockwell.

The strength of the interfacial bond achieved when these alloy systems are applied to clean work surfaces is unusually high due to the diffusibility of the activating elements. Thus these deposits offer excellent resistance to shear and tensile shear stresses.

In close tolerance applications, Unitherm deposits are best finished by grinding. It is important to grind wet, using a medium hard (H-I-J-K) silicon carbide wheel in the 24-36 grit range. Use 60 or finer grit for finishing.

**Jupiter-P**: Extremely high in nickel, this alloy offers deposits of very low hardness and correspondingly high machinability. Easily filed or drilled, Jupiter-P should be the first choice when deposits require milling, turning, facing, boring, shaping or some other metal working operation using high speed steel tools.
Fusion Powder Alloys WTN #6

as well as carbide. Overlaying shafts and other components requiring circumferential deposits is best achieved with Jupiter-P since cross-check cracking is not a problem. Further, since this alloy contains more nickel than any other, it provides best overall corrosion resistance. Hardness: Rc10-15

Polaris-P: Polaris-P is also nickel-base but contains a higher percentage of activators and is therefore higher in hardness. These deposits also polish to a somewhat smoother finish and are considered more wear resistant. Deposits are borderline-machinable with general cutting tools, but can be considered satisfactorily machinable with the carbide-tipped. This suggests that Polaris-P is the best overall compromise between hardness and machinability. Since fluidity and ease of application improve with increasing activator content, Polaris-P can be considered the best "general purpose" selection when the specific application in question has no special requisites. Hardness: Rc35-42

Apollo-P: Apollo-P can be considered the most representative alloy that best demonstrates the superiority of the Unitherm Process and the ability to apply thin overlays having "super metal" characteristics. Having the highest combined activator content, these deposits are extremely hard and wear resistant and literally glisten when subjected to sliding metal to metal service. Also nickel-base Apollo-P includes chromium to further influence the microstructure and provide such outstanding features and physical properties. Hardness: Rc65.

Olympia-P: This system is specifically formulated to resist abrasion and is optimized with fragmented tungsten carbide. The nickel-chromium alloy melts in application and becomes the matrix for the tungsten carbide as it solidifies. The activator elements provide true bonding between the carbides and the matrix. Instead of being merely mechanically entrapped, carbides are "welded" in place and do not drop out in service. Further, since the matrix alloy is in itself extremely hard and wear resistant, overall wear resistance is optimized. Hardness: Rc65 (matrix) Knoop 1880 (carbides)

Venus-P: This copper alloy designed for application only to copper and copper alloys is unique in that it is ideally suited for joining as well as overlaying. The operator merely directs the flame at the joint and allows the powder to impinge the hot surface. Capillary action draws the alloy into the joint. The operation is accomplished so quickly that surface oxidation of the base metal is minimized. In applications wherein a cluster of copper tubes is joined to a copper tube sheet, the Unitherm Process is far superior to pre-placing expensive rings.

### Compare the Advantages

<table>
<thead>
<tr>
<th>UNITHERM® Process</th>
<th>Other Processes</th>
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<tr>
<td>Provides a molecular bond with the base metal — WILL NOT PEEL.</td>
<td>Relys on non-fusion mechanical attachment</td>
</tr>
<tr>
<td>Results in smooth deposits with known consistent hardness — controlled deposition.</td>
<td>Excessive dilution from base metal resulting in unknown deposit chemistry &amp; inconsistent hardness.</td>
</tr>
<tr>
<td>Provides better control, can be used in all positions with minimal alloy consumption.</td>
<td>Poor deposit control great skill required high alloy consumption.</td>
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![Porosity: No oxides = better mechanical bond](image1)

![High dilution lowers hardness](image2)

![Less control: More skill required](image3)
The oxyacetylene torch has been with us for many years and is a proven tool for the technician who uses it to braze and braze-weld. Although one can mechanically attach a powder hopper and jerryrig a powder feed system, the result is always unsatisfactory. Attachments to existing devices designed to increase the versatility of the original almost always represent compromise.

The Unitherm Torch was conceived, designed and manufactured totally for powder spray. As such, it exhibits an optimized design, powder injecting mechanism, balance and overall ease of use. Only in this way can the basic spray process become as efficient as it is.

Since the powder supply is best situated atop the torch, the method of gripping the torch is important to prevent its becoming top heavy. The pistol grip solves this problem and also improves the powder feed control. The technician chooses his trigger finger(s) and enjoys more finite control over powder feed than other devices that use the thumb to depress an overhead lever. Further, the Unitherm torch provides instant shut-off of powder to minimize losses.

All powder spray devices require periodic cleaning — as one would maintain any fine tool. The simplicity of Unitherms internal design is outstanding. The torch can be field-stripped quickly and easily — including valve removal — so cumbersome with conventional torches. The use of forward, tandem-mounted valves not only is eye appealing but a distinct safety feature as well. The more conventional rear mounting can create problems when the torch is accidentally rubbed by the clothing. Additionally, the forward design permits more rapid shut-off.

Further, conventional in-line torches often turn in the operator's hand, not possible with the pistol grip design. The pistol grip design permits one-hand operation.
The general "feel" of a powder torch is important since the technician should not become easily fatigued when spraying for long periods of time.

Overspray is another important consideration when using powder spray torches. Not only does it waste powder but often mars the work as well. Minimizing overspray not only requires good torch design — especially the tip — but careful quality control in manufacturing the powder.

There are applications such as overlaying the flights of auger screws for which powder spray torches are superior. The operator can adjust the optimum powder feed rate and the rate of travel to produce the best overlay shape.

The Unitherm powder flowing through the Unitherm torch represents the best combination available to industry.

**Operation and Application**

While the Unitherm Torch is a relatively simple tool to operate, specific procedures must be followed to obtain optimum results. Listed below are the five steps that must be followed to obtain perfect results.

1. **Cleaning**
   Clean work surfaces are absolutely essential to insure a sound bond. Remove all oxides, grease, oil, paint, or other foreign material from the area to be sprayed, by machining, grinding, or filing to a bare, clean, bright metal.

2. **Pre-Heating**
   As with normal brazing techniques, the part on which the deposit is to be made must be pre-heated. The cleaned work surface is first heated to a temperature of approximately 600°F., indicated by a blue color.

3. **Pre-Spraying**
   After 600°F. pre-heat, and while at this temperature, coating of approximately 0.004" to 0.007" is sprayed over the entire surface to be coated. (Powder will adhere to the workpiece, and will have a sandy, dull appearance.)

4. **Bonding**
   At this point, starting at one end, edge or corner of the presprayed deposit, continue heating the part to a bright red color approximately 1850°F., at which point the powder alloy will become molten, and bond to the work surface. Continue heating and bonding the entire presprayed area.

5. **Build-Up**
   After this original bond coat has been applied, powder can now be deposited to the desired thickness, using the spray and fuse technique, which is: spray a small amount of powder. Then fuse by heating until it becomes completely molten on the workpiece and is fully bonded. Then, spray more powder.

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