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A Review Paper on Inconel alloys

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ABSTRACT:
Inconel combinations genrally known for consumption resistantance to oxidation and their capacity to keep up with their primary respectability in high temperature environments. There are a few Inconel composites that are utilized in applications that requires a material that requires a material that doesn't effortlessly capitulate to scathing erosion, consumption brought about by high virtue of water, and consumption breaking. While every variety of Inconel has a remarkable qualities that makes it successful in various conditions, most of compounds are utilized regularly in synthetic, aviation enterprises. Welding Inconel amalgams is troublesome because of breaking and microstructural isolation of alloying components in the intensity impacted zone. In any case, a few combinations are have been intended to beat these issues. The most widely recognized welding strategies are gas tungsten curve welding and electron bar welding.

I. INTRODUCTION

Inconel combinations are oxidation-erosion safe materials appropriate for the outrageous conditions exposed to tension and intensity. When warmed, Inconel frames a thick, stable, passivating oxide layer shielding the surface from additional assault. Inconel holds strength over a wide temperature range, alluring for high temperature applications where aluminum and steel would capitulate to crawl because of thermally prompted precious stone opportunities. Inconel's high temperature strength is created by strong arrangement reinforcing or precipitation solidifying, contingent upon the compound.

Properties

1) Consumption execution is especially fit to the acrid conditions of down - opening raw petroleum and flammable gas wells.
2) Exceptionally high strength, appropriate to tooling applications and decreasing suspended heap of basic temperatures.
3) Fantastic protection from stress consumption breaking.
4) Fantastic protection from pitting and cleft erosion.

Applications

1) Marine and siphon shafts.
2) High strength clasp.
3) Into opening hardware for destructive/harsh help, for example, valves, holders, apparatus joints and packers.
4) Synthetic interaction industry parts

Inconel alloy types:

1) Inconel 188: It is readily fabricated for commercial gas turbines and aerospace applications.
2) Inconel 230: This plate is mainly used by the power, aerospace, chemical processing and heating industries, aerospace materials.
3) Inconel 600: It is a solid solution strengthened.
4) Inconel 617: It is a solid solution strengthened, high temperature strength, corrosion and oxidation resistant and high weld ability.
5) Inconel 625: Acid resistant and good weld ability.
6) Inconel690: It is a Low cobalt content for nuclear applications, and low resistivity
7) Inconel 713C: It is a precipitation hard enable nickel – chromium base cast alloy.
8) Inconel 718: Gamma double prime strengthened with good weld ability.
9) Inconel X-750: It is used in gas turbine components, including blades, seals and rotors.
10) Inconel 751: Increased aluminum content for improved rupture strength of 1600^0 F.
11) Inconel 792: Increased aluminum content improved high temperature properties and used in gas turbines.

12) Inconel 939: It is gamma prime strengthened to increase weld ability.
13) Inconel 925: It is non stabilized austenitic stainless steel with low carbon content.

II. LITERATURE REVIEW

1. Friction stir welding of Inconel alloy 600:
Author: Fuxing Ye

The width of the test was 6 mm and its length was 1.8 mm. The base material was a 2-mm-thick nickel-based super composite (industrially called Inconel 600) with a dissolving point of 1630 K, and its ostensible piece (wt.%) was 76.0 Ni, 15.5 Cr, 8.0 Fe, 0.25 Si, 0.50 Mn, 0.08 C and 0.008 S. welding velocity of 1.67 mm/s and a device pivot speed 400 rpm. The apparatus was shifted at 30.

Microstructure:

Large scale and microstructures of the mix zone of the cross over cross segment of the joint and the microstructure of the Inconel 600 base metal (BM) (Etched by HNO3 + HCl + H2O). No volumetric imperfection and it were seen inside the joint to kiss bond. The mix zone was recrystallized and intergranular limits were not profoundly carved. The estimation position was 1 mm from the outer layer of the test piece with an applied heap of 200 gf at 0.25 mm spans.

Conclusion:

The cross over disappointment of the joint happened through necking outside the weld locale, which additionally implies that the rigidity of the mix zone was more prominent than that of the BM. The broke joint surface displayed intergranular dimples and the break started for the most part from the grain limits and the precipitation destinations. The broke FSW mix zone showed more modest dimples, which came about part of the way from the more modest grain size in the mix zone. The yield strength of the great softening point materials is a marker as grating mix weldability.

2. A Review on Super alloys and IN718 Nickel-Based INCONEL Super alloy
Author: Enes Akca, Ali Gursel

Inconel Alloy 600: (76Ni-15Cr-8Fe) is a standard material of construction for nuclear reactors, also used in the chemical industry in heaters, stills, evaporator tubes and condensers.
Nimonic alloy 75: (80/20 nickel-chromium alloy with additions of titanium and carbon) used in gas turbine engineering, furnace components and heat-treatment equipment.
Alloy 601: Lower nickel (61%) content with aluminium and silicon additions for improved oxidation and nitriding resistance chemical processing, pollution control, aerospace, and power generation.
Alloy X750: Aluminium and titanium additions for age hardening. Used in gas turbines, rocket engines, nuclear reactors, pressure vessels, tooling, and aircraft structures,
Alloy 718: (55Ni-21Cr-5Nb-3Mo). Niobium addition to overcome cracking problems during welding. Used in aircraft and land-based gas turbine engines and cryogenic tankage.
Alloy X (48Ni-22Cr-18Fe-9Mo + W):High-temperature flat- rolled product for aerospace applications.
1) Waspaloy (60Ni-19Cr-4Mo-3Ti-1.3Al). Proprietary alloy for jet engine applications.
2) ATI 718Plus:A lower cost alloy which exceeds the operating temperature capability of standard 718 alloy by 100 F° (55 C°) allowing engine manufacturers to improve fuel efficiency.
3) Nimonic 90. (Ni 54% min Cr 18-21% Co 15-21% Ti 2-3% Al 1-2%) : used for turbine blades, discs, forgings, ring sections and hot-working tools.

Conclusion:

A super compound is a metallic composite which is created to oppose most high temperatures, generally in cases until 70 % of unquestionably the dissolving temperature. These composites have a fantastic downer, erosion and oxidation obstruction too a decent surface strength and weariness life.IN718 nickel-based super combination which is the last form of Inconel 718 has been continuing in the manner to turn into a material that aviation and protection enterprises are never supplant of some other material with consolidating its great mechanical properties, simple machinability and of minimal expense.

3. Mechanical Properties of Friction-Stir-Welded Inconel 625 Alloy:
Author: Kuk Hyun Song, Kazuhiro Nakata

The material utilized in this study was an Inconel 625 sheet with size of 65mm*150mm*2mm and its substance Composition in mass% was follows: Cr: 21.99%, Fe: 3.24%, Mo: 9.00%, Nb: 3.53%, C: 0.01%, MN: 0.10%, Si: 0.09%, S: 0.001%, Al: 0.18%, Ti: 0.32% and Ni-balance. FSW was done at a device pivot speed of 200rpm and a voyaging rate of 100mm/min and utilizing a tungsten carbide cobalt (WC-Co) instrument with a shoulder measurement of 15mm and a test with breadth and length of 6mm and 1.8mm, individually. To accomplish great weld quality, the apparatus was shifted forward by 30.

Microstructures:

To observe the macrostructures and microstructures of the welded materials, a solution consisting of 15ml HCl, 10ml CH3COOH3, and 5ml HNO3 was prepared. The surfaces of the samples were etched with solution after polishing them with abrasive paper. Furthermore, microhardness and tensile tests were carried out in order to investigate the mechanical properties of the alloy. The Vickers hardness test was carried out along the cross section of the weld zone using a load of 9.8N and a dwell time of 15s.

Conclusion:

Inconel 625, which is strong arrangement fortified material due to the presence of Mo and Nb, was effectively welded utilizing the FSW strategy without the development of any weld absconds. Moreover, the FSW brought about the grain refinement of the amalgam joined by an upgrade in its mechanical properties. Specifically, a definitive rigidity of the FSW mix zone example was worked on by over 20% when contrasted with that of the base material. Thusly, Inconel 625 produced from Ni-based super amalgams, which was broadly utilized in compound power plants, and it tends to be utilized in business applications subsequent to being erosion mix welded, on the grounds that FSW causes an improvement of its mechanical properties.

4. Microstructure IN718 and micro-texture evolution during large strain deformation of Inconel alloy

Author: Niraj Nayan a, N.P. Guraob, S.V.S. Narayan Murty

samples with dimensions of 15 mm (length) × 13 mm (width) × 12 mm (thickness) were fabricated from the hot rolled plate of IN718 super alloy. Using a thermo-mechanical simulator (Gleeble 3500) capable of controlling the specimen temperature, strain and strain rate, plane strain compression tests were performed. In order to conduct the test, specimens were heated to the desired temperature in the range of 950 °C to 1100 °C. Heating of the specimen was done at 5Ks−1 from ambient temperature to the specified temperature by direct resistance (Joule heating) and then compressed in a single stroke after soaking at the desired temperature for 60 s. The compressive deformation was carried out in the time periods of 1.38 s and 138sso as to impose nominal strain ratesof1s−1 and0.01s−1,respectively. Immediately after the deformation, the specimens were insitu water quenched. Post compression, specimens were cut from the sample by a slow speed diamond saw for optical microscopy and for EBSD analysis.

Conclusion:

IsothermalhotPSCtestsonInconel718toatruestrain dominantrole of dynamic recrystallization over at temperature scope of 950-1100 °C and at strain paces of 0.01 and 1 s−1. Just the example distorted at 950 °C and strain pace of 1 s−1 shows dynamic recuperation. Consequently at higher strains predominant in PSC, dynamic recrystallization system is extended in the temperature-strain rate space at the cost dynamic recuperation system. Notwithstanding, the perplexing condition of pressure and the job of twinning in unique recrystallization needs further examination.

5. Mechanical properties of hot deformed Inconel 718 and X750

Author: A. Nowotnik

The cuboidal examples (20x10x20mm) were conductive warmed to 1150°C at warming pace of 3°C/s, held for 300 s lastly cooled to the pressure temperature. The temperature was constrained by a sort K thermocouple embedded and welded in an opening emptied out in the focal piece of the example by flash disintegration strategy. Three extra thermocouples were utilized to secure the appropriation of the temperature from one of the countenances to the focal point of the example. A mix of graphite and molybdenum foils was utilized to diminish the grinding between the iron blocks and the example as well as the inclination of temperature along the example. The twisting for every one of the tests was constrained by the stroke and estimated through a heap cells joined to the jaws. The tests were completed in an argon climate.

Tests:

Pressure tests were done on precipitations hard empower nickel based super combinations of Inconel 718 and X750 at consistent genuine strain paces of 10-4, 4x10-4s-1 inside temperature through which precipitation solidifying stages process happened (720-1150°C) utilizing thermo mechanical test system Gleeble and dilatometer Baehr 850D/L outfitted with pressure unit.

Conclusion:

High-temperature distortion of the analyzed Inconel compounds may perhaps discover a viable use in the studio practice to foresee a stream pressure values, yet just inside a specific temperature and strain rate ranges. Different energy initiation values got under different circumstances (contingent upon an examination community) or for various materials make difficult to do an immediate correlation of estimations.

6. Microstructure and Mechanical Properties of Borided Inconel 625 Super alloy

Author: Ali Gunen

Prior to a boriding treatment, 40x40x5 mm rectangular samples were cut from 5-mm thick alloy sheet. All samples were ground using 1200 grit Sic paper and then washed in distilled water and ultrasonically cleaned in acetone for a 10 minutes. The samples were then packed with commercially Ekabor II powders in a stainless steel container. Boriding was performed at 800, 900 and 1200 ºC for 2, 4, and 6 h. Commercial Ekrit powders (finely ground Si C) were added a thin layer to minimize oxidation. After boriding, the steel container was removed from the furnace and allowed to cool in the open air.

The borided samples were cut to dimensions of 10×10×5 mm, cold mounted and then ground with up to 1500 grit Si C papers and polished with 0.25 µm alumina paste followed by 1µm diamond paste to obtain a good surface finish. The polished samples were then etched with a solution of 5 ml HNO3 ml, 10 CH3COOH ml and 15 HCI ml to reveal fine microstructural.

Microstructure: Metallographic studies were carried out using a Nikon MA-200 inverted metallurgical microscope equipped with Clemex Vision software. Scanning Electron Microscopy (SEM) studies were conducted using a JEOL JSM-5600 SEM equipped with Energy Dispersive Spectroscopy (EDS) capability, at 25 kV accelerating voltage. Microhardness values of boride layers were obtained by utilizing a Highwood HWMMT-X3 hardness tester using 100 g load and 15 s dwell time. Hardness measurements on silicide layers were made using 25 g load after cracking was observed at 100 and 50 g load.

Conclusion:

Inconel 625 Ni-based super alloy was pack borided efficiently at temperatures of 800 °C, 900 °C and 1000 °C for 2, 4 and 6 h durations. The coating layers produced the surface had a smooth morphology. The layer produced consisted of three zones:

1) These zones, moving from the outer surface to the core were marked as the silicide layer, the multi-phase boride layer, the diffusion zone and substrate respectively.

2) The application of the boriding treatment under Ar atmosphere has a positive effect on reducing silicide formation especially at high duration time (6h).

3) Increase in boriding temperature and duration time did not only contribute to increase in microhardness v Both surface hardness and applied load were effective in changing the wear mechanism and wear resistance of the Ni-based Inconel 625 super alloy.

7. Microstructure and Phase of INCONEL Alloy 617

Author: W. L. MANKINS

Creep specimens were selected for the study because they would provide a close approximation of material exposed to temperature under load in actual service. The specimens were 0.252 in. diameter with a 2.25 in. gauge length. The maximum amount of plastic strain recorded for any specimen was 9.39 pct, and the creep curves indicated that none of the specimens had begun tertiary creep.

Microstructure:

Samples for optical microscopy were prepared from the gage length of each creep specimen. The samples, about 0.250 in. (6.35 mm) diameter, were mounted, polished, and electro lytically etched at 10 V and 0.5 A in 80 pet phosphoric acid/20 pct of distilled water.

Conclusion:

INCONEL alloy 617 is used for its exceptional creep and rupture properties at temperatures in excess of 1800 of compares rupture properties of this alloy with those of INCONEL alloy 625. Unlike INCONEL alloy 625, which depends on a sluggish precipitation of Ni- and Cb-rich gamma prime for its strengthening, INCONEL alloy 617 achieves its strengthening through the precipitation of stable, discrete M~3C 6 carbides. It therefore maintains its strength in the temperature range (1400 to 1800) and (760 to 982) where gamma prime is in solution. From (1400 to 1600) and (760 to 871)~ the impact strength is improved, and this is to be expected in view of the microstructures that has been presented.

8. Processing and characterization of Inconel 625 Nickel base Super alloy

Author: R. K. Gupta

The progress of aerospace industry witnessed all over the world in the last few decades would not have been possible but for the major advancement in the high temperature materials area. Nickel based alloys assume prime role among the super alloys are used in aerospace systems. The principal characteristics of Nickel as an alloy base are

i) high phase stability of the face centred cubic (FCC) matrix, ii) high modulus of elasticity, iii) low diffusivity of secondary alloying elements at service temperatures and iv) greater solubility of alloying elements. The FCC structure being a close packed lattice, and offers more resistance to the time dependent deformation processes like creep and hence imparts high strength along with corrosion resistance at room temperature as well as elevated temperatures to the super alloys.
The alloy was processed through primary vacuum induction melting (VIM) followed by secondary electro slag refining (ESR) process. Nickel, chromium, carbon are charged in to the crucible, in atmospheric condition. A leak rate of 10 micron/ metre square was maintained. Once the melting starts at 20 Torr pressure & 17.0A melting current with 700 kW power, nickel and chromium are added twice to build the Ingot. To make the ingot chemically uniform, stirring was carried out for 1 to 2 minutes after addition of the alloying elements. This stirring was done automatically by induction method. De oxidation was done by maintaining argon flushing. Primary VIM ingot of diameter of 350 mm was melted to obtain a secondary ingot of 450mm Dia. Melting rate of 420 Kg+/- 20 Kg /hr was maintained in steady state. Generally during melting it varies anywhere from 520Kg/hr to 300 Kg/hr. Hot topping was carried out to avoid the pipe defects and bring homogeneity to the ingot. This was done by bringing down the current from 15.0 A to 11.0 A.

Conclusion:

Processing of Ni based super alloy Inconel 625 was carried out through vacuum induction melting followed by electro slag refining route. Forging/ rolling was carried out in the temperature range of 1070-1100°C. The material has resulted in grain size of the ASTM 4-7 confirming good amount of mechanical working in blocks of 50mm thick sections. The forgings were also meeting the AMS 5599 specification and NDT requirements specified and found suitable for the intended for end use.

9. A Review on Laser Powder Bed Fusion of Inconel 625 Nickel- Based Alloy

Author: Zhihua Tian

Inconel 625 (IN625) is a nickel-based super alloy. It mainly draws support from solution strengthening of some elements in the Ni–Cr matrix, such as Mo and Nb, to obtain high-temperature strength, high creep resistance. It also exhibits excellent corrosion resistance in various environment conditions and good weldability . However, due to its high hardness, low thermal conductivity, and high workhardeningrate,IN625 is considered as an alloy difficult to machining or subtractive processing. Machining tools are worn too fast and it is difficult to control the properties of IN625 in casting or forging. Therefore, new technologies are ingreatneed for manufacturing complex-shapedIN625parts, which are often demanded in aerospace industries.

Macroscopic:

The surface morphology of LPBF parts is related to the laser scanning process. In the work conducted by Li et al. the surface of the as-built IN625 sample presented a typical "V" shape morphology, which is similar to the situation in the welding process. The width of the melt track is about 100 μm, and the adjacent tracks overlap closely, resulting in nearly 100% density and almost no gaps. The "V" angle increases as the laser scanning speed decreases.

Conclusion:

Characterize the macroscopic defects and microstructure of as-built and post-treated IN625 alloy to deeply explore the formation mechanism of macroscopic defects (pores, micro cracks, balling, un-melted zone) and the microstructure evolution mechanism (grain boundary, second-phase, dislocation, sub grain boundary, stacking fault, etc.).Study the anisotropy and site-specific features of high and low-temperature performance(strength, fatigue,creep,corrosion,etc.).LPBFIN625alloy and clarify the reasons, especially the influence of macro anisotropy and microstructure anisotropy at the as-built and post-treated states on the above-mentioned properties. Establish models to predict the microstructure evolution and residual stress distribution of LPBF IN625 alloy, i.e., building the relationship between the LPBF parameters, microstructure, residual stress, and mechanical properties

10. Welding processes for Inconel 718- A brief review

Author: Jose Tom Tharappel

Inconel 718 is a super alloy with higher amount of nickel initially developed by Elseistein of International Nickel Company for use in wrought condition. Now this alloy has been extensively using in investment cast form in the manufacturing of hot-section components of aero engines, gas turbines, and other high- temperature applications mostly involving high temperature environment such as chemical and process industries, and nuclear reactors. This is due of its oxidation and corrosion resistance and relatively good strength at elevated temperatures [1-4]. Investment cast structures welded during their fabrication stage or for some weld repairs. Table.1 shows a typical chemical composition of this alloy. Inconel 718 alloy has outstanding weldability in both age hardened or annealed condition. However, this alloy has high resistant to strain-age cracking yet this alloy has still weldability problems such as micro fissuring and solidification cracking. Formation of Nb rich Laves phase which is a brittle intermetallic phase of Ni, Cr, Fe2, or Nb, Mo, Ti, in the inter dendritic region at the time of solidification is another main problem.

III. CONCLUSION:

Use of Inconel 718 is stretching due to its ability to maintain high strength at temperatures ranging from 450 to 700°C complimented by excellent oxidation and corrosion resistance and outstanding weldability in either the age hardened or annealed condition. However, alloy 718 is reputed to possess good weldability liquation cracking and weld metal cracking problems persist. Fusion zone cracking, liquation cracking (micro fissuring) are serious defects in Inconel 718 weldments. Researchers presented different wedging processes, heat treatment methods, selection of process parameters and alloying elements to minimize these defects. Laves phase are main culprits for liquation cracking and formation of this phases depends on initial grain size and composition of the base metal. Proper pre/post weld heat treatment minimises the Liquation.

REFERENCES

[1]. Fuxing Ye Æ Hidetoshi Fujii Æ Takuya Tsumura Æ Kazuhiro Nakata, et al, Friction stir welding of Inconel alloy 600 , Received: 8 February 2006/Accepted: 3 April 2006/Published online: 5 August 2006 Springer Science Business Media, LLC 2006.PERIODICALS OF ENGINEERING AND NATURAL SCIENCES Vol. 3 No. 1 (2015) Available online at: http://pen.ius.edu.ba .

[2]. Enes Akca, et al, A Review on Super alloys and IN718 Nickel-Based INCONEL Super alloy, Department of Mechanical Engineering, Faculty of Engineering and Natural Sciences, International University of Sarajevo, Hrasnicka cesta 15, 71210, Sarajevo, Bosnia and Herzegovina eakca@ius.edu.ba

[3]. Kuk Hyun Song* and Kazuhiro Nakata, et al, Mechanical Properties of Friction-Stir-Welded Inconel 625 Alloy, Joining and Welding Research Institute, Osaka University, Ibaraki 567- 0047, Japan.

[4]. S. Hemakumar and P. Kuppan ,et al, Experimental investigations and optimisation of process parameters in dry finish turning of Inconel 625 super alloy , School of Mechanical Engineering, Vellore Institute of Technology, Vellore – 632014, India Email: pkuppan@vit.ac.in Email: mail2hemakumar@gmail.com.

[5]. Niraj Nayan a, N.P. Guraob, S.V.S. Narayana Murty a,□ ,Abhay K. Jhaa, Bhanu Panta, Koshy M. Georgea, et al, Microstructure and micro-texture evolution during large strain deformation of Inconel alloy IN718, a Materials and Mechanical Entity, Vikram Sarabhai Space Centre, Trivandrum 695 022, India b Department of Materials Science and Engineering, Indian Institute of Technology, Kanpur 208 016, India. Article history: Received 2 January 2015 Received inrevised form22October2015 Accepted 23 October 2015 Available online 27October 2015.

[6]. A. Nowotnik*, P. Pędrak, J. Sieniawski, M. Goral ,et al,Mechanical properties of hot deformed Inconel 718 and X750,Department of Materials Science, The Faculty of Mechanical Engineering and Aeronautics, Rzeszow University of Technology, Al. Powstańców Warszawy 12, 35-959 Rzeszow, Poland * Corresponding e-mail address: nowotnik@prz.edu.pl Received 11.12.2011; published in revised form 01.02.2012.

[7]. A Thakur and S Gangopadhyay , et al, .Evaluation of micro-features of chips of Inconel 825 during dry turning with uncoated and chemical vapour deposition multilayer coated tools, Proc I MechE Part B: J Engineering Manufacture 1–16 IMechE 2016 Reprints and permissions: sagepub.co.uk/journals Permissions.navs DOI: 10.1177/0954405416661584.

[8]. 8.. So-dam Ban1, Young-Taek Shin2, Sung Riong Lee3, Hae- woo Lee1,* et al, Corrosion Resistance of Inconel 625 Overlay Welded Inside Pipes as a Function of Heat Treatment Temperature 1 Department of Materials Science and Engineering, Dong-A University, Busan Rep. of Korea 2 Department of Naval Architecture and Offshore Engineering, Dong-A University,

Busan, Rep. of Korea. 3Departmnet of Materials and Metallurgical Engineering, Kangwon National University, Kangwon-do, Rep. of Korea. *E-mail: hwlee@dau.ac.kr .

[9]. Ali Gunen1, Erdogan Kanca2, et al, Microstructure and Mechanical Properties of Borided Inconel 625 Super alloy 1Metallurgical and Materials Engineering, Technology Faculty, Iskenderun Technical University,31200 Hatay, Turkey e-mail: ali.gunen@iste.edu.tr ,

[10]. aligunen2013@gmail.com2MechanicalEngineering, Mechanical Engineering Faculty, Iskenderun Technical University,31200 Hatay, Turkey e-mail: erdogan.kanca@iste.edu.tr .

[11]. W. L. MANKINS, J. C. HOSIER, AND T. H. BASSFORD,et al ,Microstructure and Phase of INCONEL Alloy 617 Stability ,INCONEL* alloy 617 is a nickel-chromium-cobalt- INCONEL is a registered trademark of The International Nickel Company, Inc.

[12]. R. K. Gupta1*, V. Anil Kumar1, U.V. Gururaja2, B.R.N.V. Shivaram1, Y. Maruti Prasad1, P. Ramkumar1, K.V.A. Chakravarthi1, P. Sarkar2 , et al, Processing and characterization of Inconel 625 Nickel base Super alloy, 1Materials and Mechanical Entity, Vikram Sarabhai Space Centre, Trivandrum-22 2MishraDhatu Nigam Limited, Hyderabad*Corresponding author :rohitkumar_gupta@vssc.gov.in.

[13]. Zhihua Tian 1,2,† , Chaoqun Zhang 1,*,†, Dayong Wang 3,4 , Wen Liu 5 , Xiaoying Fang 6, Daniel Well Mann 1,7, Yongtao Zhao 2 and Yingtao Tian 7 ,et al, A Review on Laser Powder Bed Fusion of Inconel 625 Nickel-Based Alloy, Received: 17 November 2019; Accepted: 18 December 2019; Published: 20 December 2019.High Speed Machining of Inconel 718 Focusing on Tool Surface Topography of CBN Tool Tatsuya SUGIHARA1*† and Toshiyuki ENOMOTO1 1Osaka University, Osaka, JAPAN. t-sugihara@mech.eng.osaka-u.ac.jp, enomoto@mech.eng.osaka- u.ac.jp.

[14]. Prabhat Kumar, Kanhaiya Saw, Uday Kumar and Somnath Chattopadhyaya ,et al, detail investigation of microstructures and mechanical properties of inconel 617 sheet of fiber laser welding, Department of Mechanical Engineering, Indian School of Mines, Dhanbad, India E-Mail: kumar.prabhat0365@gmail.com .Welding processes for Inconel 718- A brief review Jose Tom Tharappel, Jalumedi Babu MED, SJCET, Choondacherry,686579, Kerala, India. Corresponding author E- mail ID: jalumedi.babu@gmail.com.IOP Conf. Series: Materials Science and Engineering 330 (2018) 012082 doi:10.1088/1757-899X/330/1/012082.

[15]. Hui-Chi Chen & Andrew J. Pinkerton & Lin Li, et al,Fibre laser welding of dissimilar alloys of Ti-6Al-4V and Inconel 718 for aerospace applications,Received: 10 February 2010/Accepted: 15 June 2010 /Published online: 30 June 2010 # Springer-Verlag London Limited 2010.

[16]. alloy X. S. Xiea, J. X. Dongb, M.C. Zhangc ,et al

[17]. ,Research and Development of Inconel 718 Type Super, High Temperature Materials Research Laboratories, University of Science and Technology Beijing, Beijing 100083, China axishanxie@mater.ustb.edu.cn, bjxdong@mater.ustb.edu.cn, cmczhang9@mater.ustb.edu.cn.

[18]. Copyright© Special Metals Corporation, 2013 (Aug 13) INCONEL and INCOLOY are trademarks of the Special Metals Corporation group of companies, INCONEL® alloy 625.

[19]. Gauri Mahallea, Nitin Kotkundea*, Amit Kumar Guptaa, Swadesh Kumar Singhb ,et al, Study of Mechanical Properties and Microstructural Analysis for Inconel Alloy sheet at Elevated Temperature, a. Department of Mechanical Engineering, BITS Pilani, Hyderabad, Telangana, 500078, India. B. Department of Mechanical Engineering, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, Telangana, 500090, India.

[20]. Neenu Joy1 ,Jobil Varghese2 1 PG Student, et al, Study on Behaviour of Steel, Monel and Inconel at Elevated Temperature

[21]. ,Civil Engineering, MBITS, Kerala, India 2 Assistant Professor, Civil Engineering, MBITS, Kerala, India.

[22]. G.Archana1, Dr .K. Dharma Reddy2, Dr. P.Venkataramaiah3 ,et al, Study on Machining Response in Wire EDM OF Inconel 625 ,1,2,3 Department of Mechanical Engineering, Sri Venkateswara University College of Engineering, Tirupati, Andhra Pradesh 517502, India.

[23]. H. L. Eiselstein and D. J. Tillack ,et al, THE

INVENTION AND DEFINITION OF ALLOY 625 lnco Alloys International, Inc. P. 0. Box 1958 Huntington, WV 25720. Super alloys 71.8,625 and Various Derivatives Edited by Edward A. Lmia The Minerals, Metals & Materials Society, 1991.

[24]. Esteban Broitman1,et al ,Indentation Hardness Measurements at Macro-, Micro-, and Nano scale: A Critical Overview ,Received: 25 September 2016/Accepted: 15 December 2016 The Author(s) 2016. This article is published with open access at Springerlink.com.

[25]. R. Ramesha,□ ,I. Dinaharanb, Ravi Kumar c, E.T. Akinlabib ,et al, Microstructure and mechanical characterization of friction stir welded high strength low alloy steels, a. Department of Mechanical Engineering, PSG College of Technology, Coimbatore 641004, Tamilnadu, India b. Department of Mechanical Engineering Science, University of Johannesburg, Auckland Park Kingsway Campus, Johannesburg 2006, Gauteng, South Africa c Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai 600036, Tamilnadu, India.

[26]. G. D. SMITH and D. H. YATES ,et al, Optimization of the Fatigue Properties of INCONEL Alloy 617,Inco Alloys International, Inc. Huntington, WV 25720. THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS 345 E. 47 St., New York, N.Y. 10017.

[27]. N.G.Patil a*,Ameer Asema, R. S. Pawadeb, D.G.Thakurc, P.K.Brahmankarb, et al, Comparative study of high speed machining of Inconel 718 in dry condition and by using compressed cold carbon dioxide gas as coolant ,a Department of mechanical engineering, Marathwada Institute of Technology,Aurangabad,431028,Indiab.Dr. Babasaheb Ambedkar Technological University, Lonere, India c. Defence Institute of Advanced Technology, Pune, India.

[28]. Vrushali Bunde a, aP.G Student , Dr. R. S. Dalub ,et al, Machining of Inconel 718 Alloy using EDM-A Review, Production Engineering, Government College of Engineering, Amravati, Maharashtra b. Head of the Department , Mechanical Engineering, Government College of Engineering, Amravati, Maharashtra.

[29]. Nader El-Bagoury1,2, Mohamed Ramadan1,et al, Heat Treatment Effect on Microstructure and Mechanical Properties of Re-Containing Inconel 718 Alloy ,Central Metallurgical Research and Development Institute (CMRDI), Cairo, Egypt 2Department of Chemistry, Faculty of Science, Taif University, ElHaweyah, Saudi Arabia 3College of Engineering, University of Hail, Hail, Saudi Arabia Email: *mrnais3@yahoo.com, nader_elbagoury@yahoo.com .Received July 1, 2012; revised August 10, 2012; accepted September 5, 2012.

[30]. Bu Xiaoqing Wang, Tahmina Keya,et al, Kevin Chou ild Height Effect on the Inconel 718 Parts Fabricated by Selective Laser Melting ,Department of Mechanical Engineering The University of AlabamaTuscaloosa,AL35487xwang127@crimson.ua.edu, tkeya@crimson.ua.edu, kchou@eng.ua.edu.

[31]. Wakshum M. Tuchoa,□ , Priscille Cuvilliera, Atle Sjolyst- Kvernelandb, Vidar Hansena,et al, Microstructure and hardness studies of Inconel 718 manufactured by selective laser melting before and after solution heat treatment ,a Department of Mechanical and Structural Engineering and Materials Science, University of Stavanger, N-4036 Stavanger, Norway b Roxar/Emerson Process Management, POB 112, 4065 Stavanger, Norway.

[32]. Sh Mukhtarov, et al, Mechanical properties of nanostructured nickel based super alloy Inconel 718A, Ermachenko Institute for Metals Super plasticity Problems RAS, 39, Khalturina, Ufa, 450001, Russia.