PLASMA HEARTH MELTING OF TITANIUM AND TITANIUM ALLOYS

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The development and acceptance of plasma melting for the production of titanium has moved rapidly in the past five years. I would like to briefly cover this development and mention some of the benefits that can be realized with the application of plasma technology.

There are several advantages to consider in utilization of plasma melting for a variety of metals and melting applications. Some of the advantages are as follows:

1. Non-consumable melting tool.
2. Can be operated over a large range of pressures.
3. Used in cold wall or refractory lined furnaces.
4. A wide range of plasma gas chemistry can be applied.
5. Relatively low voltage operation 100 to 600 volts.
6. Long directional arc with appropriate gas flow.
7. Expensive gases (helium) can re recycled.
8. Mobility of arc permits hearth melting.
9. Clean up capability.
10. Excellent far difficult alloy combinations.

The above listed advantages have been the result of a continuing expansion of melting applications and a continuing improvement in techniques, equipment and understanding of the process.

The application of plasma melting technology to the production of titanium in the United States was initiated in 1981 when the Frankel Corporation had a plasma consolidation system built to enable the consolidation of a variety of titanium scrap that could be sweetened with virgin material when required. The Frankel unit was a horizontal boat melter that was used to consolidate materials that were fed into a water cooled copper boat which was moved in a horizontal motion below the plasma torch allowing the material to be fused into electrodes that could then be vacuum arc melted. The Frankel unit could produce consolidated

electrodes up to six meters in length and weighing approximately 3000 kilograms.
Following the Frankel unit "Oregon Plasma" installed a vertical withdrawal type melter in late 1983. This unit has been in successful operation for approximately eight years and has the capability of producing first melt titanium ingots from 350 mm in diameter to 700 mm in diameter and lengths up to 5 meters.

During this same period of time some of the U.S. aircraft engine manufacturers were engaged in active programs related to making powder products via the use of plasma. It was also found that plasma melting had some real advantages in melting of metals and alloys having high vapor pressures that were not compatible to vacuum melting. With its relatively long arc characteristics, it has also proved to be effective in hearth melting of a variety of materials including the following:

1. Titanium and Ti Alloys
2. Zirconium and Zirconium Alloys
3. Nickel Base Alloys
4. Niobium and its alloys
5. Chromium
6. Copper Alloys
7. Super Conducting Alloys
8. Memory Metals
9. A variety of other special alloys with wide variations in vapor pressures.

In 1985 Retech initiated the first plasma hearth melting in the United States with a two torch system. The initial hearth melting unit was equipped with a hearth torch rated at 250 kw and a crucible torch that operated at 100 kw. This furnace produced ingots primarily for R&D applications and to enable process development on hearth melting procedures. Since its start-up in 1985 the furnace has been upgraded to include two 350 kw plasma torches.

The Retech R&D furnace has been a very valuable tool to enable the advance development of computer aided torch programming, the study of appropriate gas recirculation systems, and a variety of other parameters that have proven to be helpful in the design and application of plasma melting equipment.

In 1987 Wyman Gordon started up a large 2250 kw melter at its Worcester plant that has the capability of melting ingots to 7000 kg and also for producing nickel base powder. An R&D hearth metter has also been installed at Pratt & Whitney, East Hartford. In addition, General Electric has been very active in pursuing plasma processing for both ingot and powder applications.

In the latter part of 1989 Teledyne Allvac started up a plasma hearth furnace utilizing four 750 kw electrodes arranged in a rectangular pattern to facilitate torch mounting and movement. In the rectangular mounting geometry there is less interference with torch manipulation than is experienced when torches are lined up in a linear geometry.

The Teledyne plasma hearth furnace is used exclusively for melting of titanium, and titanium alloys. The capacity of the Teledyne plasma hearth melter is to produce ingots to 7500 kg.

It should be emphasized that the melting of titanium can be accomplished by using either helium, argon, or a mixture of these gases to obtain a desired melting result. When considering the use of helium for a plasma gas, it is almost mandatory to use a gas recycling system to enable an economic operation. In some applications a gas recycling system is not sufficient and a complete gas purification system may be required.

Generally speaking the best results in melting of titanium and its alloys are obtained when melting with helium or a helium argon mixture. In some cases melting at identical power levels the melt rate of a helium plasma gas and atmosphere will be double that which can be obtained with argon.

Another very important requirement for the successful operation of a multi torch plasma hearth melting system is the implementation of an appropriate automatic torch profiling system. It is virtually impossible for a furnace operator to manually control multiple torches and perform in a consistent manner to maximize ingot quality.

Retech has developed a computer aided system that controls not only the patterns and timing of four or more torches but also controls ingot withdrawal. Once torch profiles bave been established for a given alloy and ingot size, they can be stored and then recalled as required. The torch profiler has also built into the software, an interlocking system to prevent the crashing of torches into each other when overlapping patterns are required.

Many other interesting parameters relate to not only the gas or gas alloy that is applied to melting of a given material. Por example, the furnace pressure can have a dramatic effect on not only tbc arc length (voltage gradient) of the plasma torch but it can also effect the melt rate depending upon the arc gas used and in some instances torch and crucible geometry.

A continuing effort is underway at Retech to improve many of the physical conditions appropriate to improving melting practice and applications of plasma processing.

Some of the additional applications of plasma technology presently being developed at our plant afe related to the following technologies:

l. Recycling of metal dross and scrap.
2. Plasma pyrolysis and vitrification of toxic waste by application of plasma centrifugal furnace technology.
3. The application of plasma for welding of primary titanium electrodes.

To date, Retech has melted on an R&D basis in excess of 100 different metals and metal alloys, There is no doubt that the application of plasma melting techniques can be and will be applied to a very broad spectrum of melting requirements in the future as higher performance, cleanliness and alloy control become mandatory far advanced metals and ceramic applications.

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