Reclamation of Machinery Components using Plasma Weld Surfacing

D.K. Biswas and V.V. Modak**

ABSTRACT

Reclamation techniques are gaining momentum due to the cost and downtime involved in the replacement cost of worn out components One of the latest techniques for rejuvenating worn out critical machinery components is to combine the plasma spraying and plasma welding techniques in a semi-transferred arc mode. Arc is controlled independently and precisely so that optimum deposition and welding currents can be used to melt and spray the metal powders of interest and then weld it to the base metal. Thus the process provides a good metallurgical bonding with minimum heat input and avoids warpage which is a vital parameter in case of critical components where dimensional stability to close tolerance are important.

Many important machinery components have been reported to be reclaimed using this technique. However, the success of the process depends on many important parameters like choice of powder metal, joint fit-up, machine settings, control of gas flows, powder feed rate, arc length, etc. The paper describes in detail the process used for reclamation of a critical aircraft component using programmable plasma weld surfacing machine and also mentions evaluation techniques used for assessment of quality standard of weld surfacing.

1. INTRODUCTION

Thermal plasma techniques were being applied for specific applications almost a hundred years ago, although it was only in the late 50's that it became viable and attractive metal processing routes to overcome problems of prolonged down time, saving in foreign exchange, etc. Reclamation techniques by various processes like electroplating, welding and thermal spraying etc. are attractive method. One of the latest and attractive technique for rejuvenating worn out components, is plasma weld surfacing which combines the plasma spraying and plasma welding technique. Of the various processes available, plasma weld surfacing provides a metallurgical bonding between overlay and substrate using low heat input which avoids warpage. Thus, strong build up having strength as that of the base metal can be achieved without any warpage.

The objective of this paper is to review the basics of the plasma weld surfacing as it applies to the reclamation of the worn out component and to high light the similiarities and differences between other thermal processes. Experiment carried out in Naval Chemical and Metallurgical Laboratory, Bombay to build up worn out component, "Brake disc" of an aircraft has also been described and results obtained has been evaluated for the specific application.

The component was required to be reclaimed for the correct dimensions for re-use. The brake disc comes in contact with frictional lining during operation and in process of use, the surface of the brake disc gets frequently worn out. It is, therefore, of imperative necessity to impart in the build-up material, additional wear resistant properties compatible with the line material. The component is made up of two parts namely (a) Housing and (b) brake disc as shown in Fig. 1.

Material of brake disc is plain carbon steel. Composition of housing is a low carbon steel having carbon content of 0.14%.

2. SELECTION OF THE PROCESS

Conventional welding processes like TIG, MIG, MMAW lead to warpage due to their inherent high heat input. Thermal spraying and electroplating considered to be cold processes lacking in bond strength. Hence, selection of the process was dificult.

It was then decided to employ the latest technique plasma weld surfacing technique, in semi-transferred arc mode. The technique can give good metallurgical bonding between substrate and surfaced layer ensuring elimination of total warpage by controlling judiciously various welding parametres. Nickel base alloy powder was selected for the reclamation work considering application and compatibility with base metal

* Naval Chemical and Metallurgical Laboratory, Naval Dockyard, Bombay - 400 023.

The paper was presented in the IIW Bombay Branch Seminar 1987

* Diesel engine wear parts
* Wear rings and plates
* Oil drill tool bits
* Pump journals
* Cutter blades
* Turbine blades and roots

8. CONCLUSION

Using latest weld surfacing technique, judicious use of various welding parameters, it is possible to critical aircraft component like brake disc.

REFERENCES :

1. Technical Literature M/s. Wall Colmonoy Ltd. U.K., not published.

2. Payne B.E. "Nickel-base Welding Consumables for dissimilar metal welding applications" Metal Construction and British Welding Journal, Dec.1969, Vol.1, Number 12S.

Table I

Parameters for plasma weld surfacing of Brake Disc

Plasma Arc Current	:	80 A
Transferred Arc current	:	120 A
Reduced to	:	80 A
Powder flow	:	3 cm^3/min
Shielding gas flow	:	12.5 lit/minute
Plasma gas flow	:	8.0 lit/minute
Oscillation stroke length	:	2.5 cm
Oscillation frequency	:	6 cycle/minute
Rotator : rotation speed	:	6 min/revolution
Transferred arc current decay	:	-4 sec

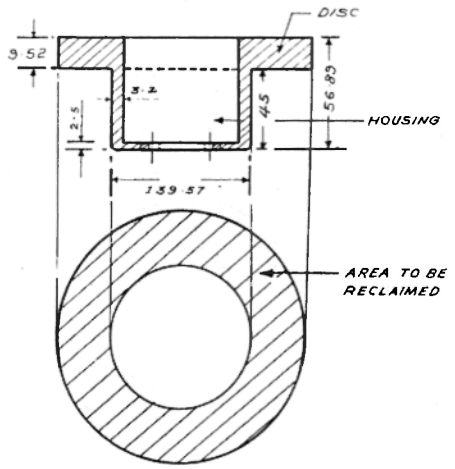

Fig.1 Sketch Showing Break Disc Area To Be Reclaimed

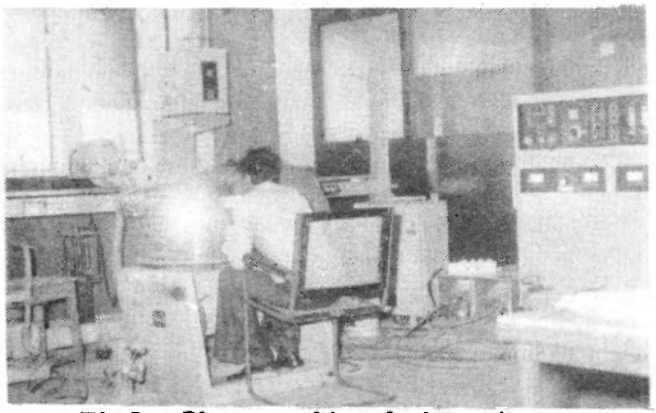

Fig.2 Plasma weld surfacing unit

3. ADVANTAGES OF PLASMA WELD SURFACE PROCESS

Plasma weld surfacing gives precise control of penetration into base metal, which can be held to as low as 0.12 mm. Dilution level of weld metal with base material can be held down upto 5%, if desired. It is possible to make very thin deposits of 0.25 mm and thick deposits upto 6 mm in a single pass. Multiple passes build up much higher thickness, if required. Plasma weld surfacing gives flatter, and smoother deposits other than fusion process. High quality deposits may be made on any surface with little or no surface preparation. Deposits have the full density and integrity of any other welding process in which metal is melted and solidified. It gives high weld surfacing efficiency upto 95% and more of the metal powder fed into the plasma used up as fused deposit. The process can be completely automated with proper fixturing for continuous surfacing from part to part where high deposition rate upto 4 kg/hr, can be achieved.

4. EQUIPMENT USED

A semi-transferred type plasma weld surfacing machine (Fig.2) was used for this purpose. The system works by striking a pilot arc between the electrode and the nozzle. In semi-transferred mode, arc established is then transferred between electrode and work piece whereas in plasma weld surfacing, the pilot arc melts the filler metal initially and thereby allows the heat input of transferred arc between the electrode and work piece to be maintained at the lowest level. The pilot and transferred arc can be varied independently and precisely so that total control over heat input is obtained.

A schematic diagram explaining the principle of semi-transferred arc plasma weld surfacing used is shown in Fig.3. Plasma is formed by ionising a gas in the extreme heat energy from the arc. A plasma is a gas of sufficient energy content that a significant fraction of the species present are ionised. It consists of a mixture of electrons, ions and neutral species and in such proportions that the overall is electrically neutral. The ionised conducting plasma is then forced through a constricting orifice and thereby the plasma jet is accelerated to sonic velocity (12 m/sec) with intense heat.

Metal and alloy powder is stored in a hopper. Argon carrier gas conveys the powder from hopper to the torch. Argon/Hydrogen gas mixture is used as shielding gas which protects weld pool and metal powder from atmosphere. Metal particles heated sufficiently in the plasma and then deposited on the work piece The homogeneous deposit fuses to the work forming a permanent bond The weld surfacing system configuration consisted of power pack, plasma torch, carriage and oscillator mounted on work horse, rotator, Argon gas bottles.

5. EXPERIMENTAL WORK

Schematic diagram of weld surfacing cycle used in the reclamation work is shown in Fig.4.

Number of trial runs were conducted during experimental stage for establishing correct welding cycle parameters. The considered parameters are :

> Operating cycle, Gas flow, Current, Powder flow, Movement of torch and work piece.

These parameters are required to be set before the surfacing cycle begins. Permutation and combination of these parameters lead to innumerable experimental conditions. Hence, selection of proper parameters become exceedingly difficult task.

It is essential to know the effects of these parameters on weld pool. This will help in understanding the efforts required for obtaining correct solution to the problem.

Effects of these parameters on the quality of weld are briefly described in the succeeding paragraph :

a) **Operating Mode**

Transferred Arc	Semi-transferred Arc
Dilution level high	Dilution level low
High heat input leading to distortion	No distortion

b) **Gas Flow**

Powder flow

- Excess pressure	- Powder blockage
- Less pressure	- Insufficient powder flow

Plasma gas flow

- Higher gas flow	- Hotter base metal
	- Under cutting
- Lower gas flow	- Colder base metal
	- Improper fusion

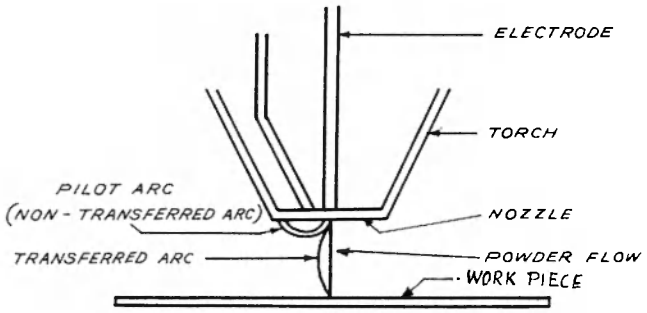

Fig.3 Schematic diagram illustrating principle of semi-transferred arc plasma weld surfacing

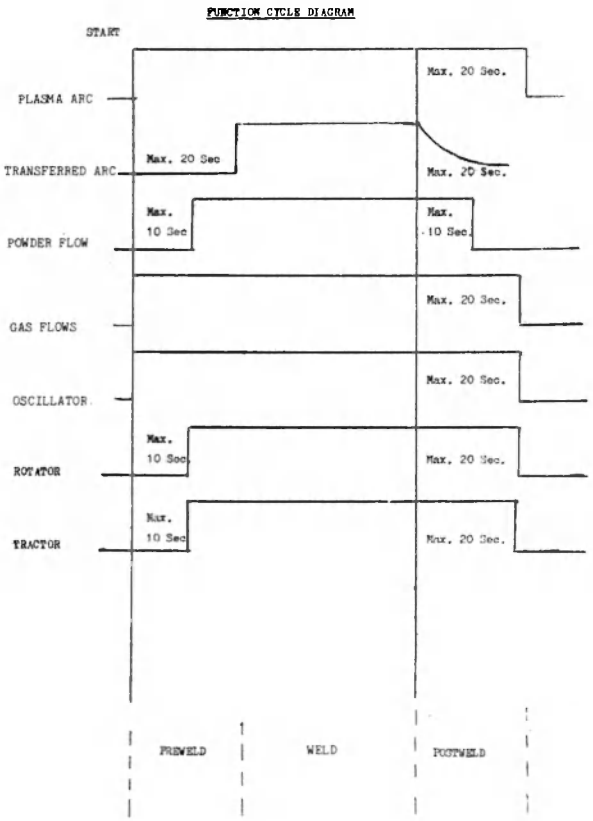

Fig.4 Schematic diagram of weld surfacing cycle used in the reclamation work

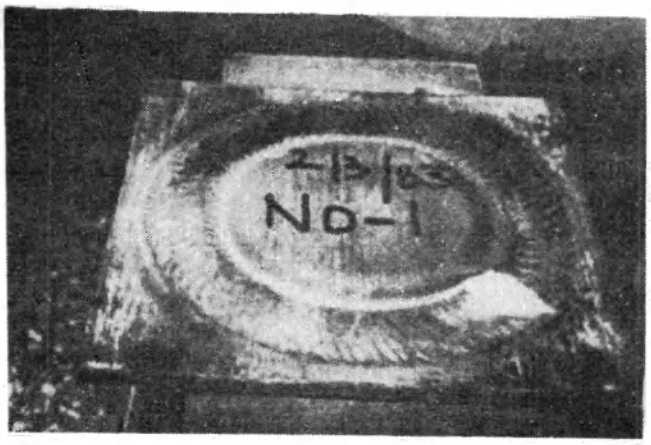

Fig.5 En 9 plate plasma arc weld surfaced

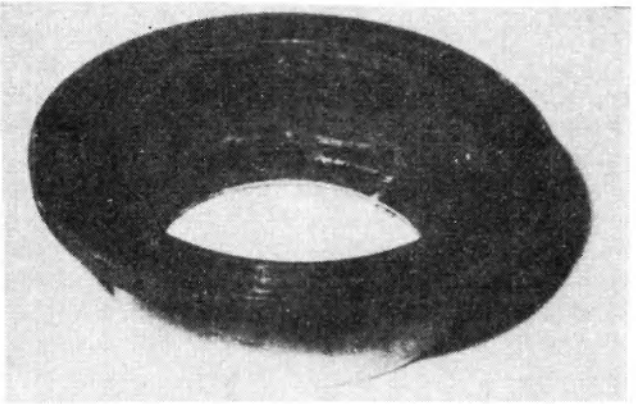

Fig.6 Brake Disc before reclamation

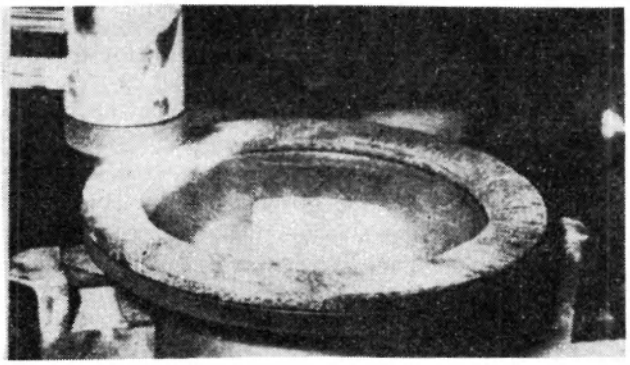

Fig.7 Brake Disc during reclamation

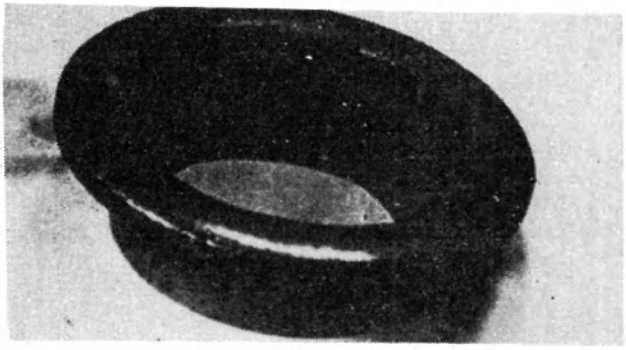

Fig.8 Brake Disc after reclamation

Shielding gas flow

- Higher gas flow - Hotter base metal
  - Under cutting
- Lower gas flow - Ingress of oxygen from surrounding air leading to discoloured oxidised surface.

c) **Current**

Plasma arc and transferred arc current.

Thin components :

- High plasma arc current - 1500 amp. max
- Low transferred arc current - 5-30 amp. min. Low dilution, no distortion, low heat input.

Large components :

- Low plasma arc current
- High transferred arc current to maintain good weld pool.

  High deposition rate, high heat input.

d) **Preweld Current**

For precise control of temperature rise in small parts, to avoid warpage and melting.

For preheating of components where carbon equivalent values of base material are higher. This is necessary to avoid weld defects like cracks.

e) **Current Decay**

Transferred arc current is slowly reduced to zero in 20 seconds (Max) after welding cycle is over thereby avoiding welding defects like crater and shrinkage cracks.

f) **Powder Flow**

Powder flow decides the amount of material deposited i.e. layer thickness control and size of bead.

Higher flow rate leading to colder weld pool. This results in either low dilution or sometimes insufficient fusion.

It should be ensured that the powder flow is stopped before arc is extinguished. Phasing out of these events become exceedingly important to avoid welding defects.

Selection of proper size of metal alloys powder is to be done correctly. Fine powders do not flow properly through conduits and coarse powder particles block the flow leading to improper material deposition.

g) **Movement of Torch and Work Piece**

Interaction time between arc and work piece has direct bearing on quality of weld. Use of improper interaction time leads to welding defects like melting of parts, high dilution, uneven and unfused deposition.

Interaction time between arc and work piece will depend on :

Oscillator stroke length and stroke rate,
RPM of rotator,
Sequencing of start and stop position of torch oscillator and rotator,
Selection of time at the begining and at the end of oscillator stroke.

h) **Preheat**

Preheat selection is based upon shape, size and chemistry of base metal. Higher preheat than optimum allows lower transferred arc current and higher rate of deposition at the same arc current. However, lower preheat than optimum may lead to higher rate of cooling. This chills the weld pool and produces unsound weld.

6. RECLAMATION OF BRAKE DISC

It is stated that a set of parameters used for one component differs from the set used for any other component. Hence, numerous test pieces were made during this experimental stage. These test pieces were subjected to various tests like dye penetrant, radiography, etc.

The correct parameters were established (Table 1) for this particular work. Figs. 5,6,7,8 show the brake disc passing through the various stages of reclamation. Test samples prepared using these approved parameters were tested for dye penetrant, radiography, metallography, hardness survey and EPMA studies, for evaluation of the quality standard of the surfaced layer Figs. 9,10 show the microstructure of the deposited metal and the substrate respectively.

The reclaimed brake discs have undergone field trials successfully.

7. OTHER COMPONENTS

Some other critical components which can be reclaimed successfully using plasma weld surfacing technique are listed below :

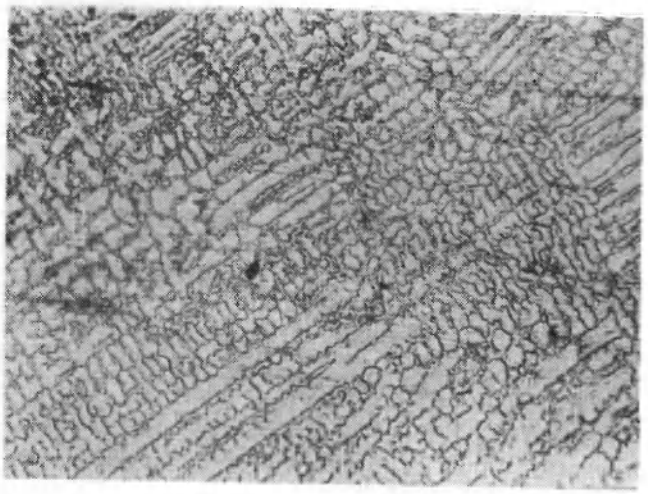

Fig.9 Micro-structure of deposited metal showing dendridic structure

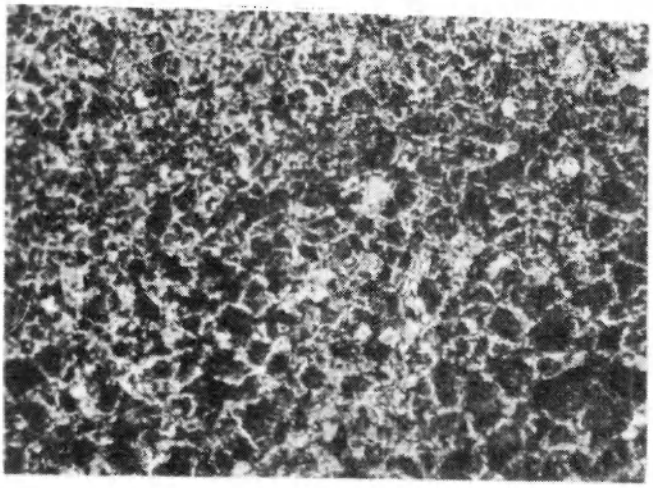

Fig.10 Micro-structure of substrate showing pearlite ferrite

International Welding Conference-

International Conference on Welding Technology in Developing Countries - Present Status & Future Needs

- **September 26-28, 1988, Roorkee, India.**
- **Organised by Welding Research Laboratory University of Roorkee**

The abovementioned conference is 3rd in the series being organised to provide a common platform to scientists and technologists from developing and advanced countries so as to exchange or share their experiences in the area of welding technology.

The conference is intended to focus the status of welding technology with special reference to the trends in the manufacture of welding equipments and consumables, weldment design and evaluation, welding in repair and maintenance, quality control and assurance. In the area of research and development, it is proposed to stress on the mechanisation and automation in welding, improvements in welding consumables, non-conventional welding processes and specific case studies.

Call for papers has been announced. Last date of submission of abstract is January 31, 1988, and completed manuscripts in camera ready form must be submitted by May 30, 1988. The papers will be accepted after a review by a technical expert committee.

All correspondence on presentation of technical papers should be addressed to -

Dr. S.R. Gupta, Co-Chairman,
Technical Publication Committee,
Department of Mechanical & Industrial Engg.
University of Roorkee, Roorkee - 247 667
U.P., INDIA

For registration form and other details, write to

Prof. P.C. Gupta, Organising Secretary,
International Conference on Welding Technology in Developing Countries - Present Status & Future Needs at the abovementioned address.