ANITS

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (Autonomous)

(Affiliated to AU, Approved by AICTE & Accredited by NBA & NAAC)
Sangivalasa - 531 162, Bheemunipatnam (Mandal), Visakhapatnam (District)
Phones : 08933 - 225083, 225084, 9154220250.

Website : www.anits.edu.in e-mail : principal@anits.edu.in

Details of functional MoUs during A.Y 2017-18

S. No	Organisation with which MoU is signed	Year of signing MoU	Duration	List the actual activities under each MOU year-wise
1	APSSDC	2017	3 Years	1. Workshop on Embedded systems (IoT) Fundamentals (02-01-2018 to 04- 01-2018) 2. Workshop on Embedded systems (IoT) Advanced (15-02-2018 to 17-02- 2018)
2	Avantel Limited, Visakhapatnam	2016	3 Years	1. Received consultancy project on "design of UHF antenna" 2. Training to Avantel staff by ANITS faculty
3	Infosys Limited	2015	2 years	1. Infosys campus placements 2. Principal's meet
4	Andhra University	2017	No limit	Offered Diploma in French language course
5	Process Engineers Group	2017	3years	Workshop on Application of theory to process industry for engineers on 08-12-2017 to 09-12-2017
6	Metallic Bellows, Chennai	2015	5 years	1. Published journal paper titled "Investigation of Stresses in U-Shaped Metal Bellow Using EJMA Standards, Int J Advanced Design and Manufacturing Technology, Volume. 1,Issue. ,pp.25-35 2. Published journal paper titled "Effect of pulse current micro plasma arc welding parameters on pitting corrosion rate of AISI 321 sheets in 3.45 N NaCl medium" in Journal of Mechanical

R. Srikanth.
IQAC CONVENOR

PRINCIPAL

Anil Neerukonda Institute of Technology & Sciences
Sangivalasa-531 162
Visakhapatnam Dist.

CHIEF MINISTER'S
SKILL EXCELLENCE CENTER

MEMORANDUM OF AGREEMENT (MoA)

BETWEEN

ANDHRA PRADESH STATE SKILL DEVELOPMENT CORPORATION

AND

Anil Neerukonda Institute of Technology & Science(Autonomous), Visakhapatnam

Skill Development, Entrepreneurship & Innovation Department
(SDE&I. Dept.), Government of Andhra Pradesh.

AGREEMENT BETWEEN

ANDHRA PRADESH STATE SKILL DEVELOPMENT CORPORATION

AND

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE

SANGHIVALASA

Annexure – II

Details of course wise fee

S No	Programs Offered for ECE, EEE & EIE	Duration	Fee
1	Embedded systems Fundamentals (Embedded C ,8051)	6 Days	150
2	Embedded Systems Advanced (ARM)	3 Days	300
3	Internet of Things (IoT)	1 Week	300
4	PCB (Software)	3 Days	100
5	PCB (Hardware)	3 Days	100
6	Arduino With Scratch	3 Days	100
7	Mathematical Operations With scilab for Engineering Applications	3 Days	100
8	SciLab	3 Days	100
9	PLC	6 Days	300
10	SCADA	6 Days	300

S No	Programs Offered for Mechanical Engineering students	Duration	Fee
1	AUTOCAD	6 days	250
2	CATIA Phase -I (Modelling)	6 days	250
3	CATIA Phase - II (Surfacing)	6 days	250
4	Solid Edge	6 days	250

S No	Programs Offered for Civil Engineering students	Duration	Fee
1	AutoCAD	6 days	250
2	Revit Architecture	6 days	250
3	Revit Structure	6 days	250
4	ETABS	6 days	250

S No	Programs Offered in Gaming : (Computer Engg/ECE students	Duration	Fee
1	Game Development using Buildbox	3 days	100
2	Fundamentals in Game Development using Unity3D & C#	6 days	250

S No	Programs Offered in Amazon Web Services(AWS) for Computer ENGG/ECE students	Duration	Fee
1	Cloud Literacy	1 Day	Free
2	Cloud Computing_101	2 Days	Free
3	ALEXA SKILLS	5 days	100
4	Associate Cloud Architect	5 days	100

S No	Programs Offered in Python for all Engg. Students	Duration	Fee
1	Python Basics	3 Days	150
2	Advanced Python	3 Days	150
3	Applied Data Science foundations	3 Days	150
4	Web Development with Python	6 Days	300

S No	Programs Offered in Problem Solving & Programming	Duration	Fee
1	Raptor	3 Days	100
2	Data Structures and Algorithms	6 Days	250
3	Problem Solving Skills Using C	6 Days	250
4	Programming Content & Challenges(Coding Training)	6 Days	250

S No	Programs Offered in Coursera Certifications:	Duration	Fee
1	1. An Introduction to Programming the Internet of Things (IOT) Specialization- Coursera	18 Days	2800
2	2.Development of Secure Embedded Systems Specialization - Coursera	12 Days	
3	Python for Everybody	14 Days	2800
4	Applied Data Science with Python	1 Month	
5	Introduction to C# Programming and Unity , More C# Programming and Unity	12 days	2800

MEMORANDUM OF UNDERSTANDING
"(MOU)"

This Memorandum of Understanding (hereinafter referred to as the "MOU") is entered on ***20th of October 2016*** *into by and between:*

Avantel Limited a company duly incorporated under the laws of Indian Companies Act, 1956, having its registered office at Plot No: 47/P, APIIC Industrial Park, Gambheeram (V), Anandapuram (M), Visakhapatnam - 531 163, Andhra Pradesh and Corporate office at Plot No 16, Sector-III, HUDA Techno Enclave, Opp. K. Raheja IT Park, Madhapur, Hyderabad-500 081, India, (hereinafter referred to as **"AVL")**, on the first part, who is a specialist in Defence Electronics, Satellite Communication technologies and Embedded systems and having as representative, **Wg Cdr PRL Prakash (Retd), GM (marketing)** is duly authorized to sign this MOU.

AND

Anil Neerukonda Institute of Technology & Sciences (ANITS), Visakhapatnam (hereinafter referred to as **"ANITS")** an educational institution duly set up under the laws of Indian societies act having its office at Sangivalasa, Bheemunipatnam(M)-531162, on the second part, and having as representative, Prof. T.V. Hanumantha Rao, Principal, who are duly authorized to sign this MOU.

AVL & ANITS are collectively referred to hereinafter as the "**Parties"** and individually as a "**Party"**.

ARTICLE -1

This Memorandum of Understanding is proposed in order to facilitate both the parties share Academic expertise and Training/Research facilities for development / execution of projects of mutual interest in the area of Electronics and Communication Engineering.

WHEREAS, **AVL & ANITS** are willing to enter into an MOU and define the terms and conditions under which they could cooperate in mutually beneficial projects.

WHEREAS, the Parties have previously agreed on a Non-Disclosure Agreement dated 20th of October 2016.

ARTICLE 2 - NOW, THEREFORE, for and in consideration of the foregoing premises and of the terms and conditions hereinafter set-forth, the Parties have agreed, and do hereby agree as follows:

2.1 A steering committee will be set up to monitor the activities of the MoU. The committee will consist of Dr Vidyasagar, Managing Director, Avantel Limited, Visakhapatnam and the Principal, ANITS, Visakhapatnam. With mutual consent, the steering committee can be expanded to include more members from the two Institutions. The steering

AVANTEL LIMITED Hyderabad 500 081

committee will be the supreme body as far as the implementation of the activities of the MoU, the continuation of the MoU, and termination of the MoU are concerned.

2.2 ANITS and AVL shall together develop and execute projects. The projects will be executed in the premises of Avantel Limited and AVL shall designate a point of contact to ANITS for providing necessary information towards the projects proposed. The infrastructure and the resources for the conduct of projects will be mutually decided by both parties and shall be provided. If required ANITS will depute required students at Avantel to complete the projects.

2.3 Avantel limited will pay Rs. 8,000 per month per M.Tech student, deputed to work for the projects and ANITS shall ensure that the student is committed for the successful completion of the projects within the time stipulated by Avantel Limited.

2.4 Avantel Limited will pay an honorarium for faculty in-charge of the projects, which will be decided at the time of initiating the specific work.

2.5 On successful completion of the projects, the end products / systems may be taken by Avantel Limited for production/Marketing. Avantel reserves all the rights and Intellectual property of the product.

2.6 The effective date of this MOU shall be the date upon which both parties execute it. This MOU shall expire 3 years from its effective date. However both parties leave option to terminate this MOU, by giving 30days notice in advance to the other party.

Authorized Signatories:

AVANTEL LIMITED Hyderabad 500 081

Prof. T.V. Hanumantha Rao
Principal
(For ANITS), Visakhapatnam

Principal Anil Neerukonda Institute of Technology & Science Sangivalasa - 531 162 Visakhapatnam Dist

SANGIVALASA

Wg Cdr PRL Prakash (Retd)
General Manager-Marketing
(For Avantel Limited), Visakhapatnam

AS 9100C
ISO 9001:2008

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TO WHOM SO EVER IT MAY CONCERN

This is to certify that the following problems were given to the Department of ECE, by M/s AVANTEL: a) Design of Wideband Antennas for UHF SATCOM Applications. & b) Design of Wideband Antenna for S-band airborne applications.

This work is progressing well and expecting good results soon.

This is for the information and necessary action on the part of **Dr. V. Rajya Lakshmi, Professor & HOD, Dept. of ECE, ANITS**

For Avantel Limited,

AVANTEL LIMITED R&D VISAKHAPATNAM

N. SRINIVAS RAO
VICE PRESIDENT – R&D

Avantel Limited
Registered Office
Plot No. 47/P, APIIC Industrial Park
Gambheeram (V), Anandapuram (M)
Visakhapatnam - 531 163 A.P.
Tel : +91-891-6698000
Fax : +91-891-6698004

Corporate Office
Plot No. 68 & 69, 4th Floor, Jubilee Heights
Survey No's. 66 & 67, Jubilee Enclave
Madhapur, Hyderabad - 500 081. Telangana
Tel : +91-40-6630 5000
Fax : +91-40-6630 5004

CIN - L72200AP1990PLC011334

www.avantel.in
info@avantel.in

AS 9100C
ISO 9001:2008

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TO WHOM SO EVER IT MAY CONCERN

This is to certify that **Dr. Srinivas Sabbavarapu, Associate Professor, Dept. of ECE, ANITS** Conducted the Training sessions for 25 employees on **Hardware modeling through HDLs** from 6th November 2017 to 12th December 2017 in Avantel limited Premises.

For Avantel Limited,

AVANTEL LIMITED R&D VISAKHAPATNAM

N. SRINIVAS RAO
VICE PRESIDENT – R&D

Principal
Anil Neerukonda Institute of
Technology & Sciences
Sangivalasa-531 162
Visakhapatnam Dist

Avantel Limited

Registered Office
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Gambheeram (V), Anandapuram (M)
Visakhapatnam - 531 163 A.P.

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ISO 9001:2008

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TO WHOM SO EVER IT MAY CONCERN

This is to certify that **Mr. Devi Pradeep Podugu, Assistant Professor, Dept. of ECE, ANITS** Conducted the Training sessions for 25 employees on **Hardware modeling through HDLs** from 6th November 2017 to 12th December 2017 in Avantel limited Premises.

For Avantel Limited,

AVANTEL LIMITED R&D VISAKHAPATNAM

N. SRINIVAS RAO
VICE PRESIDENT – R&D

Avantel Limited

Registered Office
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ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
'UGC AUTONOMOUS'
(Permanently Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with 'A' Grade)
SANGIVALASA - 531 162, BHEEMUNIPATNAM MANDAL, VISAKHAPATNAM DIST.,
Phones : 08933 - 225083, 225084, 226131, Fax: 08933 - 226395
Website : www.anits.edu.in e-mail : principal@anits.edu.in

Infosys | Campus Connect

Renewal of Memorandum of Understanding (MOU)

Of Campus Connect Program

Infosys and **Anil Neerukonda Institute of Technology and Sciences** had entered into a Memorandum of Understanding (MOU) on **4-Mar-08** with respect to enriching the technical education process and to jointly work for enhancing the quality of education imparted to students, faculty and management of selected colleges of the University related to the field of Information Technology (IT). This MoU was subsequently renewed on **4-Mar-11, 3-Mar-13, 2-Mar-15, 1-Mar-17.** The term of MOU is expired on **1-Mar-19.** The parties wish to extend this MOU for further period of Two (2) Years, and therefore agree the term of the MOU till **28-Feb-21.**

The Campus Connect MoU has undergone some modifications. The modified version is given along with this. The terms and conditions of the partnership are detailed out in the MoU.

Date: 06/May/19

Place: Bangalore

Name: Sundar K S

Designation: Associate Vice President & Head, Campus Connect Education, Training & Assessment Dept., Infosys Ltd.

Signature:

Infosys Limited

Electronic City, Hosur Road,

Bangalore - 560100

Associate Vice President
Infosys Limited
Head Campus Connect Education
Training & Assessment
44, Electronic City, Hosur Road
Bangalore - 560 100. India

Date: Feb,2019

Place: Visakhapatnam

Name: Prof.T.Subrahmanyam

Designation: Principal

Authorized Signatory:

Principal
Anil Neerukonda Institute of Technology & Sciences
Sangivalasa-531 162
Visakhapatnam Dist

Institute Name: Anil Neerukonda Institute of Technology & Sciences(A)

Institute Seal:

Anil Neerukonda Institute of Technology and Sciences
SANGIVALASA
Dt: 2/4/19

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
'UGC AUTONOMOUS'
(Permanently Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with 'A' Grade)
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Phones : 08933 - 225083, 225084, 226131, Fax: 08933 - 226395
Website : www.anits.edu.in e-mail : principal@anits.edu.in

Infosys | Campus Connect

Memorandum of Understanding

This Memorandum of Understanding ("MOU") is between Infosys Ltd, a company incorporated under the laws of India with its registered office at Electronics City, Hosur Road, Bangalore – 560 100, India (hereafter referred to as "Infosys"); and **Anil Neerukonda Institute of Technology and Sciences** a university / engineering college committed to educational excellence having its office **ANITS Sangivalasa Bheemunipatnam Mandal,Visakhapatnam Dist,Andhra Pradesh,INDIA-531 162Ph: 091-8933-225083, 225084Fax: 091-8933-226395.** (Hereafter referred to as "Partner").

RECITALS:

A. WHEREAS Partner has been established for the purpose of enriching the technical education process and to jointly work for enhancing the quality of education imparted to students of all the engineering disciplines in the field of Information Technology (IT).

B. AND WHEREAS Infosys wishes to collaborate with the Partner for the purpose of enriching the technical education in new subject areas, learning-teaching process and to jointly work for enhancing the quality of education imparted to students of all the Information Technology ("IT") disciplines.

C. AND WHEREAS Partner with assistance from Infosys has goals for enhancing the quality of the technical education for students thereby enabling them to meet the industry needs and to be recognized globally.

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NOW THEREFORE THE PARTIES HEREBY ACKNOWLEDGE AND AGREE AS FOLLOWS:

1. This MOU is for collaboration between both parties, for mutual benefit, to enhance the quality of the educational experience of students of the Partner and for the specific purposes detailed in Annexure I of this MOU

2. Infosys shall be responsible for providing the requisite course material, publicity material such as handouts, information brochures and posters and conducting faculty enablement programmes as agreed between the parties.

3. The Partner shall be responsible for providing the requisite infrastructure, network and internet access and any other facility required for the education and training.

4. It is agreed that the terms and conditions of any agreed cooperative project (s) as outlined in Annexure 1 of this MOU shall be the subject matter of separate definitive agreements to be negotiated and agreed upon by the Parties and/or any third parties, wherever applicable, provided always the decision whether to initiate and/or implement any proposed cooperative projects shall be subject to the availability of funds and human resources on the part of each Party.

5. The parties, their representatives, and/or assignees, following the execution of this MOU, desire to maintain close contacts with each other to achieve the goals and objectives of, and to develop the ideas acknowledged in this MOU.

6. Both parties hereby agree to designate a representative from its side who will be the primary point of contact on behalf of that party.

7. Any expenses incurred by the parties for the purpose of this MOU shall be agreed upon and shall be borne as per the mutual agreement.

8. Notwithstanding any other provision of this MOU, neither party shall have any right to use any trademarks or trade name of the other party, nor to refer to this MOU or the obligations performed hereunder directly or indirectly, in connection with any product, promotion, or publication without the prior written approval of the other party

2/4/19

9. All information which has been disclosed to or obtained by either party at any time during the implementation of this MOU, is confidential information. For this purpose, the parties agree to sign the binding non-disclosure agreement in Annexure II.

10. The terms and conditions mentioned herein shall commence on the execution of this MOU and shall continue for a period of two (2) years from the date thereof or for such period as may be determined or extended by the parties from time to time by written notice, unless terminated by either party in accordance with this MOU. Either party may terminate this MOU at any time by providingthree (3) months written notice to the other party.

11. Any notice required to be given hereunder shall be in writing and shall be deemed to be sufficiently served on the party if sent by hand or by registered post to the addresses of the party as stated in this MOU. Notices shall be deemed received: -

(i) If sent by registered mail, three (3) days after posting;
(ii) If by hand, on the day of delivery; and
(iii) If sent by telex or facsimile to the correct number or designated address within seventy-two (72) working hours.

12. Both parties agree to take all reasonable steps to ensure the successful completion of the collaboration, and co-operate with each other in duly carrying out the obligation agreed upon.

13. The expiration and termination of this MOU will not affect the terms of those activities, which are in progress at the time of notification of expiry or termination of the MOU.

14. On the termination or expiry of this MOU or when requested by Infosys, the Partner undertakes to return all materials to Infosys without any delay.

15. Each party shall ensure that they do not actively solicit the faculty of the other party who is involved in the implementation of this MOU during the period of such faculty's involvement with the program and for six (6) months thereafter.

16. Both the parties agree that Infosys is not obliged on account of this MOU to recruit any fixed number of students from the Partner.

Anil Neerukonda Institute of Technology and Sciences
SANGIVALASA
Dt. 2/4/19

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17. This MOU is an indication of good faith and intent on the part of both parties and does not create any legal obligations between them. In the event of any differences or disputes arising from the implementation of the provisions of this MOU, the parties shall as far as possible settle such differences or disputes in good faith by consultation or negotiation between the parties.

18. Save and except for Clause 6, Clause 7 and Clause 8, this MOU is not a legally binding contract and under no circumstances does this MOU subject either of the parties to liability for breach, whether material or minor, of contract or any other liability under international law or the laws of the country of the respective parties or any other applicable law.

19. The parties hereby agree that they are not bound exclusively by this MOU and are at liberty to enter into any separate agreements or arrangements with any third party without reference to the other party.

In written whereof both parties put their hard seal on the day, month and year herein mentioned.

Date: 06/May/19

Place: Bangalore

Name: Sundar K S

Designation: Associate Vice President &Head-, Campus Connect Education, Training & Assessment Dept., Infosys Ltd.

Signature:

Authorized Signatory
For Infosys

Seal: Associate Vice President Infosys Limited Head Campus Connect Education Training & Assessment 44, Electronic City, Hosur Road Bangalore - 560 100

Date: Feb 2019

Place: Visakhapatnam

Name: Prof.T.Subrahmanyam

Designation: Principal

Institute: Anil Neerukonda Institute of Technology and Sciences

Signature: T. Subrahmanyam

Principal
Anil Neerukonda Institute of Technology & Sciences
Sangivalasa-531 162
Visakhapatnam Dist

AuthorizedSignatory
For Partner

Seal: 02/4/19

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ANNEXURE I

PURPOSE / SCOPE OF THE COLLABORATION:

Infosys shall facilitate and share inputs with University / College for imparting technical and soft skills training to the students. The content of the training programs and the Faculty Enablement will be done by Infosys. The details shown in Annexure I are only indicative guidelines, and Infosys may change the following at short notice at its discretion.

There will not be any cash incentive for the faculty members involved in the training programs (Technical / Soft Skills) at the institution. However, value-added offerings will be there to motivate the faculty members.

Student / Education

1. Create a project bank for final year students
2. Publish Infosys courseware On the Web and provide access
3. Conducting special lectures for students at campuses
4. Participate in Conferences at the national/international level in the college / Seminars/ Contests
5. Increase employability by providing technical and soft skills training
6. Encouraging the students to visit Infosys Campuses

Faculty

1. Sharing Industry oriented-courseware and Technology
2. Faculty Enablement Program
3. Sabbaticals at Infosys
4. Interaction with subject matter experts

University / College

1. Share best-in-class standards (a) College-college (b) Industry-college
2. Books / CDs / DVDs etc. for the library
3. Strengthen relationship with Universities / Colleges
4. Work with education bodies / universities to align the industry requirements into the college curriculum

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ANNEXURE II

MUTUAL NON-DISCLOSURE AND CONFIDENTIALITY AGREEMENT

This is an **agreement** ("Agreement" hereafter) between:

- **INFOSYS LIMITED**, with its registered office at Electronics City, Hosur Road, Bangalore 560 100 ("Infosys") including its successors; and **Anil Neerukonda Institute of Technology and Sciences** operating out **ANITS Sangivalasa Bheemunipatnam Mandal,Visakhapatnam Dist,Andhra Pradesh,INDIA-531 162Ph: 091-8933-225083, 225084Fax: 091-8933-226395.** ("Partner") including the Partner's employees, affiliates and successors at the time of the entering the agreement and during the tenure of the engagement, that is effective 01/March/19.

The parties possesses competitively valuable Confidential Information (as hereinafter defined) regarding their past, current and future services and products, research and development, customers, business plans, software, listings, holdings, alliances, investments, transactions, intellectual property and rights associated thereto and general business operations. The parties wish to enter into a mutually beneficial relationship, and as such, wish to share their Confidential Information with the other party, including its authorized employees and agents. For the purposes of this Agreement, the party that discloses Confidential Information to the other party shall be referred to as the "Disclosing Party", and the party that receives such Confidential Information from the other party shall be referred to as the "Recipient".

The Recipient may be given access to the Disclosing Party's Confidential Information or to create new Confidential Information for the Disclosing Party.

In view of the above, the parties agree as follows:

1. Confidential Information

"*Confidential Information*" includes any information:

- specifically indicated by the Disclosing Party, either verbally or in writing, as confidential;
- under the circumstances of the disclosure, that are to be treated as confidential; or

Anil Neerukonda Institute of Technology & Sciences SANGIVALASA 01/3/19

- the Recipient creates or produces while performing its obligations under this Agreement,

regardless of the media that contains the information.

Confidential Information does not include information, which:

- is generally available to the public at the time of its disclosure to the Recipient;
- becomes known to the public through no fault/action of the Recipient in violation of the terms herein;
- is legally known to the Recipient at the time of disclosure by the Disclosing Party;
- is furnished by the Disclosing Party to third parties without restriction; or
- is furnished to the Recipient by a third party who to the Recipient's knowledge legally obtained said information and the right to its disclosure.
- is developed independently by Recipient without use of or reference to the Disclosing Party's information.

2. Restrictions on Use

(a) The Recipient will not disclose any Confidential Information to third parties for any purpose without the prior written consent of the Disclosing Party. However, where the Recipient is required to disclose Confidential Information in accordance with judicial or other governmental action, the Recipient will give the Disclosing Party reasonable prior notice unless such notice is prohibited by applicable law.

(b) The Recipient will not use any Confidential Information for any purposes except those expressly contemplated or authorized by the Disclosing Party.

(c) The Recipient will take the same reasonable security precautions as it takes to safeguard its own confidential information, but in no case less than reasonable care.

(d) The Recipient undertakes to impose the confidentially obligations on all directors, officers and employees or other persons who work for the Recipient or under its direction and control, and who will have access to the Confidential Information.

(e) The Recipient will return all originals, copies, reproductions and summaries of Confidential Information in its control, or confirm its destruction as requested by the Disclosing Party.

3. Action on Breach

(a) The Recipient will notify the Disclosing Party immediately upon discovery of any breach of this Agreement by the Recipient, and will cooperate in every reasonable way to help the Disclosing Party regain possession of the Confidential Information and prevent further breach.

(b) The Disclosing Party will be entitled, without waiving any other rights or remedies, to seek such injunctive or equitable relief as may be deemed proper by a court of competent jurisdiction.

4. Ownership and Warranties

(a) All Confidential Information, including the inherent intellectual properties, remains the sole and exclusive property of the Disclosing Party and the Recipient shall no right, title or interest in the same. Similarly, the Disclosing Party does not own any of the intellectual property of the Recipient, including any proprietary methodologies, tools or practices, unless otherwise agreed.

(b) The Disclosing Party, unless expressly confirmed, makes no warranty regarding the accuracy or reliability of Confidential Information.

5. Applicability of Provisions

(a) The provisions of this Agreement are jointly and severally applicable and will not be considered waived by any act or acquiescence, except by a specific prior written confirmation. Accordingly, both parties will expressly agree in writing to any changes in the Agreement.

(b) If any provision of this Agreement is held illegal, invalid or unenforceable by law, the remaining provisions will remain in effect. Moreover, should any of the obligations of this Agreement be found illegal or unenforceable for any reasons, such obligations will be deemed to be reduced to the maximum duration, scope or subject matter allowed by law.

(c) If any action at law or in equity is necessary to enforce or interpret the rights arising out of or relating to this Agreement, the prevailing party shall be entitled to recover reasonable attorney's fees, costs and necessary disbursements in addition to any other relief to which it may be entitled.

6. Jurisdiction

This Agreement will be governed by the laws of India on all substantive aspects, and both parties consent to the jurisdiction of the courts in Bangalore.

7. Tenure and Survival

All obligations created by this Agreement shall survive change or termination of the parties' business relationship for a period of two years from the date of the disclosure of the Confidential Information or the change in/termination of the business relationship of the parties whichever is later.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement by their duly authorized representatives as of the date first set forth above.

Infosys Limited

By:

Name: Sundar K S

Title: Associate Vice President &Head-
Campus connect Education Training & Assessment
Infosys Ltd.

Date: 06/May/19

Associate Vice President
Infosys Limited
Head Campus Connect Education
Training & Assessment
44, Electronic City, Hosur Road
Bangalore - 560 100, India

Seal:

M/s Anil Neerukonda Institute of Technology and Sciences

Name: Prof.T.Subrahmanyam

Title: Principal

Date: Feb,2019

Sign:

Principal
Anil Neerukonda Institute of
Technology & Sciences
Sangivalasa-531 162
Visakhapatnam Dist

Anil Neerukonda Institute of Technology and Sciences
SANGIVALASA
Dt. 2/4/19

Infosys | Campus Connect

Certificate of Participatio...

This is to certify that

B. SivaJyothi of

Anil Neerukonda Institute of Technology And Sciences, Andhra Pradesh

has participated in the 6 Days Faculty Enablement Program on

InfyTQbased & } µ v š] } v W Œ }] P Œ u held online using webinar platform from

6th May to 13th May 2019 conducted by Infosys Limited

and has been awarded with A Grade.

Thirumala Arohi
Vice President & Head - Education, Training & Assessment,
Infosys Limited

Sundar KS
Associate Vice President, & Head ±Campus Connect,
Education, Training & Assessment, Infosys Limited

Infosys® | Campus Connect

INFY TQ

Certificate of Participati...

This is to certify that

Bhagavathula Meena of

Anil Neerukonda Institute of Technology And Sciences, Andhra Pradesh

has participated in the 6 Days Faculty Enablement Program on

'InfyTQ based & } µ v š] } v W Œ } P Œ u held online using webinar platform from

6th May to 13th May 2019 conducted by Infosys Limited

and has been awarded with A Grade.

Thirumala Arohi
Vice President & Head - Education, Training & Assessment,
Infosys Limited

Sundar KS
Associate Vice President, & Head ±Campus Connect,
Education, Training & Assessment, Infosys Limited

Gmail ratan kumar <sajjaratankumar@gmail.com>

Confirmation to participate in CC Principal's meet on Friday, 23rd March 2018

Prashanth R18 <prashanth_r18@infosys.com> Thu, Mar 1
To: "amarnadhcse@cvsr.ac.in" <amarnadhcse@cvsr.ac.in>, "anandraadha@cmrcet.org" <anandraadha@cmrcet.org>, "anitha.chippakurthi@gmail.com" <anitha.chippakurthi@gmail.com>, "balu.cheepu@gmail.com" <balu.cheepu@gmail.com>, "chaitanya.dynamics@gmail.com" <chaitanya.dynamics@gmail.com>, "chandunani@cmrcet.org" <chandunani@cmrcet.org>, "chrajakishorebabu@cmrcet.org" <chrajakishorebabu@cmrcet.org>, "cnu.enr@gmail.com" <cnu.enr@gmail.com>, "cveeranjaneyulu@cmrcet.org" <cveeranjaneyulu@cmrcet.org>, "divyag.160 <divyag.1605@gmail.com>, "fatima.sidotam@gmail.com" <fatima.sidotam@gmail.com>, "glaxmi.english@gmail.com" <glaxmi.english@gmail.com>, "hemu.mlrit@gmail.com" <hemu.mlrit@gm "himabindu_s@yahoo.com" <himabindu_s@yahoo.com>, "hodcse@cvsr.ac.in" <hodcse@cvsr.ac.in>, "kande.renu@gmail.com" <kande.renu@gmail.com>, "kinneraravi.cse@cmrcet.org" <kinneraravi.cse@cmrcet.org>, "laxmi.slv@gmail.com" <laxmi.slv@gmail.com>, "madhuravani.peddi@gmail.com" <madhuravani.peddi@gmail.com>, "maheshraaj007@gmail.com" <maheshraaj007@gmail.com>, "nagamani.csedept@gmail.com" <nagamani.csedept@gmail.com>, "naguchinni@gmail.com" <naguchinni@gmail.com>, "narasimha2017.ch@gmail.com" <narasimha2017.ch@gmail.com>, "onlybarkat@gmail.com" <onlybarkat@gmail.com>, "prasadch204@gmail.com" <prasadch204@gmail.com>, "priya.palisetti@gmail.com" <priya.palisetti@gn "puramvasu7@gmail.com" <puramvasu7@gmail.com>, "ramakrishnacse@cvsr.ac.in" <ramakrishnacse@cvsr.ac.in>, "rammohan.koukuntla@gmail.com" <rammohan.koukuntla@gmail.com>, "rammohan04@gmail.com" <rammohan04@gmail.com>, "rani536@gmail.com" <rani536@gmail.com>, "rathnam578@gmail.com" <rathnam578@gmail.com>, "ravibhaveshcse@gmail.com" <ravibhaveshcse@gmail.com>, "ravindermogili@gmail.com" <ravindermogili@gmail.com>, "rosyronold@gmail.com" <rosyronold@gmail.com>, "sarikasandeep@gmail.com" <sarikasandeep@ "seelasowjanya@gmail.com" <seelasowjanya@gmail.com>, "shankar.thalla@gmail.com" <shankar.thalla@gmail.com>, "shashi1215@gmail.com" <shashi1215@gmail.com>, "sindhuangel.g@ <sindhuangel.g@gmail.com>, "sivaskandha@gmail.com" <sivaskandha@gmail.com>, "sravankumar.tappa@gmail.com" <sravankumar.tappa@gmail.com>, "srilatha@yahoo.co.in" <srilatha@y "srinivas_a@srecwarangal.ac.in" <srinivas_a@srecwarangal.ac.in>, "srinu424@gmail.com" <srinu424@gmail.com>, "suneel.danny@gmail.com" <suneel.danny@gmail.com>, "sunilgatadi116@ <sunilgatadi116@gmail.com>, "swapnagoudcse@cvsr.ac.in" <swapnagoudcse@cvsr.ac.in>, "thota_raj1201@yahoomail.co.in" <thota_raj1201@yahoomail.co.in>, "vasanthmtechsit521@gmail <vasanthmtechsit521@gmail.com>, "veeru38@gmail.com" <veeru38@gmail.com>, "venkatreddyvari@cmrcet.org" <venkatreddyvari@cmrcet.org>, "vermazzmail111@gmail.com" <vermazzma "y.sushmareddy@cmrcet.org" <y.sushmareddy@cmrcet.org>, "ahmedali.tpc@gmail.com" <ahmedali.tpc@gmail.com>, "csrit03@yahoo.co.in" <csrit03@yahoo.co.in>, "jagadeesh.siddanathi@a <jagadeesh.siddanathi@aec.edu.in>, "k.devipriya20@gmail.com" <k.devipriya20@gmail.com>, "kvgrao1234@gmail.com" <kvgrao1234@gmail.com>, "mahesh.gandikota@aec.edu.in" <mahesh.gandikota@aec.edu.in>, "mshanmugasundari@gmail.com" <mshanmugasundari@gmail.com>, "prasadarao.chatla@aec.edu.in" <prasadarao.chatla@aec.edu.in>, "rajababu.makinee <rajababu.makineedi@aec.edu.in>, "ramasree_s@aec.edu.in" <ramasree_s@aec.edu.in>, "siriviswam.lanka@gmail.com" <siriviswam.lanka@gmail.com>, "sravan.kovvali@gmail.com" <sravan.kovvali@gmail.com>, "tjalajasp@gmail.com" <tjalajasp@gmail.com>, "vanathi.andiran@aec.edu.in" <vanathi.andiran@aec.edu.in>, "ajayatripathy1@silicon.ac.in" <ajayatripathy1@sili "ashifuddin_nit@yahoo.com" <ashifuddin_nit@yahoo.com>, "hellochandrima@gmail.com" <hellochandrima@gmail.com>, "palasdey13@gmail.com" <palasdey13@gmail.com>, "sd_dash@yah <sd_dash@yahoo.com>, "smashdash_2000@yahoo.com" <smashdash_2000@yahoo.com>, "devipriya.kamparapu@aec.edu.in" <devipriya.kamparapu@aec.edu.in>, "bvg.murali@gmail.com <bvg.murali@gmail.com>, "g.nagendrakumar@adityatekkali.edu.in" <g.nagendrakumar@adityatekkali.edu.in>, "sajjaratankumar@gmail.com" <sajjaratankumar@gmail.com>, "magantisiva@ya <magantisiva@yahoo.com>, "Nilarun.mukherjee@gmail.com" <Nilarun.mukherjee@gmail.com>, "placement@cvrgi.edu.in" <placement@cvrgi.edu.in>, "mail2safikul@gmail.com" <mail2safikul "cmrcet_tpc@yahoo.co.in" <cmrcet_tpc@yahoo.co.in>, "gandhirao@gmail.com" <gandhirao@gmail.com>, "lavakumar.gopu@gmail.com" <lavakumar.gopu@gmail.com>, "pravas@koustuvgro <pravas@koustuvgroup.ac.in>, "saidatta@koustuvgroup.ac.in" <saidatta@koustuvgroup.ac.in>, "niladribihari@yahoo.com" <niladribihari@yahoo.com>, "placement.cvr@gmail.com" <placemer "placement@cvr.ac.in" <placement@cvr.ac.in>, "pccvsr@yahoo.com" <pccvsr@yahoo.com>, "head_cse.gnit@jisgroup.org" <head_cse.gnit@jisgroup.org>, "princpal_gnit@jisgroup.org" <princpal_gnit@jisgroup.org>, "braovujjeni@gmail.com" <braovujjeni@gmail.com>, "nbvprasaad@kluniversity.in" <nbvprasaad@kluniversity.in>, "nbvprasad@gmail.com" <nbvprasad@gmail.c "laxman_maddikunta@yahoo.co.in" <laxman_maddikunta@yahoo.co.in>, "pothique@gamil.com" <pothique@gamil.com>, "msitplacementcell@yahoo.co.in" <msitplacementcell@yahoo.co.in> "principal_nit@jisgroup.org" <principal_nit@jisgroup.org>, "anupam.ghosh@rediffmail.com" <anupam.ghosh@rediffmail.com>, "ssambhu_prasad@yahoo.co.in" <ssambhu_prasad@yahoo.co.i "tpo@srecwarangal.ac.in" <tpo@srecwarangal.ac.in>, "sssit@rediffmail.com" <sssit@rediffmail.com>, "prism_sridhar@yahoo.co.in" <prism_sridhar@yahoo.co.in>, "mahesh_vvr@yahoo.com" <mahesh_vvr@yahoo.com>, "bhas_ani@yahoo.co.in" <bhas_ani@yahoo.co.in>, "tpo.ars@gmail.com" <tpo.ars@gmail.com>, "prasadch@yahoo.com" <prasadch@yahoo.com>, "adityaplacem <adityaplacements@yahoo.com>, "tpoaditya@gmail.com" <tpoaditya@gmail.com>, "venkatvedula@yahoo.com" <venkatvedula@yahoo.com>, "campusconnect@svpcet.org" <campusconnect "abinash77@gmail.com" <abinash77@gmail.com>, "biswajit69@gmail.com" <biswajit69@gmail.com>, "debasish76@gmail.com" <debasish76@gmail.com>, "binoddash@synergyinstitute.net" <binoddash@synergyinstitute.net>, "sarkar.piyal@gmail.com" <sarkar.piyal@gmail.com>, "hemantadey13@gmail.com" <hemantadey13@gmail.com>, "rajini_ganta@yahoo.com" <rajini_ganta "hodcse@staff.vce.ac.in" <hodcse@staff.vce.ac.in>, "medforms@gmail.com" <medforms@gmail.com>, "msa_543@yahoo.co.in" <msa_543@yahoo.co.in>, "merajkhaja@gmail.com" <merajkh "tpognits@gmail.com" <tpognits@gmail.com>, "irpr@rediffmail.com" <irpr@rediffmail.com>, "priyabrata@silicon.ac.in" <priyabrata@silicon.ac.in>, "sovansaha12@gmail.com" <sovansaha12@ "sudakshina.kunda@wbut.ac.in" <sudakshina.kunda@wbut.ac.in>, "siri.jagannadham@gmail.com" <siri.jagannadham@gmail.com>, "bvsrau@gmail.com" <bvsrau@gmail.com>, "papinenivsl@ <papinenivsl@gmail.com>

Infosys | Building Tomorrow's Enterprise

Principals Meet 2018
Friday, 23rd March 2018 Infosys STP Gachibowli, HYD

Infosys | Campus

Dear Professor,

Warm Greetings from Infosys!

We are pleased to confirm your participation for the Principals' Meet-2018 scheduled on 23rd March 2018 at Infosys Limited, HYD STP.

We are buoyant that with your active participation, this program will set new standards for knowledge sharing between the industry and the educational institutions and significantly towards strengthening the knowledge economy itself.

Kindly note a few details regarding the program:

Date : 23rd March 2018

Time : 9:00 AM to 5:00 PM

Venue : **Concept hall, Building no 12, Infosys STP**

Note:

1. All participants are requested to make their own travel arrangements to reach Infosys HYD STP 8:30 AM on : 23rd March 2018
2. Please note that Infosys will not bear travel costs. Lunch will be arranged.
3. Please do not bring any laptops or H/W to the venue.
4. Registration counter will be set at the entrance of the Venue.

Please carry the print out of this confirmation mail for security clearance. Your college ID is also required.

Contact Details:

For information on the Campus Connect Principal's Meet-2018 Program, please contact Prashanth. R +91-96664 87234

On your arrival, please contact security at Gate no.1 for further guidance to reach the Venue.

Also please find the attached tentative agenda for your reference.

Warm Regards,

Team Campus Connect,

Infosys Limited.

PS: Any changes in the agenda will be informed during the event.

PM-Agenda.xlsx
29K

Infosys | Campus Connect

MARRI LAXMAN REDDY
GROUP OF INSTITUTIONS

TASK

Certificate of Participation

This is to certify that

Mr. S Joshua Johnson of

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES(A)

has participated in the

Faculty Enablement Program on "Foundation Program 5.0"

held at **MLR Institute of Technology, Dundigal, Hyderabad** from 02nd - 06th January

2017 conducted by **Infosys Limited.**

Pramod Prakash Panda
Senior Vice President & Head –
Education, Training and Assessment, Infosys Limited.

Satheesha B. Nanjappa
Vice President & Head – Campus Connect,
Education Training and Assessment, *Infosys Limited*

Infosys | Campus Connect

MARRI LAXMAN REDDY
GROUP OF INSTITUTIONS

TASK

Certificate of Participation

This is to certify that

D. Sailaja of

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES(A)

has participated in the

Faculty Enablement Program on "Foundation Program 5.0"

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Pramod Prakash Panda
Senior Vice President & Head –
Education, Training and Assessment, Infosys Limited.

Satheesha B. Nanjappa
Vice President & Head – Campus Connect,
Education Training and Assessment, *Infosys Limited*

Gmail ratan kumar <sajjaratankumar@gmail.com>

Invitation to participate in Campus Connect Principal's meet on Monday, 28th March 2016@Hyderabad Infosys Office(Timings 9:30 AM – 5:00 PM)

Tirumala Naga Durgesh <tirumala_naga@infosys.com> Thu, Feb 1
To: "rajesh.masina@aec.edu.in" <rajesh.masina@aec.edu.in>, "bvg.murali@gmail.com" <bvg.murali@gmail.com>, "sajjaratankumar@gmail.com" <sajjaratankumar@gmail.com>, "sivacmca@
<sivacmca@yahoo.co.in>, "singhapk@yahoo.co.in" <singhapk@yahoo.co.in>, "director@aiemd.org" <director@aiemd.org>, "krish_2511@yahoo.com" <krish_2511@yahoo.com>, "sabnam_sg
<sabnam_sg@yahoo.com>, "Nilarun.mukherjee@gmail.com" <Nilarun.mukherjee@gmail.com>, "subrat@becbbsr.ac.in" <subrat@becbbsr.ac.in>, "alok100168@yahoo.com" <alok100168@ya
"alok10068@yahoo.com" <alok10068@yahoo.com>, "alok@becbbsr.ac.in" <alok@becbbsr.ac.in>, "director@becbbsr.ac.in" <director@becbbsr.ac.in>, "bbpant@bitmesra.ac.in" <bbpant@bitm
"bvcitsplacements@rediffmail.com" <bvcitsplacements@rediffmail.com>, "placement@cvrgi.edu.in" <placement@cvrgi.edu.in>, "mail2safikul@gmail.com" <mail2safikul@gmail.com>,
"jagannadham23456@yahoo.com" <jagannadham23456@yahoo.com>, "cmrcet_tpc@yahoo.co.in" <cmrcet_tpc@yahoo.co.in>, "gandhirao@gmail.com" <gandhirao@gmail.com>, "lavakumar.
<lavakumar.gopu@gmail.com>, "ashima@koustuvgroup.ac.in" <ashima@koustuvgroup.ac.in>, "saidatta@koustuvgroup.ac.in" <saidatta@koustuvgroup.ac.in>, "niladribihari@yahoo.com"
<niladribihari@yahoo.com>, "placement.cvr@gmail.com" <placement.cvr@gmail.com>, "placement@cvr.ac.in" <placement@cvr.ac.in>, "pccvsr@yahoo.com" <pccvsr@yahoo.com>, "jagansek
<jagansekhar@dietakp.com>, "gprectap@gmail.com" <gprectap@gmail.com>, "satyajitnayak@gift.edu.in" <satyajitnayak@gift.edu.in>, "satishkumar_sidigonda@rediffmail.com"
<satishkumar_sidigonda@rediffmail.com>, "pvenkatarao@gvpce.ac.in" <pvenkatarao@gvpce.ac.in>, "gnecjkc@gmail.com" <gnecjkc@gmail.com>, "gnecdeanstudentswelfare@gmail.com"
<gnecdeanstudentswelfare@gmail.com>, "head_cse.gnit@jisgroup.org" <head_cse.gnit@jisgroup.org>, "princpal_gnit@jisgroup.org" <princpal_gnit@jisgroup.org>, "Poulami.das@heritageit.e
<Poulami.das@heritageit.edu>, "ad_arindam@yahoo.co.in" <ad_arindam@yahoo.co.in>, "gopa.goswami_iem@yahoo.com" <gopa.goswami_iem@yahoo.com>, "rkhota@iter.ac.in" <rkhota@i
"silasghosh@gmail.com" <silasghosh@gmail.com>, "supriya.k6@gmail.com" <supriya.k6@gmail.com>, "braovujjeni@gmail.com" <braovujjeni@gmail.com>, "ar_mmclub@yahoo.com" <ar_mr
"sanjeevaraju@rediffmail.com" <sanjeevaraju@rediffmail.com>, "nbvprasaad@kluniversity.in" <nbvprasaad@kluniversity.in>, "nbvprasad@gmail.com" <nbvprasad@gmail.com>,
"laxman_maddikunta@yahoo.co.in" <laxman_maddikunta@yahoo.co.in>, "saisn90@gmail.com" <saisn90@gmail.com>, "pothique@gamil.com" <pothique@gamil.com>, "Sabithakiran.ch@mlr
<Sabithakiran.ch@mlrinstitutios.ac.in>, "sajalkrsaha@gmail.com" <sajalkrsaha@gmail.com>, "devanand.kanhar@gmail.com" <devanand.kanhar@gmail.com>, "sudipto_cct@rediffmail.com"
<sudipto_cct@rediffmail.com>, "anupam.ghosh@rediffmail.com" <anupam.ghosh@rediffmail.com>, "gsmrec@yahoo.com" <gsmrec@yahoo.com>, "tpo@srecwarangal.ac.in" <tpo@srecwaran
"saispurthy@gmail.com" <saispurthy@gmail.com>, "sssit@rediffmail.com" <sssit@rediffmail.com>, "prism_sridhar@yahoo.co.in" <prism_sridhar@yahoo.co.in>, "mahesh_vvr@yahoo.com"
<mahesh_vvr@yahoo.com>, "munwar.it@gmail.com" <munwar.it@gmail.com>, "kdb_babu@yahoo.com" <kdb_babu@yahoo.com>, "tpo.ars@gmail.com" <tpo.ars@gmail.com>, "prasadch@y
<prasadch@yahoo.com>, "adityaplacements@yahoo.com" <adityaplacements@yahoo.com>, "tpoaditya@gmail.com" <tpoaditya@gmail.com>, "thyag_003@yahoo.com" <thyag_003@yahoo.
"campusconnect@svpcet.org" <campusconnect@svpcet.org>, "yprcet@yahoo.com" <yprcet@yahoo.com>, "yourpsr@yahoo.com" <yourpsr@yahoo.com>, "krishnakanth2k9@gmail.com"
<krishnakanth2k9@gmail.com>, "santhosh_ph@yahoo.co.in" <santhosh_ph@yahoo.co.in>, "valmikisatya@gmail.com" <valmikisatya@gmail.com>, "bidyutbiman@gmail.com" <bidyutbiman@
"hemantadey13@gmail.com" <hemantadey13@gmail.com>, "vrdrks@gmail.com" <vrdrks@gmail.com>, "rajini_ganta@yahoo.com" <rajini_ganta@yahoo.com>, "cmouli_n@yahoo.co.in" <cmo
"hodcse@staff.vce.ac.in" <hodcse@staff.vce.ac.in>, "medforms@gmail.com" <medforms@gmail.com>, "vrectpo@gmail.com" <vrectpo@gmail.com>, "msa_543@yahoo.co.in" <msa_543@yah
"merajkhaja@gmail.com" <merajkhaja@gmail.com>, "sivakumarpasupuleti@gmail.com" <sivakumarpasupuleti@gmail.com>, "sivakumar_pv@vnrvjiet.in" <sivakumar_pv@vnrvjiet.in>,
"nri.placements@gmail.com" <nri.placements@gmail.com>, "tpognits@gmail.com" <tpognits@gmail.com>, "irpr@rediffmail.com" <irpr@rediffmail.com>, "placementofficer@jbiet.edu.in"
<placementofficer@jbiet.edu.in>, "hodit@jbiet.edu.in" <hodit@jbiet.edu.in>, "rvrjcce_tpo@yahoo.com" <rvrjcce_tpo@yahoo.com>, "menon@sreenidhi.edu.in" <menon@sreenidhi.edu.in>,
"placement.vignanhyd@gmail.com" <placement.vignanhyd@gmail.com>, "drcskumar41@gmail.com" <drcskumar41@gmail.com>, "jyothula1971@gmail.com" <jyothula1971@gmail.com>, "nir
<niranjan@silicon.ac.in>, "sunnydeba@gmail.com" <sunnydeba@gmail.com>, "placement@driems.ac.in" <placement@driems.ac.in>, "arup_bhaumik@yahoo.com" <arup_bhaumik@yahoo.co
"sumita@gietbbsr.edu.in" <sumita@gietbbsr.edu.in>, "tnp@rungtacolleges.com" <tnp@rungtacolleges.com>, "tpo.cemk@gmail.com" <tpo.cemk@gmail.com>, "siri.jagannadham@gmail.com"
<siri.jagannadham@gmail.com>, "bvsrau@gmail.com" <bvsrau@gmail.com>, "papinenivsl@gmail.com" <papinenivsl@gmail.com>
Cc: "Dr. Srinagesh Chatarajupalli" <Srinagesh_C@infosys.com>, kumar TASK <mutyamkumar@gmail.com>, "task.campusconnect@gmail.com" <task.campusconnect@gmail.com>,
"director_sd_task@telangana.gov.in" <director_sd_task@telangana.gov.in>, "directorskilldevelopment@gmail.com" <directorskilldevelopment@gmail.com>

Infosys Building Tomorrow's Enterprise	Principals Meet 2016 Monday, 28th March 2016, Infosys Hyderabad	Infosys Campus Con

Dear Principal,

Warm Greetings from Infosys!

The past year has been an enriching experience for Infosys Campus Connect team, bringing with it new learning's and achievements. We have been able to reach out to many deserv
from your institution and hone their talent, offering them new opportunities with us. With the new academic season around the corner, there is a need for all stakeholders to meet and un
environment in which we operate and also create a plan to counter new challenges.

In our endeavor to interact and continually add value to academia, we have planned a 'Principals' Meet' for a select set of Institutions from **Telangana, Andhra Pradesh, Odisha,
Monday, 28th March 2016** at our **Hyderabad Development Centre.** We are pleased to invite you as an esteemed partner Institution to participate in this meet, and give us your valua
order to strengthen the Industry - Academia Relationship.

The objectives of Principals' Meet are to:

- Share objective feedback, in the recruitment, training and on-the-job performance, about the students joining us from your Institution
- Share the Campus Recruitment Philosophy
- Acknowledge performing Institutions for partnering in the growth of our business
- Share current perspectives on trends and ascertain the way forward
- Brainstorming with college management for sustainability of Campus Connect program
- Interact with senior management

Important dates are given below:

Event Date	Monday, 28th March 2016

Time	9:30 AM – 5:00 PM
Venue	Infosys, Hyderabad Development Centre STP
Response Form last date	Thursday, 25th Feb. 2016
Pre-work Submission last date	Thursday, 3rd March 2016

We will be emailing you the response form (Response_form.doc) and pre-work template (Prework.docx) shortly. Request you to fill them up and share the **task.campusconnect@gmail.com**

The success of this event depends on your valuable presence, and hence we would urge you to attend the same in person along with the Single Point of Contact (SPOC) or Head of the (CSE/IT/IS) or head of the institution, Principal/leadership teams from your Institute.

For any queries or clarification(s), please contact:

S.No	Name	Email	Mobile	Contact for
1	CC Team-Durgesh	tirumala_naga@infosys.com	+91-8686442727	Logistic related queries
2	CC Team-Kumar	mutyamkumar@gmail.com	+91 8886304456	Event details
3	CC Team	Task.campusconnect@gmail.com	+91 9949995815	Event details

Warm Regards,

Team Campus Connect,

Infosys Limited.

MEMORANDUM OF UNDERSTANDING

MEMORANDUM OF UNDERSTANDING

BETWEEN

Andhra University and Anil Neerukonda Institute of Technology and Sciences, Sangivalasa

This Memorandum of Understanding (hereinafter called the "MOU") is made and entered into as of ..... July, 2017, by and between:

Andhra University, Vishakhapatnam 530 003,
And **Anil Neerukonda Institute of Technology and Sciences (ANITS), Sangivalasa, Visakhapatnam District, 531162.**

Whereas, Andhra University intends to offer diploma courses in foreign languages (German/French/ Japanese) to the students of engineering to the **Anil Neerukonda Institute of Technology and Sciences (ANITS),Sangivalasa, Visakhapatnam District from the academic year 2017-2018 onwards at the convenience of both parties.**

General Terms and Conditions of the MOU

1. Andhra University will offer diploma courses in foreign languages (German/French/ Japanese) to the students of engineering from the academic year 2017-2018 onwards.
2. In order to run the diploma course, Students of Anil Neerukonda Institute of Technology and Sciences (ANITS) will pay the course fee to the Andhra University before the beginning of the course programme.
3. Each course will be offered if minimum 20 students enroll for the course
4. The fee for the each course will be fixed in mutual agreement, and an approximate minimum fee will be Rs 8,000 for each student.
5. The courses will be offered in foreign language department in Andhra University for one Semester.
6. The timings for courses will be decided depending upon the convenience of the teachers.
7. The Students of Anil Neerukonda Institute of Technology and Sciences (ANITS) will be awarded diploma certificate from Andhra University at the end of the course as per the guidelines specified by University.
8. The Parties shall not make any public announcement of the Project in any way without the prior consent of the other Party. Whenever one Party plans to make a public announcement of the Project, the Party shall discuss in good faith with the other Party and both Parties shall agree on the contents of the announcement before the public announcement is made. Anil Neerukonda Institute of Technology and Sciences (ANITS) shall not use in any manner the logo or mark used or managed by Andhra University for any purposes without prior written consent of the University.

9. In case a Party breaches its obligations, the other Party shall have the right to terminate this MOU retroactively by giving thirty (30) days prior written notice.

10. The Parties will seek to settle any difference of dispute arising out of the interpretation, implementation or application of the provisions of this MOU, or breach hereof, by mutual consultation and negotiation between the Parties.

11. No amendment, modification or waiver in respect of this MOU shall be effective unless in writing and executed by each of the Parties.

12. Any formal correspondence between the Parties will be in writing and delivered by hand or sent by registered mail or courier or email to the addresses set out below:

V. Uma Maheswara Rao

For: Andhra University
Prof. V. Uma Maheshwara Rao
Registrar
Andhra University
Vishakhapatnam 530 003.

REGISTRAR
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ANDHRA UNIVERSITY * WALTAIR *

For: Anil Neerukonda Institute of Technology & Sci.
Prof. T V Hanumantha Rao
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SANGIVALASA

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)
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2	315126511104	ADITYA AKSHINTALA	703716	Spanish	8000
3	315126511108	KOLA ANURAG	359967	Spanish	8000
4	315126511109	MOJJI BHARAT KISHORE	703705	Spanish	8000
5	315126511111	YELAMANCHILI BHARATH SIVA RAMA	404988	Spanish	8000
6	315126511113	REPAKA DHANUSH	359966	Spanish	8000
7	315126511115	DILEEP KUMAR LATCHIREDDI	703714	Spanish	8000
8	315126511119	NADIMINTI GOWRI PRAVEENA	253936	Spanish	8000
9	315126511120	KOLLA SRIDHAR	703711	Spanish	8000
10	315126511122	PAYAVARAPU HARIKRISHNA	703712	Spanish	8000
11	315126511123	KAKKALA HARSHA VARDHAN	359973	Spanish	8000
12	315126511124	HARSHA VARDHAN KARRI	703694	Spanish	8000
13	315126511126	GUDISARI JAGADISH PHANI KUMAR	703706	Spanish	8000
14	315126511127	VVURI JAGADISH REDDY	703713	Spanish	8000
15	315126511128	PUSALA KALYANI	098630	Spanish	8000
16	315126511131	SARAGADA KEERTHANA MARY	539164	Spanish	8000
17	315126511134	THOTAKURA LAHARI	253894	Spanish	8000
18	315126511135	BATCHU LAKSHMI MEENAKSHI	794083	Spanish	8000
19	315126511137	NOKARAPU LAKSHMI VARSHA	344955	Spanish	8000
20	315126511139	OBILINTALA MAHALAKSHMI	294685	Spanish	8000
21	315126511140	RAVELLA MAHARSHI	359974	Spanish	8000
22	315126511141	MAHENDRA SURYA KUMAR SARMA	703682	Spanish	8000
23	315126511142	LAMPA MANIKYAMBA	226454	Spanish	8000
24	315126511144	PARVATHINI MEHAR VINEEL	703699	Spanish	8000
25	315126511146	TADIKONDA MOHAN KRISHNA	703698	Spanish	8000
26	315126511150	MODI HARISH	703704	Spanish	8000
27	315126511154	MALLI AISHWARYA	345134	Spanish	8000
28	315126511155	PERUBILLAVIL SHRADHA NAIR	061578	Spanish	8000
29	315126511157	VENDRAPU POORNA SAI	359972	Spanish	8000
30	315126511158	TALUGU PRANEETH KUMAR	404988	Spanish	8000
31	315126511159	VALLAPALLI PRASANTHI	696656	Spanish	8000
32	315126511165	VADULA AJAY KUMAR	050969	Spanish	8000

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ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A)
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2	31512651	BENDALAM PRAVALLIKA	Spanish	703671	8000
3	31512651	BONGU PRAVEEN KUMAR	Spanish	248434	8000
4	31512651	VODDIKALA PURNIMA	Spanish	115521	8000
5	31512651	SHAIK RABBANI	Spanish	703663	8000
6	31512651	VINENI RAGHAVENDHRA	German	703661	8000
7	31512651	KARU ROHITH RAVI SHANKAR	Spanish	703707	8000
8	31512651	KANKIPATI SAHITYA	Spanish	215211	8000
9	31512651	MANYAM SAI ANULEKHA	Spanish	141098	8000
10	31512651	ANNIPALLI SAI DEEPIKA	Spanish	152379	8000
11	31512651	KADIYALA SAI PRIYA	Spanish	703679	8000
12	31512651	NAMALA SAI SAHITHI	Spanish	703680	8000
13	31512651	KANDA SAI SARAN TEJA	Spanish	703683	8000
14	31512651	PABBATHY SAI SRAVANI	Spanish	664729	8000
15	31512651	PINNAM SAI TEJA	Spanish	703670	8000
16	31512651	GUDLA SAI VENKATA LAXMI BHAVANI	Spanish	760800	8000
17	31512651	GUMMALLA SAI VENKATA PRASEEN K	Spanish	703659	8000
18	31512651	KARANAM SAI VINEETHA	Spanish	941255	8000
19	31512651	VAKKALAGADDI SAILAKSHMI	Spanish	404877	8000
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25	31512651	PATTA SIVA SAI	Spanish	703681	8000
26	31512651	SAGI SOWMYA	Spanish	007316	8000
27	31512651	VUPPALA SRI HARINI	Spanish	941257	8000
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29	31512651	GUMMADI SRIRUPA	Spanish	237394	8000
30	31512651	PEDDAYYALA SUCHARITHA	Spanish	582719	8000
31	31512651	GANDHI SUHAS	Spanish	516981	8000
32	31512651	DANTULURI SUNDARA VINYA	Spanish	417550	8000
33	31512651	GANDEPALLI SURESH BABU	Spanish	555663	8000
34	31512651	KONA URJITA	Spanish	228380	8000
35	31512651	PUTNURU V V V RAHUL	Spanish	703678	8000
36	31512651	SARKY VANDANA	Spanish	503272	8000
37	31512651	CHANGALA VARUN	Spanish	703658	8000
38	31512651	NALLI VENKATA RAMANA SUSHANTH	Spanish	771023	8000
39	31512651	MAJJI VENKATA SATYA ANIL KUMAR	Spanish	703669	8000
40	31512651	VEERAGANDHAM VENKATA SUBBA RAO	Spanish	703672	8000
41	31512651	MOTTAYYA VISHNUDATTA	Spanish	562003	8000
42	31512651	ARAYASOMAYAJULA VSK VYSHNAVI	Spanish	703664	8000
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HOD, IT

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MEMORANDUM OF UNDERSTANDING

Recognizing the need for 'Industry-Institute Interaction' and to keep abreast of the latest developments in the field of Chemical Engineering, **Anil Neerukonda Institute of Technology & Sciences**, Sangivalasa, Bheemunipatnam Mandal, Visakhapatnam Dt-531162, a self- financing institution, hereinafter referred to as **'ANITS'**.

and

M/s Process Engineers Group, Hyderabad, a company engaged in process engineering and training services for Chemical, Biochemical, Petrochemical, Oil and Gas, Refineries and Technical Institutions, entered and signed a Memorandum of Understanding (MOU) on this day the 8th of December, 2017.

The MOU is valid for a period of **3 years beginning with 8th December, 2017.**

The MOU envisages the following:

1. **M/s Process Engineers Group, will, where possible, assist ANITS in**

A) **Students projects:**

By suggesting some industry – oriented projects, guiding the project students and permitting them to use the facilities, if required, for successful completion of the projects.

B) **Guest lectures:**

By providing resource persons, for giving guest lectures in frontier areas, not forming part of the curriculum, especially in the areas of Chemical and Allied Technologies.

C) **Refresher courses, workshops and seminars:**

In conducting national seminars, symposiums, workshops etc by ANITS, by providing some intellectual inputs.

D) **Training for the students and faculty:**

In providing industrial training to the students and faculty of ANITS, as and when required particularly in summer vacation.

E) **Value – addition Programs:**

In conducting value-addition programs for the students of ANITS if necessary, at a mutually agreed cost.

2. **ANITS will, where possible, assist M/s Process Engineers Group Limited in**

A) **Value – addition Programs:**

In conducting value-addition training programs like computational techniques for process design etc for the working personnel of your industry, if necessary, at a mutually agreed cost.

B) **Consultancy:**

In taking of industrial relating programs and assisting them in arriving at reasonable solutions

For & on behalf of
M/s Process Engineers Group

Anil Neerukonda Institute of Technology & Sciences SANGIVALASA

For & on behalf of
ANITS

$SSOLFDWLRQ RI WKHRU\ WR SURFHVV LQGXVWU\ WR HQJLQH

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CIN No. : U28990TN1980PTC008115

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QUALITY SYSTEM CERTIFICATION ISO 9001:2008
AS 9100C

Memorandum of Understanding

This Memorandum of Understanding (MOU) is between M/s Metallic Bellows (I) Pvt Ltd, Chennai, a company incorporated under the laws of India with its registered office at East Coast Road, Vettuvankeni Village, Injambakkam, Chennai.

Anil Neerukonda Institute of Technology & Sciences an engineering college committed to educational excellence having its office at Sangivalasa, Bheemunipatanam (Mandal) 531162, Visakhapatnam, Andhra Pradesh. (here after referred to as "partner").

RECITALS:

A. Where as Partner has been established for the purpose of enriching the technical education process and to jointly work for solving technical problems arising in the field of Mechanical Engineering.

B. Whereas M/s Metallic Bellows (I) Pvt Ltd, Chennai wishes to collaborate with the partner for the purpose of enriching the technical knowledge of their employees in new subject areas and to jointly work for solving technical problems arising in the field of Mechanical Engineering.

C. Wheras Partner with assistance from M/s Metallic Bellows (I) Pvt Ltd, Chennai has goals for enhacing the quality of the technical education for students and faculty of Mechanical Engineering thereby enabling them to meet the industry needs and to recognize globally.

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Investigation of Stresses in U-Shaped Metal Bellow Using EJMA Standards

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Abstract: Metal Bellows finds wide application in expansion joints, which are used in aerospace, chemical plants, power system, heat exchangers, automotive vehicle parts, piping system, petrochemical plant, refineries, etc. During service they are subjected to various stresses and exposed to different environments, which leads to failure. Hence there is a need for proper design of metal bellow as per the application. The main objective of the paper is to evaluate the stresses generated in the metal bellow and the cycle life working at different working pressures. In this paper, the stresses are calculated using Expansion Joint Manufacturing Association (EJMA) standards and compared with the results obtained using ANYS software for two different materials namely Inconel 625 and Inconel 718 for the pressure values ranging from 20 to 40 bar.

Keywords: EJMA, Expansion joints, Metal bellow

Reference: Prasad, K. S., Pavanai, G., "Investigation of Stresses in U-Shaped Metal Bellow Using EJMA Standards", Int J of Advanced Design and Manufacturing Technology, Vol. 11/No. 2, 2017, pp. 25-35.

Biographical notes: Kondapalli Siva Prasad obtained PhD from Andhra University, India in 2003. He is currently working as Associate Professor at the Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, India. His current research interest includes Manufacturing and product design. **Gudla Pavanai** is PG student of Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, India.

1 INTRODUCTION

An expansion joint is an assembly designed to safely absorb the heat-induced expansion and contraction of construction materials, to absorb vibration, to hold parts together, or to allow movement due to ground settlement or earthquakes. Bellow is corrugated part of the expansion joint which is capable of compensating large amount of axial, lateral and angular movements as a single unit. It must be strong enough circumferentially to withstand the pressure and flexible enough longitudinally to accept the deflections for which it is designed, and as repetitively as necessary with a minimum resistance. This strength with flexibility is a unique design problem that is not often found in other components in industrial equipment. Based on the application the material of the bellow is selected. Its present requirement is for the aerospace applications at the bleed air outlet of aircraft engine.

In the field of expansion joints very limited literature is available. Only few technical books and hand books of piping includes about the expansion joints which are used in the piping. But these references are limited up to the working principle of expansion joints. No text or reference books include, design of expansion joints, as this is a specialized area. But all authors are mentioning the reference of standards developed by EJMA. Since major contribution in the design of bellows expansion joint is given by Expansion Joints Manufacturers' Association (EJMA). EJMA has established the codes and guidelines for the design of bellows expansion joints. These codes are available based on membership of EJMA. Jayesh. B. Khunt and Rakesh. Prajapathi [1] studied different types of expansion joints used in industry.

S. H. Gawande et al. [2] performed numerical analysis to find various characteristics of stresses in U-shaped metal expansion bellows as per the requirement of vendor and ASME standards. Lu Zhiming et al. [3] discussed the effects of axial deformation load on U-shaped bellows. Brijeshkumar et al. [4] analyzed the failure of bellows expansion joints made of SS 304. Zhiming Lu et al. [5] analyzed the failure of metal bellow made of austenitic stainless steel. Kazuyuki Tsukimori [6] carried out modeling of creep behavior of bellows. Norton's law is used to study the creep property of bellows. K. Brodzinsko et al. [7] studied the failure mechanism of LHC cryogenic distribution line. Hasan Shaikh et al. [8] analyzed the failure of an AM 350 steel bellows. Jinbong Kim [9] analyzed the effect of geometry on fatigue life for automotive bellows. F. Elshawesh et al. [10] investigated that the expansion joint failed as a result of initiation of fatigue cracks at the corrosion pits that propagated through bellow's circumference. Bijayani Panda et al. [11] discussed the metallurgical factors responsible for failure of bellows due to stress corrosion cracking. Asril Pramutadi et al. [12] observed the corrosion behavior conducted on the bellows of the bellow-sealed valve used in a lithium circulation loop. Abhay K. Jha et al. [13] observed various metallurgical features in stainless steel bellows. Y.Z. Zhu et al. [14] proposed the effect of environmental medium on corrosion fatigue life. C. Becht IV [15] predicted the fatigue life of bellows by partitioning the bellow fatigue data based on a geometry parameter.

In the above literature review most of the work is done on bellows made of various grade stainless steels which are subjected to different types of corrosion such as fatigue corrosion, liquid droplet erosion, and stress corrosion when used at high temperatures. Fatigue analysis of bellows is less concentrated. Based on these studies, there is a necessity that the materials used should possess great corrosion resistance at elevated temperatures. The fatigue life of the bellows is of great importance as they are subjected repeated loads. Therefore, these two high temperature nickel-chromium alloys Inconel 625 and Inconel 718 are used in our work. These materials have good oxidation resistance, excellent strength and are easily fabricated. As most of the bellows are used in corrosive environment use of these nickel chromium alloys will minimize the failure due to corrosion. So, these material properties are used to calculate the stresses produced in bellows. Hence this work focusses on selection of proper bellow material, design, calculation of stresses both analytically and numerically and finally comparing both with the allowable stress limits.

2 DESIGN OF BELLOW USING EJMA STANDARDS

The design of a bellow is complex and it involves an evaluation of pressure capacity, stresses due deflection and pressure, fatigue life, spring forces and instability. The bellow used in this joint will be tested for two high temperature materials. The design should be based on the actual bellow metal temperature expected during operation. The design values are considered based on conditions available at the bleed air outlet of aircraft engine. Detailed design calculations of bellow used in gimbal joint are shown below.

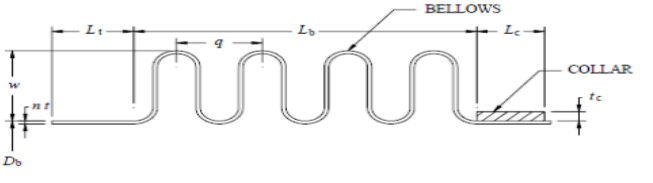

Fig. 1 Geometry of bellow

Design considerations

Normal Working Pressure = 37 bar
Normal Working Temperature = 650ºC
Angular Moment required = 17.5Nm
Maximum Permissible Deflection = ±6º
D_m= Mean diameter of bellows convolution=50.5mm
D_b = Inside diameter of bellows convolution = 42mm
D_c= mean diameter of bellows tangent reinforcing collar=45 mm
n = number of plies (Assume initially) = 4
t = Bellows nominal material thickness of one ply (Assume initially) = 0.25mm
t_p = Bellows material thickness for one ply corrected for thinning during forming =0.228mm
w = convolution height minus bellows thickness = 7.25mm
Assume Number of convolutions N = 7
L_b = Bellows convolute length = 43mm
L_t = Bellows tangent length = 6.5mm
L_c= Bellows tangent collar length =6.5mm
t_c = Bellows tangent reinforcing collar material thickness =1mm
q= Pitch =6.143 mm
e = Total equivalent axial moment per convolution = $e_{\theta,}$ since only rotational movement is allowed= e_θ= 0.378 mm
k = A factor which considers the stiffening effect of the attachment weld and the end convolution on the pressure capacity of the bellows tangent and k value is calculated by using formula

$$k = \frac{L_t}{1.5\sqrt{D_b \times t}} = \frac{6.5}{1.5\sqrt{42 \times 0.25}} = 1.337$$

But if k>=1, k should be taken as 1
Hence k =1

2.1 The Stresses induced in bellow

The main causes for the stresses in the bellows are pressure and initial deflection. Pressure and deflection causes circumferential and meridional stresses in the bellows. Stresses due to internal pressure remain largely unaffected by the number of piles except for the convolution meridional bending stress, which are reduced when the total bellows thickness increases. The deflection stresses are reduced due to thinner material per ply resulting in an increase in fatigue life. The equations used below are based on norms followed by Expansion Joint Manufacturer's Association (EJMA) and accepted by ASME (American Society of Mechanical Engineers).

The following are the stresses

1. Bellows Tangent Circumferential Membrane stress due to pressure (S_1)
2. Primary Collar Circumferential Membrane stress due to pressure (S_1^1)
3. Circumferential Membrane stress is also induced in the convolutions (S_2)
4. Bellows Meridional Membrane stress due to pressure (S_3)
5. Bellows Meridional Bending stress due to pressure (S_4)
6. Bellows Meridional Membrane stress due to deflection(S_5)
7. Bellows Meridional Bending stress due to deflection (S_6)

For Inconel 625 Material

I. Bellow tangent circumferential membrane stress due to pressure (S_1)

$$S_1 = \left[\frac{P \times \left(D_h + n \times t\right)^2 \times L_t \times E_h \times k}{2 \times \left\{ n \times t \times E_h \times L_t \times \left(D_h + n \times t\right) + t_c \times k \times E_c \times L_c \times D_c \right\}} \right]$$

$E_b = E_c$ = 16700 kgf/mm^2
S_1= 3.89kgf/mm^2
S_u = Ultimate tensile strength of Inconel 625 at design temperature (650ºC) = 760Mpa or76 kgf/mm^2
S_{ab} = allowable material stress of Inconel 625 at design temperature = 76/2.5 =30 kgf/mm^2
C_w = Factor accounting for Welding joint efficiency = 0.7
Effective $S_{ab} = C_w \times S_{ab}$ = 21 kgf/mm^2
From the above calculations, it is clear that $S_1 < S_{ab}$.
Hence design is safe.

II. Primary collar circumferential membrane stress due to pressure (S_1')

This is the circumference membrane stress induced in the collar directly due to pressure p

$$S_1' = \left[\frac{P \times D_c^{\,2} \times L_t \times E_c \times k}{2 \times \left\{ n \times t \times E_b \times L_t \times \left(D_b + n \times t\right) + t_c \times k \times L_c \times D_c \right\}} \right]$$

$S_1^{'}$ = 4.25 Kgf/mm^2
Effective S_{ab} = 21 kgf/mm^2
$S_1' < S_{ab}$
Hence design is safe.

III. Circumferential membrane stress induced in the convolutions (S_2)

$$S_2 = \frac{P \times D_m}{2 \times n \times t_p}\left[\frac{1}{0.571 + 2 \times w/q}\right]$$

(1) $S_2 = 3.4\ kgf/mm^2$

$S_2 < S_{ab}$ (Thus design is safe)

IV. Meridional membrane stress in the bellow convolution is induced due to pressure (S_3)

It is a primary stress that follows the longitudinal axis of the bellows at the crest and root of the convolutions

$$S_3 = \left[\frac{P \times W}{2 \times n \times t_p}\right]$$

S_3 =1.52 kgf/mm^2

V. Meridional bending stress induced in the bellow convolution due to pressure (S_4)

It is a primary stress that follows the longitudinal axis of the bellows across the convolutions

$$S_4 = \left[\left(\frac{p}{2 \times n}\right) \times \left(\frac{w}{t_p}\right)^2 \times C_p\right]$$

The factor C_p =0.625

$S_4 = 31.29 kg/mm^2$

C_m = Material strength factor at temperatures below the creep range

From EJMA standards, C_m =3.0 for bellows in the formed condition (with cold work)

$S_3 + S_4$ = 1.52 + 31.29 = 32.81 kgf/mm^2

$C_m * S_{ab}$ =3*21=63 kgf/mm^2

$S_3 + S_4 < C_m * S_{ab}$

Hence design is safe.

VI. Meridional membrane stress induced in the bellow convolution due to deflection(S_5)

It is a secondary stress since the applied load is limited by the deflection. It follows the longitudinal axis of the bellows.

$$S_5 = \left[\frac{E_b \times t_p^{\,2} \times e}{2 \times w^3 \times C_f}\right]$$

E_b= 20800 kgf/mm^2 (at room temperature)

C_f is a shape factor = 1.38

$S_5 = 0.351 kg/mm^2$

VII. Meridional bending stress in the bellow induced due to deflection (S_6)

It is a secondary stress and follows the longitudinal axis of the bellows. To find the value of the maximum moment, the convolution is modeled as a fixed guided strip beam with a concentrated load and a length w.

(2) $$S_6 = \left[\frac{5 \times E_b \times t_p \times e}{3 \times w^2 \times C_d}\right]$$

(3) Where

C_d is shape factor = 1.78

$S_6 = 29.84 kg/mm^2$

The Stresses S_5 and S_6 are used in the evaluation of bellows fatigue life.

2.2 Column Squirm (Calculation of P_{sc})

Column Squirm is defined as a gross lateral shift of the centre section of the bellows. It results in curvature of curvature of the bellows centre line. This condition is mostly associated with bellows which have a relatively large length to diameter ratio and is analogous to the buckling of a column under compressive load. The bellows have to be designed for either elastic or inelastic condition based on length to diameter ratio.

i.e.

For $L_b / D_b > = C_z$, the squirm pressure P_{sc} is evaluated as

$$P_{sc} = \left[\frac{0.34 \times \prod \times C_\theta \times f_{iu}}{N^2 \times q}\right]$$

For $L_b/D_b < C_z$, the squirm pressure P_{sc} is evaluated as

$$P_{sc} = \left[\frac{0.87 \times A_c \times S_y}{D_b \times q}\right]\left[1 - \frac{0.73 \times L_b}{C_z \times D_b}\right]$$

L_b / D_b = 43/42 = 1.02

$$C_z = \textit{Transition point factor} = \sqrt{\frac{4.72 \times f_{iu} \times q^2}{S_y \times D_b \times A_c}}$$

This indicates the value of length to Diameter ratio where the critical instability pressure transitions to a maximum value at the length of one convolution which represents purely inelastic behavior.

Where

S_y = Yield Strength at room temperature of bellows

For Inconel 625

S_y= 49 kgf/mm^2 (at room temperature for Inconel 625)

$$f_{iu} = \left[\frac{1.7 \times D_m \times E_b \times t_p^{\,3} \times n}{w^3 \times C_f}\right] = 116.75 \text{ kg/mm per convolution}$$

D_b = 42 mm

A_c =cross-sectional area of one bellows convolution $= (0.571 \times q + 2 \times w) t_p \times n$ = 16.88 mm^2

Substituting the values, C_z =0.776

Since $L_b / D_b \geq C_z$

P_{sc} should be evaluated for elastic region

$$P_{sc} = \left[\frac{0.34 \times \prod \times C_\theta \times f_{iu}}{N^2 \times q} \right]$$

C_θ =column instability pressure reduction factor based on initial angular rotation

$$C_\theta = 1 - 1.822 \times \gamma + 1.348 \times \gamma^2 - 0.529 \times \gamma^3$$

γ = Ratio of initial to final angular rotation

$$= \frac{\theta \times D_m}{\theta \times D_m + 0.3 \times L_b} = 0.2907$$

b) C_θ= 0.5713

P_{sc} = 0.236 kgf/mm^2

2.4 In-plane Squirm (Calculation of P_{si})

This is defined as a shift or rotation of the plane of one or more convolutions such that the plane of these convolutions is no longer perpendicular to axis of the bellows. It is characterized by tilting or warping of one or more convolutions. The stress induced due to this squirm is evaluated as follows

$$P_{si} = \left[\frac{0.51 \times S_y}{K_2 \sqrt{\alpha}} \right]$$

where

P_{si} = Limiting Design Pressure based on Inplane instability (both ends rigidly supported)

b) K_2 = Inplane Instability factor

$$K_2 = \frac{D_m}{2 \times n \times t_p} \left[\frac{1}{0.571 + 2 \frac{w}{q}} \right] = 9.189$$

α = Inplane instability stress interaction factor

$$= 1 + 2 \times \delta^2 + \left(1 - 2 \times \delta^2 + 4 \times \delta^4\right)^{0.5}$$

Inplane instability stress ratio= $\delta = \frac{K_4}{3 \times K_2}$

Inplane instability factor $K_4 = \frac{C_p}{2 \times n} \left[\frac{w}{t_p} \right]^2 = 84.53$

α =38.13

For Inconel 625

S_y= 49 kgf/mm^2

P_{si} = 0.44 kgf/mm^2

For all the materials a factor of safety for limiting stress of 2.25 is used in the relation for P_{sc}, P_{si}. As P_{sc}, P_{si}< Normal Working pressure (37 bar), theoretically it is required to go for higher thickness, however there bellows were tested for burst pressure of 125 bar 'g' and found satisfactory.

2.3 Fatigue Life

Fatigue life of a bellow is a function of the sum of the meridional pressure stresses range and the total meridional deflection stresses range. The equation for fatigue life is as follows.

$$N_c = \left(\frac{c}{S_t - b} \right)^a$$

where a, b and c are material and manufacturing constants. These constants are derived from the graph of total stress range S_t versus number of cycles N_c.

From EJMA standards, the values of a, b and c are as

a= 3.4, b = 54,000, c = 1.86×10^6

Total Stress S_t = 0.7 (S_3 + S_4) + (S_5 + S_6)

S_3 = 1.52 kgf/mm^2, S_4 = 31.29 kgf/mm^2

For Inconel 625

S_5 = 0.351 kgf/mm^2 , S_6 = 29.84 kgf/mm^2

S_t = 53.158 kgf/mm^2=77099.161 psi

N_c (at design temperature) = 3.02×10^6 cycles

3 NUMERICAL INVESTIF\GATION OF STRESSES

At first the bellow surface model is designed with the help of CATIA V5 software, which is one of the leading design software, and after that the surface model is saved in IGES format and the geometry is imported to ANSYS software. After importing the geometry, the material properties are given with a thickness of 1 mm. The bellow part is analyzed with the help of ANSYS WORKBENCH 15.0. Figure 2 shows the surface model and figure 3 shows the meshed ANSYS model with the thickness given. The loading conditions are given such that one edge of the bellow is fixed and internal surface is subjected to pressure varying from 20 bar to 40 bar for the materials Inconel 625 and Inconel 718. Figure 4 shows the loading conditions of bellow.

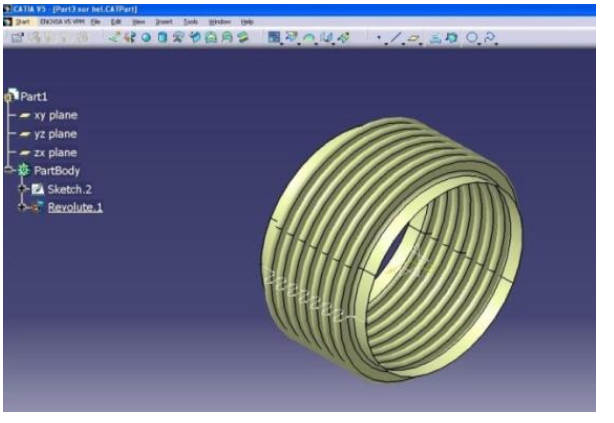

Fig. 2 The surface model

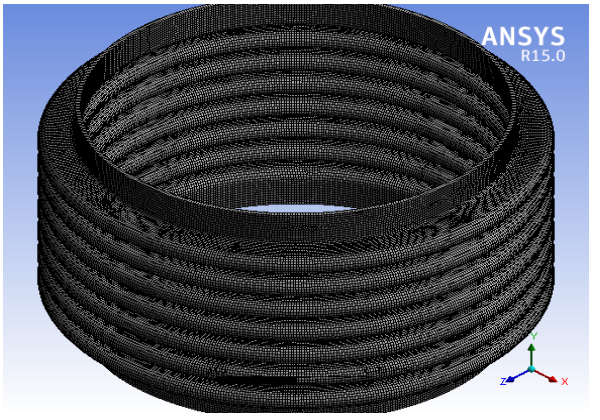

Fig. 3 The meshed model

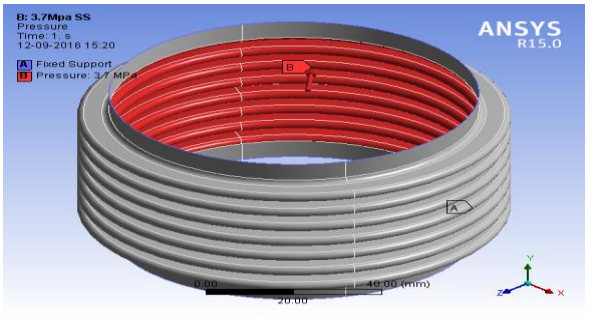

Fig. 4 The loading conditions

2 RESULTS & DICUSSIONS

4.1 Theoretically calculated Values

Theoretical values of design stresses, squirm values and fatigue life values for the two materials at 4 different pressures are calculated using EJMA standards.

Table 5.1 Stresses developed at different pressures in Inconel 625

At Pressure	20 Bar	30 Bar	37 Bar	40 Bar
S_1(kgf/mm^2)	2.10	3.152	3.887	4.20
S_1'(kgf/mm^2)	2.30	3.452	4.25	4.602
S_2(kgf/mm^2)	1.84	2.757	3.4	3.676
S_3(kgf/mm^2)	0.822	1.23	1.52	1.645
S_4(kgf/mm^2)	16.91	25.36	31.29	33.81
S_5(kgf/mm^2)	0.351	0.351	0.351	0.351
S_6(kgf/mm^2)	29.84	29.84	29.84	29.84

Table 5.2 Stresses developed at different pressures in Inconel 718

At Pressure	20 Bar	30 Bar	37 Bar	40 Bar
S_1(kgf/mm^2)	2.10	3.152	3.89	4.202
S_1'(kgf/mm^2)	2.30	3.452	4.25	4.602
S_2(kgf/mm^2)	1.838	2.757	3.4	3.675
S_3(kgf/mm^2)	0.822	1.234	1.52	1.645
S_4(kgf/mm^2)	16.91	25.36	31.29	33.81
S_5(kgf/mm^2)	0.337	0.337	0.337	0.337
S_6(kgf/mm^2)	28.692	28.692	28.692	28.692

4.1.1 Design Stresses induced in Bellow

In the above tables 5.1, and 5.2, the stresses developed in two high temperature metals at four different pressures are calculated and it is observed that the stresses S_1, S_1^1,S_2, S_3 ,S_4 are increasing within increase in pressure whereas the deflection stress S_5,S_6 are calculated by using room temperature material properties which does not have any significant change with the change in pressure and vary according to the material used. These stress values are checked with the allowable stress values and the design is found to be safe.

4.1.2 Column and In-plane Squirm

A factor of safety for limiting stress of 2.25 is used in the relation for P_{sc} and P_{si}. As P_{sc},P_{si}< 2.25 times of working pressure, theoretically it is required to go for higher thickness but these bellows were tested for burst pressure of 125 bar and are found satisfactory.

Table 5.3 Squirm values for different materials

INSTABILITY	Inconel	Inconel
Column Squirm	**0.236**	**0.23**
Inplane Squirm P_{si}	**0.44**	**1.056**

4.1.3 Fatigue Life

Table 5.4 Fatigue life values (number of cycles N_c)

Pressure (Bar)	20	30	37	40
Inconel 625	1.2×10^8	8.94×10^6	3.022×10^6	2.078×10^6
Inconel 718	2.78×10^8	1.281×10^7	3.908×10^6	2.613×10^6

From theoretical calculations, it is observed that fatigue life values depend upon the working pressure as the pressure increases fatigue life values decreases. Inconel 718 has better fatigue life at all the pressures.

4.1 Comparison of Analytical and Numerical Stresses due to Internal Pressure for Inconel 625 and Inconel 718

The analytical stresses obtained from EJMA standards and numerical stresses obtained from FEA are compared and tabulated below.

4.2.1 For Inconel 625

Table 5.5 Theoretical and Numerical stresses of Inconel 625 at different pressures

STRESS	SOURCE	20 Bar	30 Bar	37 Bar	40 Bar
S_1(kgf/mm^2)	EJMA	2.10	3.152	3.887	4.20
	FEA	9.21	13.84	16.47	18.18
S_1^1(kgf/mm^2)	EJMA	2.30	3.45	4.25	4.602
	FEA	8.41	13.54	15.72	17.14
S_2(kgf/mm^2)	EJMA	1.84	2.76	3.4	3.675
	FEA	11.45	17.29	20.942	23.18
S_3(kgf/mm^2)	EJMA	0.822	1.23	1.52	1.644
	FEA	11.14	16.43	20.97	22.85
S_4(kgf/mm^2)	EJMA	16.91	25.36	31.29	33.81
	FEA	13.94	20.42	25.35	28.38

From the table 5.5 it is observed for Inconel 625 that all the stresses obtained by both the approaches are within the allowable limit and are increasing with increase in the pressure. The difference in the stress profile is comparatively large and is due to variation of the approach methods.

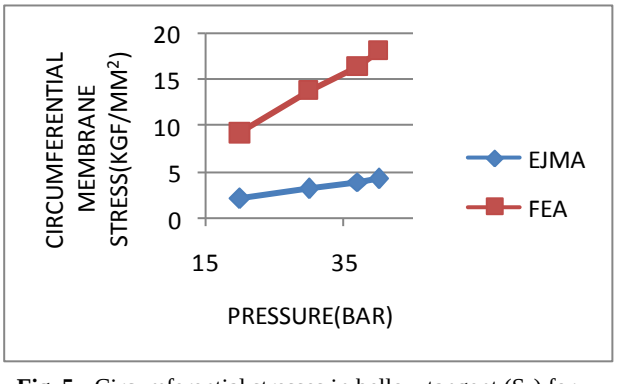

Fig. 5 Circumferential stresses in bellow tangent (S_1) for Inconel 625.$S_1 < S_{ab}$(21 kgf/mm^2)

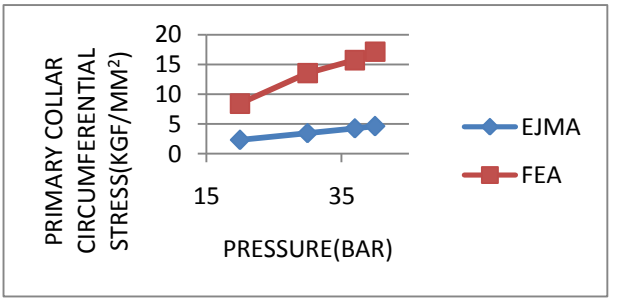

Fig. 6 Primary collar circumferential stress (S_1^1) for Inconel 625.$S_1^1 < S_{ab}$ (21 kgf/mm^2)

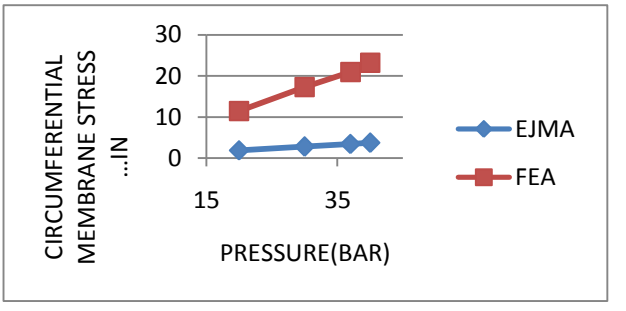

Fig. 7 Circumferential membrane stress induced in convolution (S_2) for Inconel 625 $S_2 < S_{ab}$ (21 kgf/mm^2)

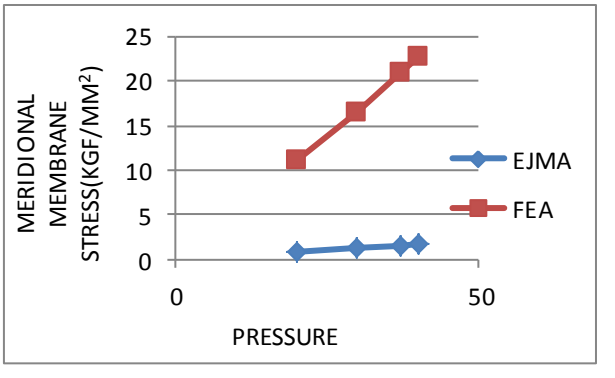

Fig. 8 Meridional membrane stress (S_3) for Inconel 625

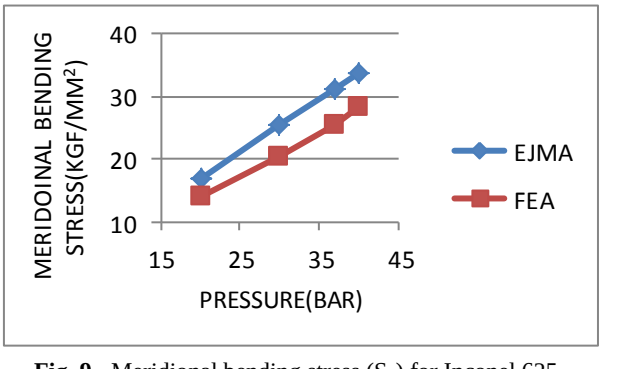

Fig. 9 Meridional bending stress (S_4) for Inconel 625 (S_3+S_4) <$C_m \times S_{ab}$(63 kgf/mm^2)

The allowable stress value (S_{ab}) for circumferential stresses S_1, S_1^1 ,S_2 is 21 kgf/mm^2. Whereas for meridional stresses (S_3+S_4) <C_m×S_{ab} i.e.63 kgf/mm^2 for the design to be safe. Figures 5 to 9 show the comparison graphs of the stresses in the bellow when subjected to internal pressure.

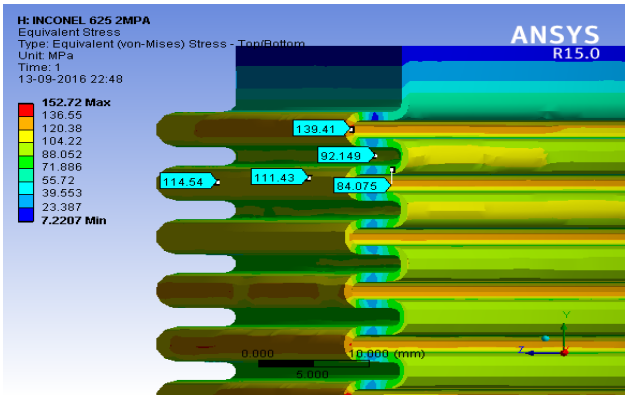

Fig. 10 Stress distribution at pressure 20 Bar

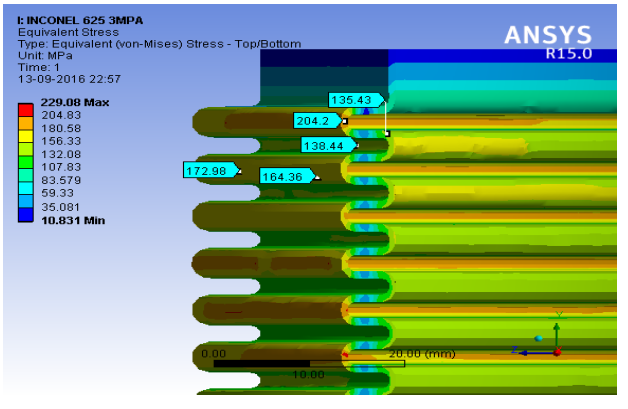

Fig. 11 Stress distribution at pressure 30 Bar

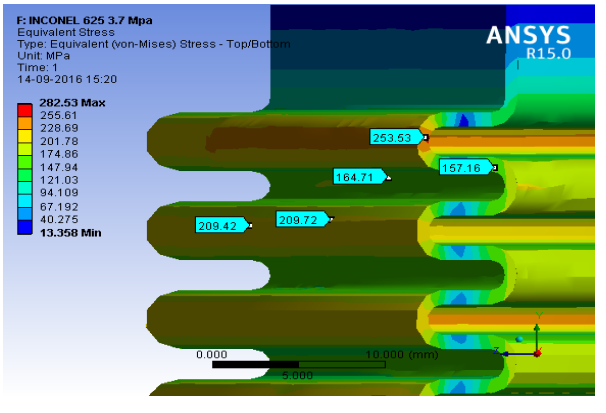

Fig. 12 Stress distribution at pressure 37 Bar

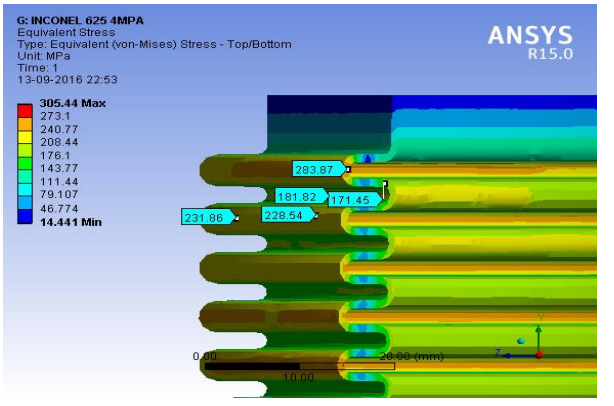

Fig. 13 Stress distribution at pressure 40 Bar

When compared to the meridional bending stress (S_4) all the other stresses have considerable variation, but as per design criteria they are within the allowable limit. The circumferential membrane stress induced in convolution (S_2) for the pressure 40 bar is slightly above the allowable stress which states that withstanding the pressure more than 40 bar there is a necessity to go for higher thickness of the bellow. Figures 10 to 13 show the stress distribution for Inconel 625 at different pressures. It is also incurred from the diagrams that the maximum and minimum values of stresses developed in bellow when compared to theoretically calculated stresses show a close match.

4.2.2 For Inconel 718

From the table 5.6 it is observed for Inconel 718 that all the stresses obtained by both the approaches are within the allowable limit and are increasing with increase in the pressure. The difference in the stress profile is comparatively large and is due to variation of the approach methods.

Table 5.6 Analytical and Numerical stresses of Inconel 718 at different pressures

STRESS	SOURCE	20 Bar	30 Bar	37 Bar	40 Bar
S_1(kgf/mm^2)	EJMA	2.10	3.152	3.89	4.202
	FEA	9.77	15.06	18.63	20.18
S_1^1(kgf/mm^2)	EJMA	2.301	3.452	4.25	4.602
	FEA	8.39	14.76	17.58	19.51
S_2(kgf/mm^2)	EJMA	1.838	2.757	3.4	3.676
	FEA	14.15	21.46	26.36	28.50
S_3(kgf/mm^2)	EJMA	0.822	1.234	1.52	1.645
	FEA	13.47	19.29	23.51	23.60
S_4(kgf/mm^2)	EJMA	16.907	25.361	31.29	33.814
	FEA	15.12	22.58	29.06	31.37

Figures 14 to 18 show the comparison graphs of the stresses in the bellow when subjected to internal pressure in Inconel 718. When compared to the meridional bending stress (S_4), all the other stresses have considerable variation, but as per design criteria, they are within the allowable limit.

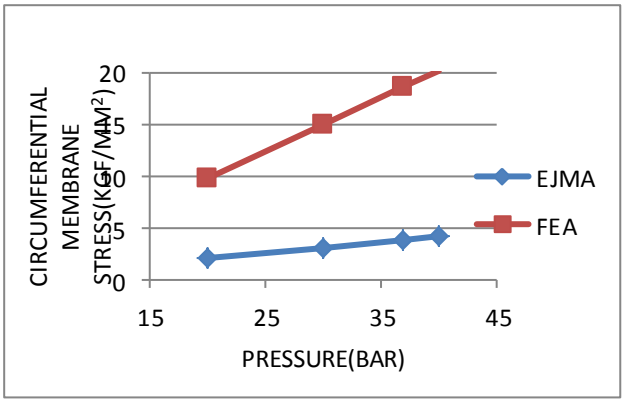

Fig. 14 Circumferential stresses in bellow tangent (S_1)for Inconel 718$S_1 < S_{ab}$(32.34 kgf/mm^2)

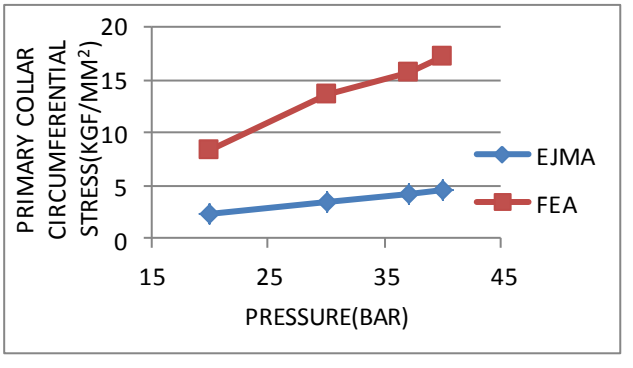

Fig 15 Primary collar circumferential stress (S_1^1) for Inconel 718$S_1^1 < S_{ab}$ (32.34 kgf/mm^2)

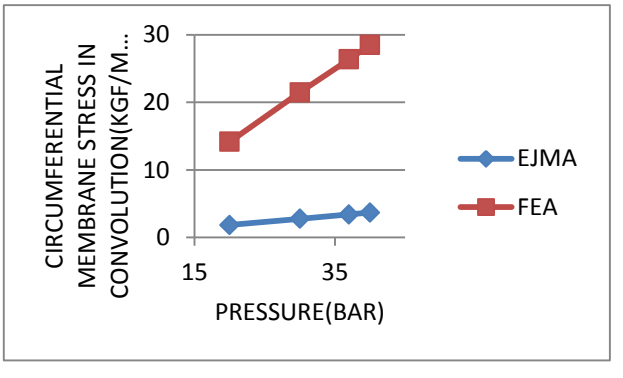

Fig. 16 Circumferential membrane stress induced in convolution (S_2) for Inconel 718 $S_2 < S_{ab}$ (32.34 kgf/mm^2)

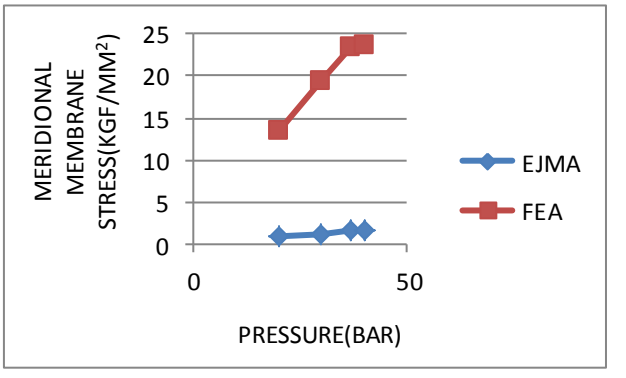

Fig. 17 Meridional membrane stress (S_3) for Inconel 718

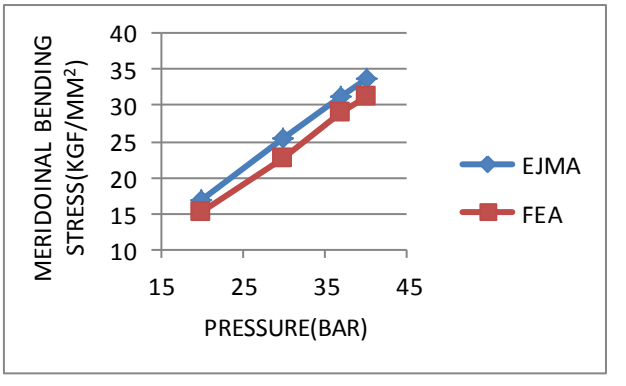

Fig. 18 Meridional bending stress (S_4) for Inconel 718(S_3+S_4) $< C_m \times S_{ab}$(97.02 kgf/mm^2)

Figures 19 to 22 show the stress distribution for Inconel 718 at different pressures varying from 20 bar to 40 bar. It is also incurred from the diagrams that the maximum and minimum values of stresses developed in bellow at these pressures show a close match.

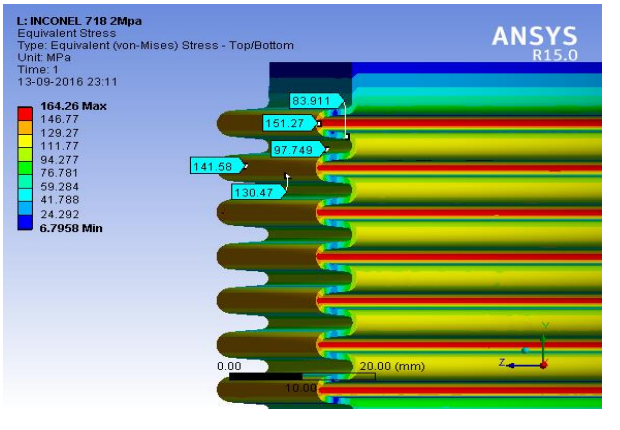

Fig. 19 Stress distribution at Pressure 20 Bar

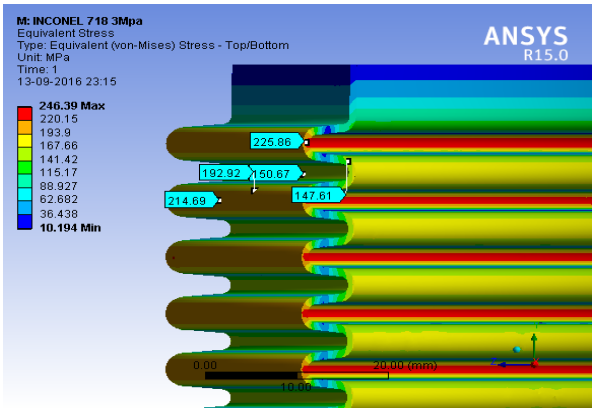

Fig. 20 Stress distribution at Pressure 30 Bar

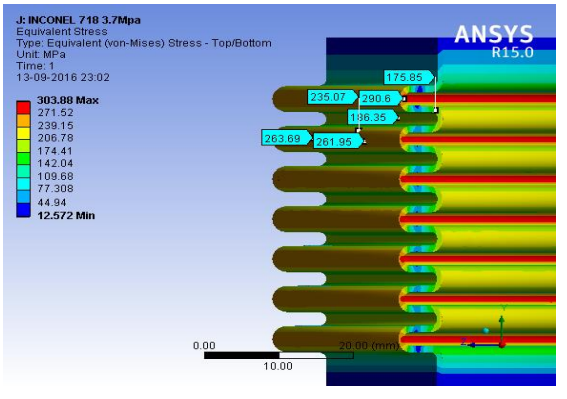

Fig. 21 Stress distribution at Pressure 37 Bar

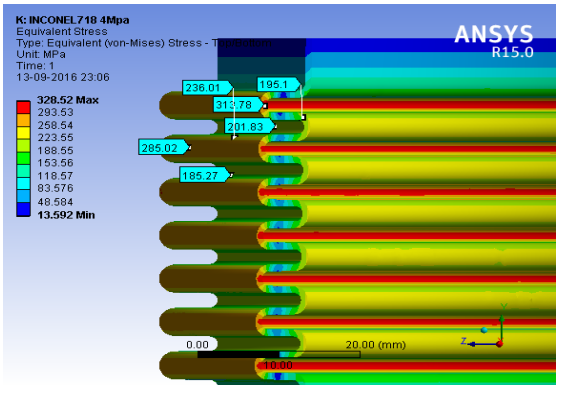

Fig. 22 Stress distribution at Pressure 40Bar

6 CONCLUSIONS

In this paper the design of the metal bellow and theoretical evaluation of the stresses is done using EJMA standards and the numerical evaluation is done by using ANSYS WORKBENCH software. The results obtained are compared and there is slight variation in the stress values and is due to different approaches followed. From the theoretical calculations it can be said that the maximum stress value is Meridional bending stress and this value is checked with the allowable stress value so that the bellow does not fail.

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EFFECT OF PULSE CURRENT MICRO PLASMA ARC WELDING PARAMETERS ON PITTING CORROSION RATE OF AISI 321 SHEETS IN 3.5 N NACL MEDIUM

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ABSTRACT

Austenitic stainless steel sheets are used for fabrication of components, which require high temperature resistance and corrosion resistance such as metal bellows used in expansion joints in aircraft, aerospace and petroleum industries. When they are exposed to sea water after welding they are subjected to corrosion as there are changes in properties of the base metal after welding. The corrosion rate depends on the chemical composition of the base metal and the nature of welding process adopted. Corrosion resistance of welded joints can be improved by controlling the process parameters of the welding process. In the present work Pulsed Current Micro Plasma Arc Welding (MPAW) is carried out on AISI 321 austenitic stainless steel of 0.3 mm thick. Peak current, Base current, Pulse rate and Pulse width are chosen as the input parameters and pitting corrosion rate of weldment in 3.5N NaCl solution is considered as output response. Pitting corrosion rate is computed using Linear Polarization method from Tafel plots. Response Surface Method (RSM) is adopted by using Box-Behnken Design and total 27 experiments are performed. Empirical relation between input and output response is developed using statistical software and its adequacy is checked using Analysis of Variance (ANOVA) at 95% confidence level. The main effect and interaction effect of input parameters on output response are also studied.

KEYWORDS: *Plasma Arc Welding; Austentic Stainless Steel; Pitting Corrosion Rate*

1.0 INTRODUCTION

Austenitic Stainless Steel (ASS), being the widest in use of all the stainless steel groups finds application in the beverages industry, petrochemical, petroleum, food processing and textile industries amongst others. It has good tensile strength, impact resistance and wear resistance properties. In addition, it combines these with excellent corrosion resistant properties (Dillon, C. P., 1994).

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Welding is one of the most employed methods of fabricating ASS components. ASS is largely highly weldable; the higher the carbon content, the harder the SS and so the more difficult it is to weld. The problem commonly encountered in welded ASS joints is intergranular corrosion, pitting and crevice corrosion in severe corrosion environments. Weld metals of ASS may undergo precipitation of $(CrFe)_{23}C_6$ at the grain boundaries, thus depleting Cr and making the SS weldment to be preferentially susceptible to corrosion at the grain boundaries. There may also be the precipitation of the brittle sigma Fe-Cr phase in their microstructure if they are exposed to high temperatures for a certain length of time as experienced during welding. High heat input welding invariably leads to slow cooling. During this slow cooling time, the temperature range of 700 - 850^{o}C stretches in time and with it the greater formation of the sigma phase (Pickering, F.B., 1985).

In Pulsed current MPAW process, the interfuse of metals was produced by heating them with an arc using a non consumable electrode. It is widely used welding process finds applications in welding hard to weld metals such as aluminium, stainless steel, magnesium and titanium (H. B. Cary, 1989). The increased use of automated welding urges the welding procedures and selection of welding parameters must be more specific for good weld quality and precision with minimum cost (Z. Samati, 1986) . The bead geometry plays an important role in determining the microstructure of the welded specimen and the mechanical properties of the weld (P.J. Konkol and G. F. Koons,1978). The proper selection of the input welding parameters which influence the properties of welded specimen ensure a high quality joint. Stainless steels are corrosive resistance in nature finds diversified application. Even stainless posses good resistance, they are yet susceptible to pitting corrosion. The pitting corrosion is a localized dissolution of an oxide-covered metal in specific aggressive environments. It is most common and cataclysmic causes of failure of metallic structures. The detection and monitoring of pitting corrosion is an important task in determining the weld quality. The pitting corrosion is a random, sporadic and stochastic process and their prediction of the time and location of occurrence remains extremely difficult and undefined (Fong – Yuan Ma, 2012, Rao, P. S, 2004, Srinivasa Rao, P., O. P. Gupta, and S. S. N. Murty,2005).

Stainless steels may also suffer from different forms of metallurgical changes when exposed to critical temperatures. In welding, the heat affected zone often experiences temperatures which cause sufficient microstructural changes in the welded plates. The precipitation of chromium nitrides, carbides and carbonitrides in the parent metal occur under various welding and environmental conditions and also depends on the grades of stainless steel. During pulsed MPAW process, the formation of coarse grains and inter granular chromium rich carbides along the grain boundaries in the heat affected zone deteriorates the mechanical properties.

In the present paper the effect of welding parameters namely peak current, base current, pulse rate and pulse width on pitting corrosion rate of AISI 321 sheets are studied. Linear polarization method is adopted in measuring the pitting corrosion rate.

2.0 WELDING PROCEDURE

Weld specimens of 100 x 150 x 0.3mm size are prepared from AISI 321 sheets and joined using square butt joint. The chemical composition and tensile properties of AISI 321 stainless steel sheets are presented in Table .1 & 2. Argon is used as a shielding gas and a trailing gas to avoid contamination from outside atmosphere. The welding conditions adopted during welding are presented in Table .3. From the earlier works (K.Siva Prasad, Ch.Srinivasa Rao, D.Nageswara Rao, 2013,2014) carried out on Pulsed Current MPAW it was understood that the peak current, back current, pulse rate and pulse width are the dominating parameters which effect the weld quality characteristics. The values of process parameters used in this study are the optimal values obtained from our earlier papers (K.Siva Prasad, Ch.Srinivasa Rao, D.Nageswara Rao, 2013,2014). Hence peak current, back current, pulse rate and pulse width are chosen as parameters and their levels are presented in Table .4. Details about experimental setup are shown in Figure1 . Four factors and three levels are considered and according to Box-Benhken Design matrix, 27 experiments are performed as per the Design matrix shown in Table 5.

Figure 1. Micro Plasma Arc Welding Setup.

Table 1. Chemical composition of AISI 321 (weight %)

C	Si	Mn	P	S	Cr	Ni	N
0.05	0.52	1.30	0.028	0.021	17.48	9.510	0.04

Table 2. Mechanical properties of AISI 321

Elongation (%)	Yield Strength (MPa)	Ultimate Tensile Strength (Mpa)
53.20	272.15	656.30

Table 3. Welding conditions

Power source	Secheron Micro Plasma Arc Machine (Model: PLASMAFIX 50E)
Polarity	DCEN
Mode of operation	Pulse mode
Electrode	2% thoriated tungsten electrode
Electrode Diameter	1mm
Plasma gas	Argon & Hydrogen
Plasma gas flow rate	6 Lpm
Shielding gas	Argon
Shielding gas flow rate	0.4 Lpm
Purging gas	Argon
Purging gas flow rate	0.4 Lpm
Copper Nozzle diameter	1mm
Nozzle to plate distance	1mm
Welding speed	260mm/min
Torch Position	Vertical
Operation type	Automatic

Table 4. Process parameters and their limits

		Levels		
Input Factor	**Units**	**-1**	**0**	**+1**
Peak Current	Amperes	6	7	8
Base Current	Amperes	3	4	5
Pulse rate	Pulses /Second	20	40	60
Pulse width	%	30	50	70

3.0 MEASUREMENT OF PITTING CORROSION RATE

Welded joints of stainless steel are subjected to pitting corrosion when exposed to different environments. The pitting corrosion rate depends upon the type, concentration of the exposed environment and exposure time of the welded joint. The details about sample preparation and testing procedure for measurement of pitting corrosion rate are discussed in the following sections.

3.1 Surface Preparation for Plating

The welded test specimen surface is polished with 220 and 600 mesh size emery papers in the presence of distilled water continuously. The polished specimen is first rinsed with distilled water, cleaned with acetone and again rinsed with distilled water to remove the stains and grease. Finally the specimen is dried to remove the moisture content on the surface of the sample.

3.2 Sample Preparation for Corrosion studies

Once the sample is cleaned, the entire sample is covered by insulating film and only a cross sectional area of 225 mm^2 is exposed as shown in Figure 2. The perplex tube as shown in Figure 3 is attached to the test specimen.

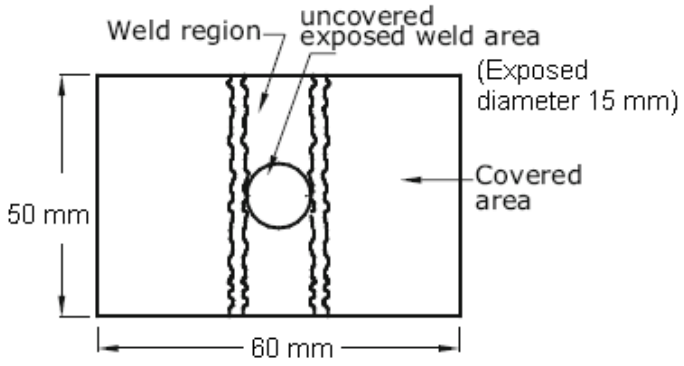


Figure 2. Dimensions of corrosion test specimen.

Figure 3. Setup of perplex tube

3.3 Procedure for Corrosion Studies

The electrochemical cell (test specimen with tube) is initially washed with distilled water followed by rinsing with filtered electrolyte NaCl. Around 100 ml of filtered electrolyte is poured into the electrochemical cell. The entire electrode assembly is now placed in the cell. The reference electrode (standard calomel electrode) is adjusted in such a way that the tip of this electrode is very near to the exposed area of working

electrode (test specimen). The auxiliary platinum electrode is also placed in the cell. Now the cell assembly has been connected to the AUTOLAB/PGSTAT12. The black colored plug has been connected to the auxiliary electrode, red colored plug to the working electrode and blue to the reference electrode. The sample has been exposed to electrolytic medium for a span of 2 hours.

As the start button of the potentiostat is switched on, the electrode potential changes continuously, till the reaction between the electrode and the medium attains equilibrium. After some time the potential remains nearly constant without any change. This steady potential which is displayed on the monitor is taken as open circuit potential (E_{rest}). Now the equipment is ready for obtaining the polarization data.

Potential is scanned cathodically until the potential is equal to E_{rest} minus the limit potential. Measurements of potential (E) and current (I) are made at different intervals and the data is displayed on the monitor itself as E vs log I plot. After reaching the cathodic limit, the scan direction is then reversed. Similarly anodic polarization data is obtained. The scan is again reversed and finally terminated and the cell is isolated from the potentiostat when the potential reached E_{rest}. The data recorded gives the Tafel plot (current vs potential data). Using the software available corrosion rate, corrosion current, polarization resistance and Tafel slopes are evaluated by Tafel plot methods. The Experimental setup is shown in Figure 4.

Figure 4. Pitting corrosion setup

3.4 Corrosion Testing Methodology

Passive metals may become susceptible to pitting corrosion when exposed to solutions having a critical content of aggressive ions such as chloride. This type of corrosion is potential-dependent and its occurrence is observed only above the pitting potential (E_{corr}), which can be used to differentiate the resistance to pitting corrosion of

differentmetal/electrolyte systems. The E_{corr} value can be determined electrochemically using both potentiostatic and potentiodynamic techniques.

3.5 Linear Polarization method

The linear polarization method utilizes the Tafel extrapolation technique. The electrochemical technique of polarization resistance is used to measure absolute corrosion rate, usually expressed in milli-inches per year (mpy), which is further converted in to mm per year. Polarization resistance can be measured very rapidly, usually less than ten minutes. Excellent correlation can often be made between corrosion rates obtained by polarization resistance and conventional weight-change determinations. Polarization resistance is also referred to as "linear polarization".

Polarization resistance measurement is performed by scanning through a potential range which is very close to the corrosion potential, E_{corr} the potential range is generally ±25 mV about E_{corr}. The resulting current vs. potential is plotted. The corrosion current, I_{corr} is related to the slope of the plot through the following equation

$$\frac{\Delta E}{\Delta I} = \frac{\beta_a \beta_c}{2.3 I_{corr}(\beta_a + \beta_c)} \quad (1)$$

where $\Delta E/\Delta I$ = slope of the polarization resistance plot, where ΔE is expressed in volts and ΔI in μA. This slope has units of resistance, hence, polarization Resistance. β_a,β_c are anode and cathode Tafel constants (must be determined from a Tafel plot as shown in Figure5).

These constants have the units of volts/decade of current. I_{corr}= corrosion current, μA. Rearranging equation (1)

$$I_{corr} = \frac{\beta_a \beta_c}{2.3(\beta_a + \beta_c)} \frac{\Delta I}{\Delta E} \quad (2)$$

The corrosion current can be related to the corrosion rate through the following equation.

$$\text{Corrosion rate (mpy)} = 0.131(I_{corr})(\text{Eq.Wt})/\rho \quad (3)$$

where

Eq.Wt = equivalent weight of the corroding species
ρ = density of the corroding species, g/cm^3
I_{corr} = corrosion current density, $\mu A/cm^2$

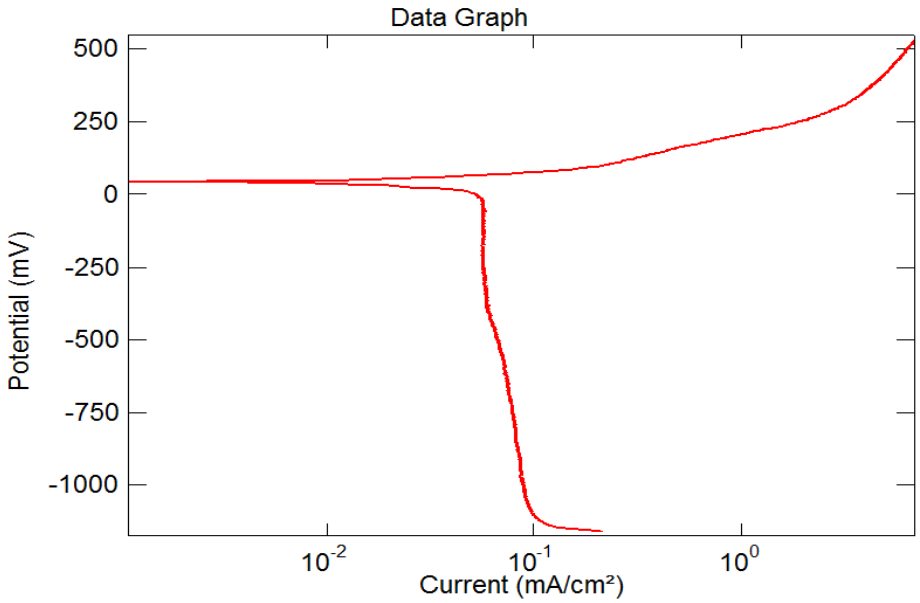


Figure 5. Modal Tafel plot

4.0 STATISTICAL ANALYSIS

The pitting corrosion rates for all the 27 samples are performed and presented in Table 5.

Table 5. Design matrix with experimental results

Experiment No.	Peak Current (Amperes)	Base current (Amperes)	Pulse Rate (Pulses/ second)	Pulse width (%)	Pitting Corrosion Rate (mm/year)	
					Experimental	Predicted
1	6	3	40	50	0.16938	0.16298
2	8	3	40	50	0.17676	0.17423
3	6	5	40	50	0.16686	0.16735
4	8	5	40	50	0.17266	0.17702
5	7	4	20	30	0.16366	0.16320
6	7	4	60	30	0.16966	0.16628
7	7	4	20	70	0.16836	0.17087
8	7	4	60	70	0.16566	0.16390
9	6	4	20	50	0.16716	0.16820
10	8	4	60	50	0.17966	0.17672
11	6	4	20	50	0.16716	0.16820
12	8	4	20	50	0.16756	0.16670
13	7	3	60	30	0.17802	0.17666
14	7	5	40	30	0.16786	0.16650
15	7	3	40	50	0.16536	0.16644
16	7	5	40	50	0.17046	0.17002
17	6	4	40	30	0.14716	0.15090

18	8	4	40	30	0.17386	0.17667
19	6	4	40	70	0.16876	0.16885
20	8	4	40	70	0.16486	0.16402
21	7	3	20	50	0.16826	0.16934
22	7	5	20	50	0.17966	0.17530
23	7	3	60	50	0.16166	0.16978
24	7	5	60	50	0.16966	0.17098
25	7	4	40	50	0.16326	0.16119
26	7	4	40	50	0.15916	0.16119
27	7	4	40	50	0.16216	0.16119

4.1 Empirical Mathematical Modeling

In RSM design, mathematical models are developed using polynomial equations. The type of polynomial equation depends on the problem.

In most RSM problems (M Balasubramanian,V Jayabalan,V Balasubramanian, 2007, 2008) the type of the relationship between the response (Y) and the independent variables is unknown. Thus the first step in RSM is to find a suitable approximation for the true functional relationship between the response and the set of independent variables.

Usually, a low order polynomial is some region of the independent variables is employed to develop a relation between the response and the independent variables. If the response is well modeled by a linear function of the independent variables then the approximating function in the first order model is

$$Y = b_o + \sum b_i x_i + \in \quad (4)$$

where b_o, $b_i$are the coefficients of the polynomial and $\in$ represents noise or error.

If interaction terms are added to main effects or first order model, then the model is capable of representing some curvature in the response function, such as

$$Y = b_o + \sum b_i x_i + \sum\sum b_{ij} x_i x_j + \in \quad (5)$$

A curve results from Equation -5 by twisting of the plane induced by the interaction term $b_{ij}x_ix_j$. There are going to be situations where the curvature in the response function is not adequately modeled by Equation -5. In such cases, a logical model to consider is

$$Y = b_o + \sum b_i x_i + \sum b_{ii} x_i^2 + \sum\sum b_{ij} x_i x_j + \in \quad (6)$$

where b_{ii} represent pure second order or quadratic effects. Equation -3 represents a second order response surface model. Using MINITAB Ver.14, statistical software, the significant coefficients are determined and final model is developed incorporating these coefficients to estimate the pitting corrosion rate. In the empirical model only significant coefficients are considered.

Pitting Corrosion Rate = $0.314280 - 0.016337X_1 - 0.059210X_2 - 0.002214X_3 + 0.001769X_4 + 0.007036X_2^2 + 0.000299X_1X_3 - 0.000382X_1X_4$

where X_1, X_2, X_3 and X_4 are the coded values of peak current, base current, pulse rate and pulse width respectively.

4.2 Checking the adequacy of the developed model for pitting corrosion rate.

The adequacy of the developed models is tested using the ANOVA. As per this technique, if the calculated value of the F_{ratio} of the developed model is less than the standard F_{ratio}(F-table value 4.60) value at a desired level of confidence of 95%, then the model is said to be adequate within the confidence limit. ANOVA test results are presented in Table 6.1 for pitting corrosion rate. From Table 6 it is understood that the developed mathematical models are found to be adequate at 95% confidence level. Coefficient of determination ' R^2' is used to find how close the predicted and experimental values lie. The value of ' R^2' for the above developed models is found to be about 0.84, which indicates a good correlation to exist between the experimental values and the predicted values. Figure6 indicate the scatter plots for pitting corrosion rate of the weld joint and reveal that the actual and predicted values are close to each other within the specified limits.

Table 6 ANOVA test results for pitting corrosion rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	14	0.000949	0.000949	0.000068	3.63	0.016
Linear	4	0.000206	0.000294	0.000074	3.94	0.029
Square	4	0.000338	0.000267	0.000067	3.57	0.039
Interaction	6	0.000404	0.000404	0.000067	3.61	0.028
Residual Error	12	0.000224	0.000224	0.000019		
Lack-of-Fit	9	0.000215	0.000215	0.000024	7.96	0.057
Pure Error	3	0.000009	0.000009	0.000003		
Total	26	0.001173				

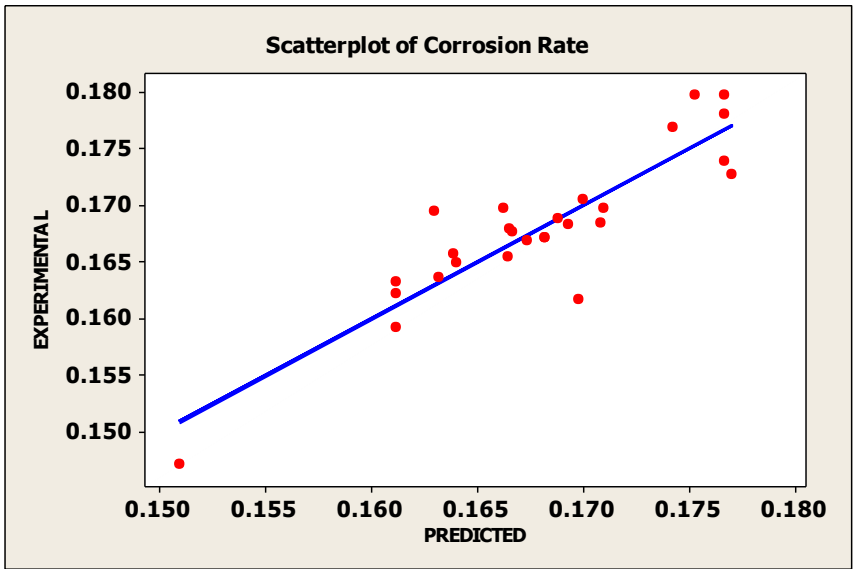


Figure 6. Scatter plot of pitting corrosion rate

5.0 RESULTS AND DISCUSSIONS

Effect of welding parameters on pitting corrosion rate is indicated by the main effect plot as shown in Figure7.

5.1 Main effect plots

From Figure 7, it is understood that the variation of each individual parameter on pitting corrosion rate can be assessed. Pitting corrosion rate increase with the peak current from 6 Amps to 8 Amps. This is because as the current increases heat input increases. At higher heat input, precipitation of $(CrFe)_{23}C_6$ at the grain boundaries takes place, thus depleting Cr and making the weldment to be preferentially susceptible to corrosion at the grain boundaries. Pitting corrosion rate decrease with the base current from 3 Amps to 4 Amps, afterwards it increases. The variation is because, at low base current generally low peak current will be used, however as the purpose of base current is to maintain the arc, instead of melting the workpice, the Pitting corrosion rate tends to decrease as precipitation of $(CrFe)_{23}C_6$ is low. But when the base current crosses over 4 Amps, corresponding peak current will increase leading to more precipitation of $(CrFe)_{23}C_6$ and hence the pitting corrosion rate increases upto 5 Amps. Pitting corrosion rate decrease with the pulse rate from 20 pulses/sec to 40 pulses/sec. This may be because, at low pulse rate, the current variation between base current and peak current is less, which leads to low heating of the base metal. However, when the pulse rate is above 40 pulses/sec, the current variation between base current and peak current is high, which leads to more melting of base metal and precipitation of $(CrFe)_{23}C_6$ at the grain boundaries. Pitting corrosion rate increase with the pulse width from 20% to 50 %. This is because as the pulse with increases, the peak current duration will be more in pulsed mode, leading to more melting and high correction rate. When the pulse width crosses

50 % , it shows a negative trend because of high time gap for cooling the base metal, which leads to lower precipitation of $(CrFe)_{23}C_6$ at the grain boundaries.

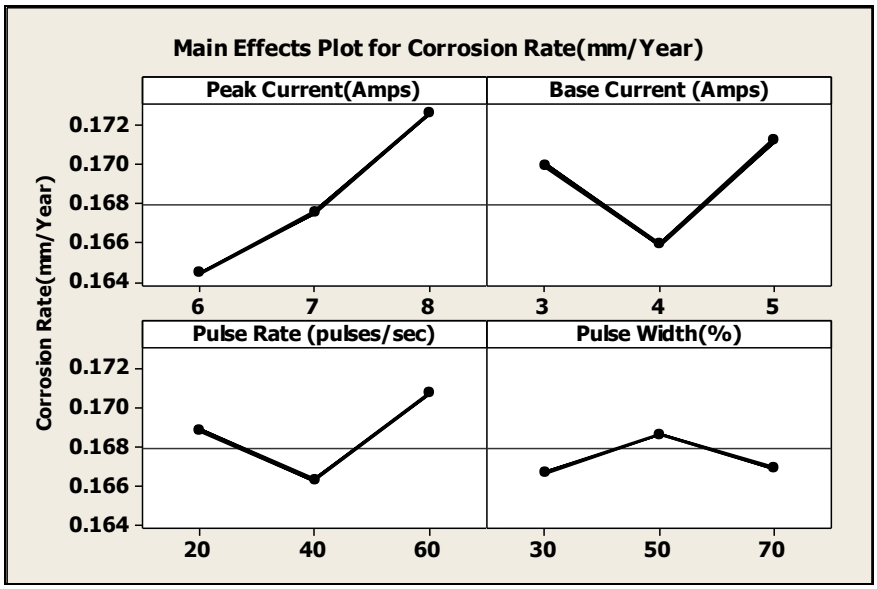


Figure 7. Main effect plot of pitting corrosion rate

5.2 Contour plots of pitting corrosion rate of 3.5N NaCl

The simultaneous effect of two parameters at a time on the output response is generally studied using contour plots and surface plots. Contour plots play a very important role in the study of the response surface. By generating contour plots using statistical software (MINITAB Ver.14) for response surface analysis, the most influencing parameter can be identified based on the orientation of contour lines. If the contour patterning of circular shaped contours occurs, it suggests the equal influence of both the factors; while elliptical contours indicate the interaction of the factors. Figure's 8a to 8f represent the contour plots for pitting corrosion rates. From these plots, the interaction effect between the input process parameters and output response can be observed as:

(i) From Figure 8a, it is understood that Pitting corrosion rate is more sensitive to change in peak current than in the base current, since the contour lines are more diverted towards peak current.

(ii) From Figure 8b, it is understood that Pitting corrosion rate is sensitive to peak current than in the pulse rate , since the contour lines are more diverted towards peak current.

(iii) From Figure 8c, it is understood that Pitting corrosion rate is more sensitive to peak current than pulse width , since the contour lines are more diverted towards peak current.

(iv) From Figure 8d, it is understood that Pitting corrosion rate is more sensitive to pulse rate than base current, since the contour lines are more diverted towards pulse rate.

(v) From Figure 8e, it is understood that Pitting corrosion rate is more sensitive to pulse width than base current , since the contour lines are more diverted towards pulse width.

(vi) From Figure 8f, it is understood that Pitting corrosion rate is more sensitive to pulse width than pulse rate , since the contour lines are more diverted towards pulse width. From the above welding parameters considered, it is understood that peak current is the most important parameter which affects the pitting corrosion rate of the welded joints.

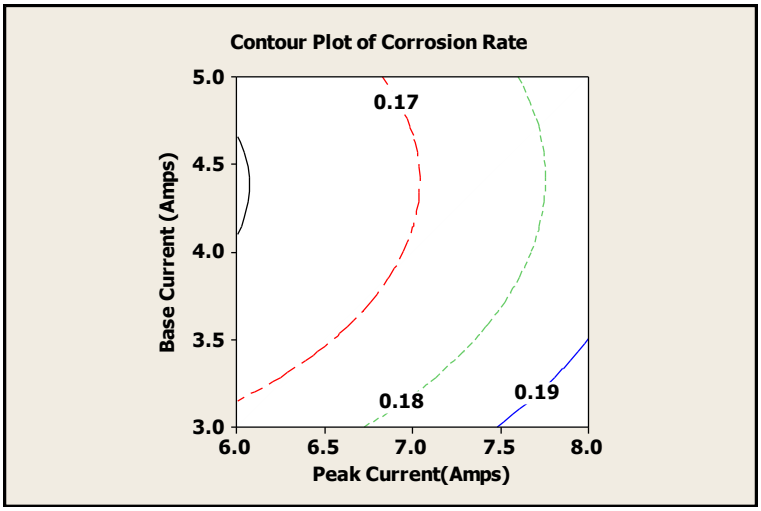


Figure 8a. Contour plot for peak current vs base current for corrosion rate (3.5N NaCl).

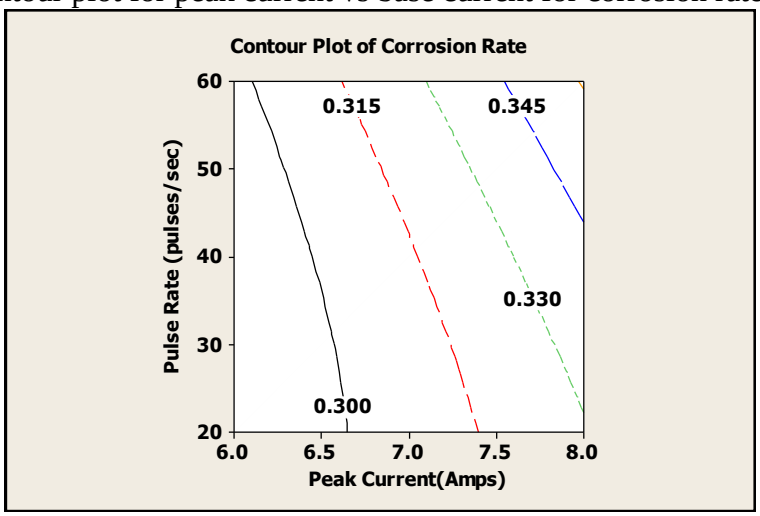


Figure 8b. Contour plot for peak current vs pulse rate for corrosion rate (3.5N NaCl).

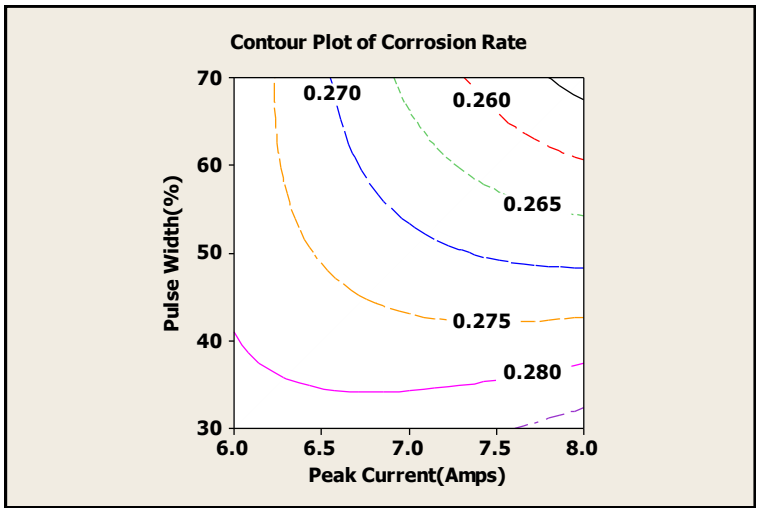


Figure 8c. Contour plot for peak current vs pulse width for corrosion rate(3.5N NaCl).

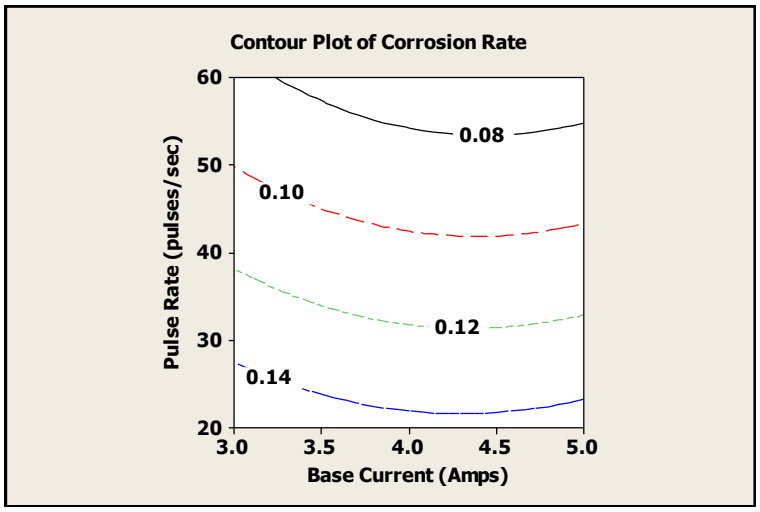


Figure 8d. Contour plot for base current vs pulse rate for corrosion (3.5N NaCl).

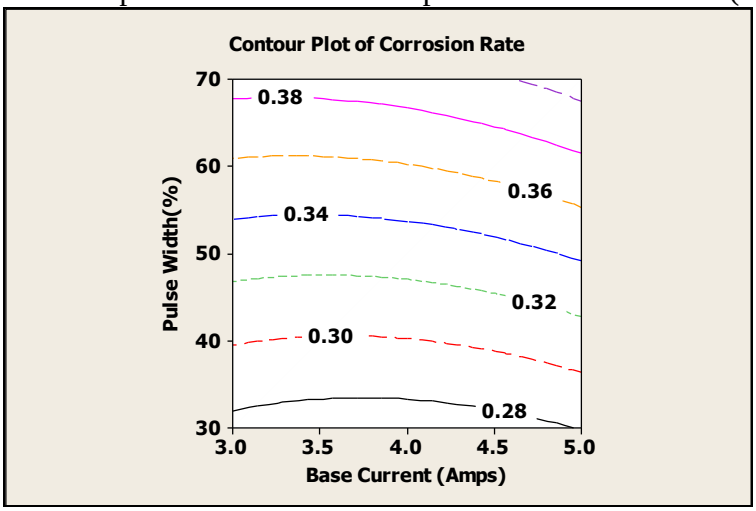


Figure 8e. Contour plot for base current vs pulse width for corrosion rate (3.5N NaCl).

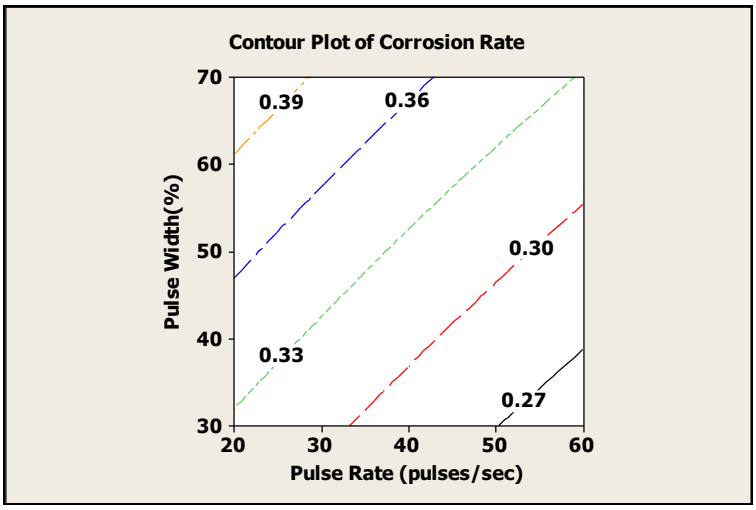


Figure 8f. Contour plot for pulse rate vs pulse width for corrosion rate (3.5N NaCl).

5.3 Surface plots

Surface plots help in locating the maximum and minimum value of the response. The maximum value of the response is represented by the apex of the surface plot, whereas the minimum value is indicated by nadir of the surface plot. The minimum pitting corrosion rate is indicated by the nadir of the response surface, as shown in Figure 9a to Figure 9f. Figure 9a the minimum pitting corrosion rate is exhibited by the nadir of the response surface. It can be seen from the twisted plane of surface plot that the model contains interaction. From the response plot, it is identified that at a peak current of 6 Amps and base current of 4 Amps, pitting corrosion rate is minimum. Figure 9b depicts that at a peak current of 6 Amps and pulse rate of 20 pulses/second, pitting corrosion rate is minimum. Figure 9c shows the three dimensional response surface plot it can be seen from the twisted plane of surface plot that the model contains interaction. From the response plot, it is identified that at the peak current of 8 Amps and pulse width of 60%, pitting corrosion rate is minimum. Figure 9d indicates that at a base current of 3 Amps and pulse rate of 60 pulses/second, pitting corrosion rate is minimum. Figure 9e represents that at a base current is 3 Amps and pulse width of 30 %, pitting corrosion rate is minimum. Figure 5.41f discusses that when pulse rate is 60 pulses/second and pulse width of 30 %, the pitting corrosion rate is minimum. It is clear from the above observations, that for a peak current of 6 Amps, base current of 3 Amps, pulse rate of 60 pulses/second and pulse width of 30 % minimum pitting corrosion rate is achieved.

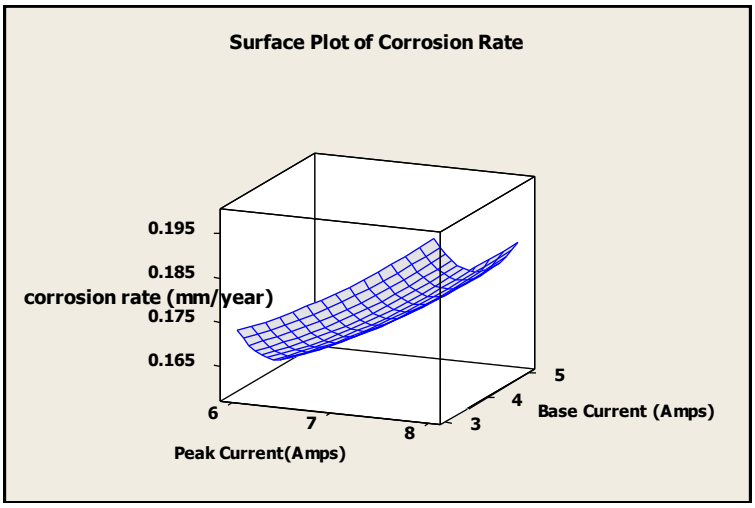


Figure 9a. Surface plot for peak current vs base current for corrosion rate (3.5N NaCl).

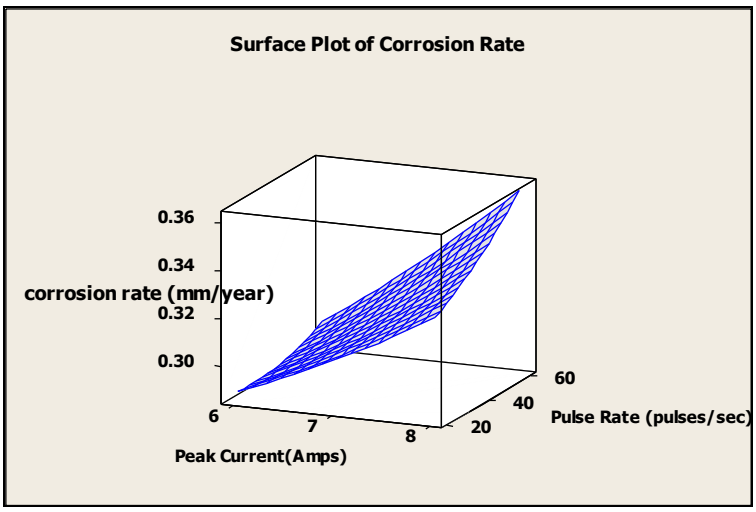


Figure 9b.Surface plot for peak current vs pulse rate for corrosion rate (3.5N NaCl).

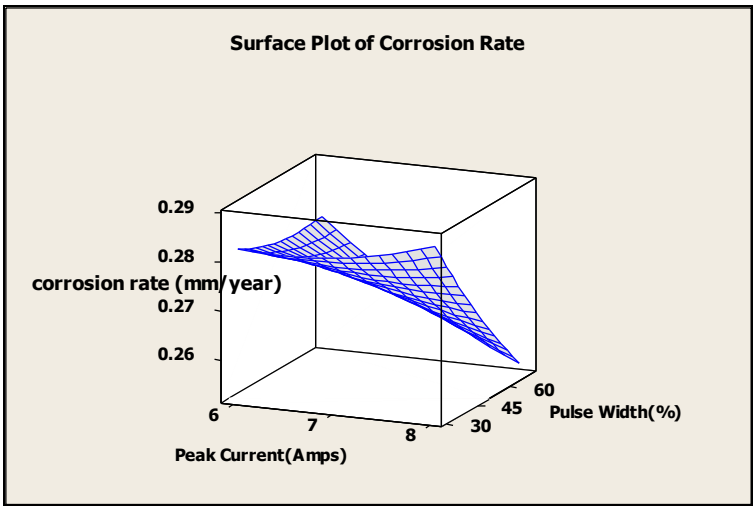


Figure 9c. Surface plot for peak current vs pulse width for corrosion rate (3.5N NaCl)

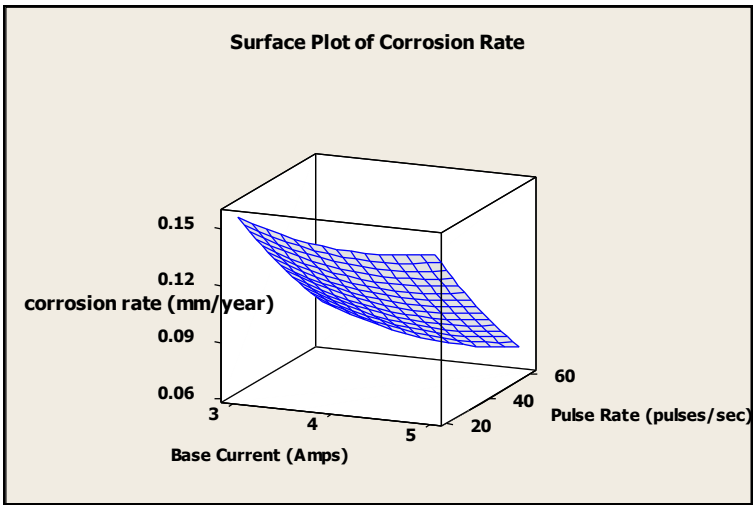


Figure 9d. Surface plot for base current vs pulse rate for corrosion rate (3.5N NaCl)

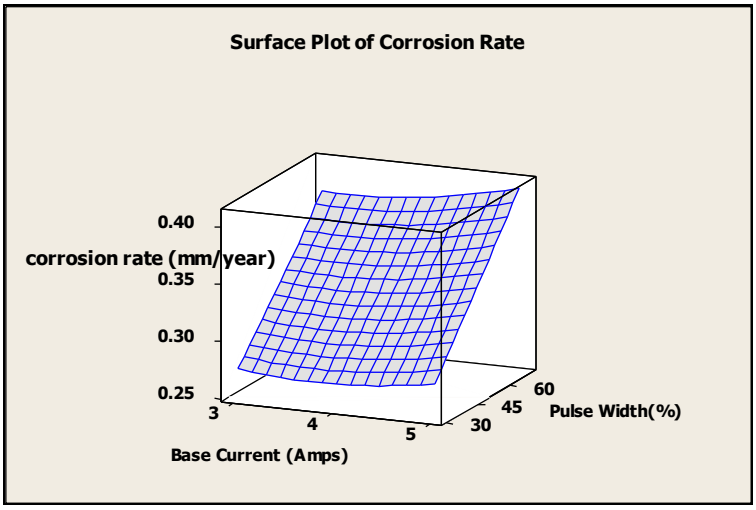


Figure 9e.Surface plot for base current vs pulse width for corrosion rate (3.5N NaCl).

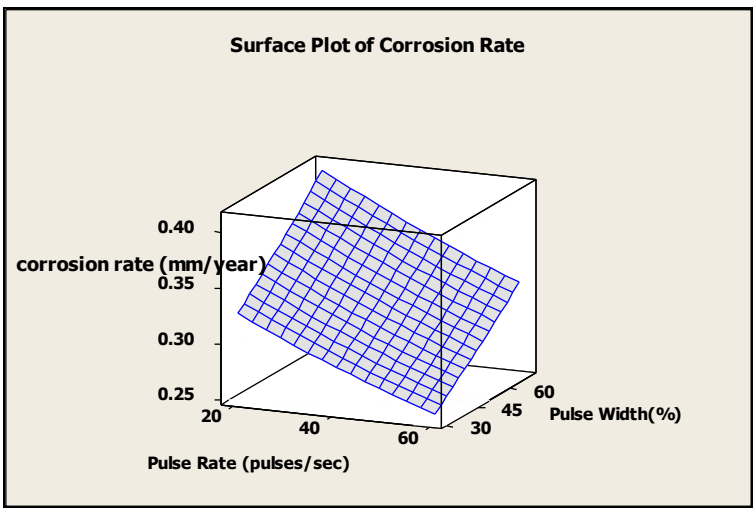


Figure 9f. Surface plot for pulse rate vs pulse width for corrosion rate (3.5N NaCl).

5.4 Microscopic analysis of weld joint

Figure 10a and 10b indicate the weld joint before corrosion and after pitting corrosion. The dark round spots indicates the area where pitting corrosion has taken place. Scanning Electron Microscope (SEM) analysis is carried out to identify the depleting of Cr % after the weld joint is subjected to pitting corrosion in 3.5N NaCl solution. Figure 11a and 11b indicate the SEM images before and after corrosion and the chemical compositions. It is observed that depletion of 3.15 % (wt.%) of Cr takes place because of corrosion.

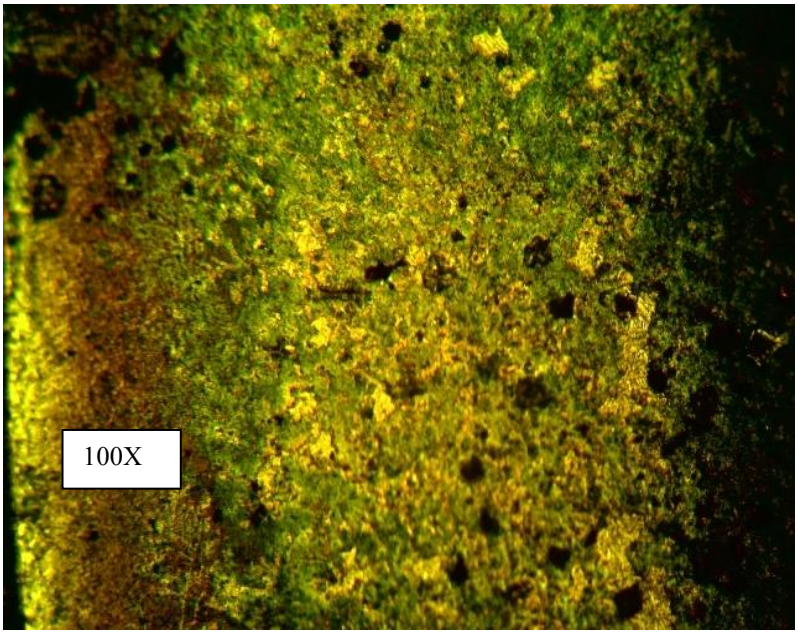


Figure.10a Weld joint before corrosion

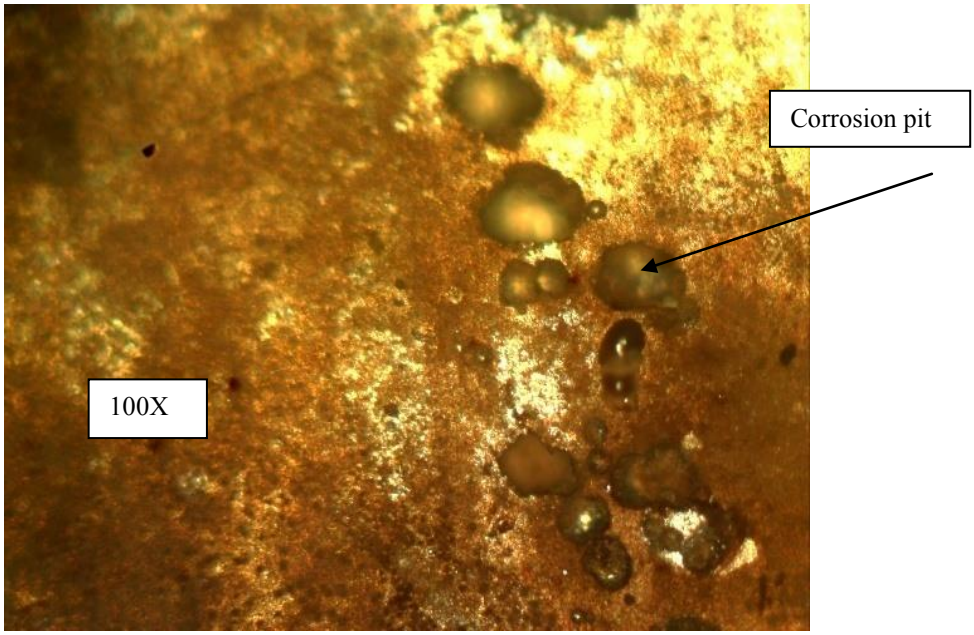
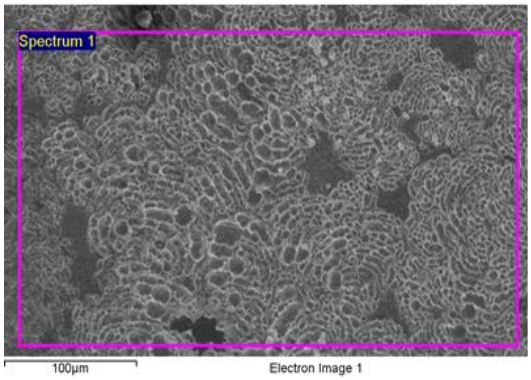


Figure.10b Weld joint after corrosion



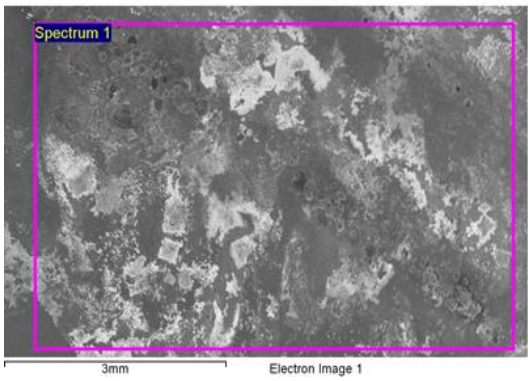


Figure11a. SEM before corrosion Figure11b. SEM after corrosion

From SEMEDAX, the chemical composition obtained of base metal and weld joint after corrosion are shown in Table7 and Table8

Table 7. Chemical compositions before corrosion

Element	O	Na	Si	Cl	Ti	Cr	Mn	Fe	Ni	Mo
Weight %	6.36	1.46	0.76	1.21	1.25	15.23	1.31	60.30	9.28	2.34
Atomic %	19.87	2.94	1.26	1.58	1.21	13.57	1.11	50.02	7.32	1.13

Table 8. Chemical compositions after corrosion

Element	O	Na	Si	Cl	Ti	Cr	Mn	Fe	Ni	Al	Cu
Weight %	12.54	16.99	0.35	8.03	0.18	12.08	0.72	42.17	5.32	0.21	0.41
Atomic %	27.04	25.49	0.43	8.79	0.13	8.01	0.45	26.04	3.12	0.27	0.22

6.0 CONCLUSIONS

The following conclusions are drawn from the experiments performed and statistical analysis. An empirical mathematical model for predicting pitting corrosion rate of pulsed current MPAW AISI 321 sheets in 3.5 N NaCl medium has been developed. From the main effect plots, it is understood that peak current is the important parameter which influences the corrosion rate, followed by base current, pulse rate and pulse width. Corrosion rate increased gradually with peak current from 6 Amps to 8 Amps, this is because of more heat input leading wider weld fusion area and higher Heat Affected Zone (HAZ). Corrosion rate decreased from Base current of 3 Amps to 4 Amps and there after it increased upto 5 Amps. This is because of variation of heat input. At 4 Amps of Base current the peak current and base current combination is optimal. Corrosion rate decreased from pulse rate of 20 pulses/sec to 40 pulses/sec and there after it increased upto 60 pulses/sec. Too low pulse rate leads to over melting of weld joint and similarly too pulse rate leads to lack of fusion. Corrosion rate increased from Pulse width of 30% to 50% and there after it decreased to 70%. Too low pulse width leads to overlapping of weld joint and similarly too high pulse width leads to lack of fusion and gaps between the weld joint. From the contour plots, it is clear that peak current is the most important parameter which affects the pitting corrosion rate of the

welded joints, followed by base current, pulse rate and pulse width. From the surface plots, it is understood that for a peak current of 6 Amps, base current of 3 Amps, pulse rate of 60 pulses/second and pulse width of 30 % minimum pitting corrosion rates are obtained for both AISI 316Ti and AISI 321. The optimal welding conditions obtained are out of the 27 combinations as per design matrix; however their values are within the range of the chosen values of welding variables. From SEMEDAX, it is observed that there is depletion of depletion of 3.15 % (wt%) chromium after corrosion was noticed in AISI 321. This is due to high heat input generated because of welding current. The developed empirical mathematical model is valid for the chosen material, however the accuracy can be improved by considering more number of factors and their levels.

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