Issue 18 January 2018

SFA Newsletter

Seasons Greetings!

Welcome you all to join as members of SFA! Please find the membership form inside; kindly fill in and contact Secretary of SFA through email.

Experts and experiences:

- Dr.R R Bhat, HAL, Bangalore
- Sri.Pradeesh Kumar, CEMILAC, Bangalore
- Sri.Suryaprakash, Kuwait

Message from our President

Dear readers,

Happy New Year! Warm season's greetings! I am happy to find the 18th issue of SFA newsletter rolling out coinciding with New Year 2018! The beginning of every New Year brings with it the opportunity and the excuse to make a new start. Part of the exhilaration that accompanies every January 1st is the optimism that starting over is possible and the belief that new beginnings can create new and successful outcomes. SFA made its beginning in 2006, over a decade, it had made valuable contributions in promulgating knowledge and concerns on failure analysis to academia, industries and Government establishments in various forums. The efforts, guidance and vision of the past presidents of the Society have built SFA into a leading professional body. With the efforts of ten registered local Chapters, the society has grown with 1000 plus members and is continuing to inspire and serve as a common forum for individuals, institutions, organisations and industries.

While I extend hearty New Year Wishes to You and your near & dear ones and also pray to Almighty for yours Prosperity, Peace, and all Happiness, I recollect the quotation "Whatever you do or dream you can do—begin it. Boldness has genius and power and magic in it". I congratulate all authors for their contributions and news on various events. *Best wishes to all the readers!*

P.Jayapal
PRESIDENT, SFA

Edited by: Dr.P.Parameswaran, Metallurgy & Materials Group, IGCAR, Kalpakkam

From the Desk of Editors

Dear Readers:

Happy New year 2018! Season's Greetings! You are glancing through the 18th issue of the Newsletter of Society for Failure Analysis (SFA). It is gratifying to observe that SFA has stepped into 10th year of existence. Our efforts to build the society have seen success. Activities are progressing well during the past few years with the conduct of several events by our local chapters at various locations. In this respect, indeed the efforts of SFA, Trichy chapter in organizing an event at Sangli, Maharashtra is worth mentioning. Similarly the Koraput chapter conducted an event for the members of industries and defence institute around the place. The successful conduct of general body meeting at various chapters is due in the next few months and Chapters have to take steps. ICONS2018, second in the series since its inception in 2014 is announced by SFA, Chennai. Details can be seen inside the current issue.

We solicited articles for the current issue from failure analysis experts of our country who had worked on many case histories.

We thank the authors (Dr Bhat, Sri Pradeesh Kumar and Dr Surya Prakash) for their contributions which are quite interesting ones based on their experience in the field.

We take this opportunity to appeal to the Indian industry to use SFA as a forum to share their experiences on trouble shooting. A great way to add content to this newsletter is to include a calendar of upcoming events. The details of important forthcoming international and national events are included; so also the books recently published on the topics of the subject.

We value your comments, which really boost our enthusiasm to perform better. Therefore, as always, your views and comments, mailed to param@igcar.gov.in are welcome. We wish you all success free of failures and a joyful life!

You may visit our web site for your comments/suggestions or any queries: www.sfaindia.org

Kalpakkam

31-01-2018 (P.Parameswaran)

Editor

We encourage you to join the society, Kindly fill up the application form (enclosed at the end of the newsletter) and contact secretary: pjayapal59@yahoo.co.in; alternatively, post your application with draft to Sri.B Jana, Treasurer, ***RCMA,*** *CEMILAC, Kanchanbagh, Hyderabad, 500 058*

Aims and Objectives of Society for Failure Analysis

The aims and objectives of the Society shall be:

To serve as National Society to promote, encourage and develop the growth of "Art and Science of Failure Analysis" and to stimulate interest in compilation of a database, for effective identification of root causes of failures and their prevention thereof.

To serve as a common forum for individuals, institutions, organizations and Industries interested in the above.

To disseminate information concerning developments both in India and abroad in the related fields.

To organize lectures, discussions, conferences, seminars, colloquia, courses related to failure analysis and to provide a valuable feed back on failure analysis covering design, materials, maintenance and manufacturing deficiencies / limitations.

To train personnel in investigation on failures of engineering components and their mitigation.

To identify and recommend areas for research and development work in the Country relating to failure analysis.

To establish liaison with Government, individuals, institutions and commercial bodies on failure analysis, methodologies and to advise on request.

To cooperate with other professional bodies having similar objectives.

To affiliate itself to appropriate international organization(s), for the promotion of common objectives and to represent them in India.

To organize regional chapters in different parts of the country as and when the need arises.

To do all such other acts as the Society may think necessary, incidental or conducive to the attainment of the aims and objectives of the Society.

National seminar on
Failure Analysis and Advances in Welding Technology for Aero-engine
SFA, Koraput Chapter

National Seminar on "Failure Analysis and Advances in Welding Technology for Aero-engine" organised by SFA, Koraput chapter in association with HAL, Koraput and RCMA(Koraput) at HAL Koraput on 15thSep.2017. Eighty two participants registered as delegates which includes 55 from outstation representing HAL, DRDO, CSIR, MIDHANI, BHEL, IAF, Indian Navy, NIT & IITs and CTTC, Bhubaneswar. Inaugurating the seminar, Shri.P.Jayapal, Sc-H, Outstanding Scientist, Chief Executive (A), CEMILAC, Bengaluru appreciated the efforts of SFA, Koraput Chapter in organising the national event. Seven invited speakers drawn from ARCI Hyderabad, NAL Bangalore, IIT Chennai, IIT Bhubaneswar, former scientist from NML, Jamshedpur & RCMA, Nasik and HAL, Koraput delivered talks during the seminar:

- Challenges in Aerospace Welding by Shri Shishir Kumar Patra, AGM(Mfg), HAL, SED, Koraput
- LASER based joining technologies for aerospace applications by Dr.G.Padmanabham, Director, ARCI, Hyderabad
- Role of NDT in Failure analysis by Dr.Narayana Parida, Dean, R&D, CV Raman College of Engg, BBSR, Former Scientist-NML, Jamshedpur
- Welding of magnesium alloy by Dr.G.D.Janaki Ram, Associate Professor, Dept. of Metallurgical and Materials Engg, Indian Institute of Technology Madras, Chennai
- Failure analysis of aero engine components leading to incidents/accidents by Dr.M.Sujata, Senior Principal Scientist, Materials Science Division, NAL, Bangalore
- Accurate determination of residual stresses in welded components through the thickness and life estimation by Dr.M.M.Mahapatra, School of Mechanical Science, IIT, Bhubaneswar
- Stress corrosion cracking identification and remedial measures for aircraft structural components by Shri. A.K.Bakare, Sc-G, Regional Director, RCMA (Nasik), CEMILAC, DRDO.

FAILURE IS NOTHING MORE THAN A CHANCE TO REVISE YOUR STRATEGY.

Sissy Gavrilaki

Study of high density inclusions in Friction Stir Welded AA 2219 Alloy

Nilesh H. Warthi, Vaisakhi Nandi, K. Shashidhar and R. R. Bhat
Foundry & Forge Division, Hindustan Aeronautics Limited, Bangalore-560017

Introduction

Modern aircraft have been built almost universally from aluminium alloys. Since their introduction, these alloys have undergone steady incremental improvements and these improvements were driven by engineering needs for high strength combined with resistance to friction, fatigue, general erosion and stress corrosion failure. From the point of higher specific strength, elevated temperature properties and fabricability of the material, Al-Cu alloys were developed and commercialized. Al-alloy 2X19 with Cu, Mn and Zr have developed higher mechanical properties at temperatures above 230°C. Alloy 2219-T8 possesses superior properties at cryogenic temperatures, good weldability and resistance to corrosion by most chemicals. Thus, this alloy finds applications in welded tanks in space shuttle. The present work is a study on the high density inclusions observed during radiography of the welded AA 2219 Aluminium alloy.

In friction stir welding (FSW), a rotating cylindrical tool with a pin or probe at the bottom is plunged into a rigidly held workpiece and traversed along the joint to be welded. AA 2219 alloy could be friction stir welded successfully. In FSW of Al-Cu alloy, there have been instances of workpiece reaching to lower bound of the melting temperature range (eutectic temperature i.e. 548 °C) and trigger liquation and agglomeration of inter-metallic particles.

Background:

Cut sample from *Friction Stir Welded (FSW)* part made of AA 2219 aluminium alloy plate was investigated at Laboratory after *high density inclusions (HDI)* were observed during X-ray (radiography) inspection carried out after the welding in the weld region. A cut sample from the welded plate was examined to find the nature of the defect observed in the weld region and also to find the constituents of HDI.

Observation and Discussion:

The cut sample was metallographically polished and the defect location was examined under **Scanning Electron Microscope (SEM)** in as-polished condition. Compositional analysis of the defect location was carried out using *semi-quantitative* **Energy Dispersive X-ray Spectroscopy (EDX)** facility attached to SEM.

Figure 1 shows photomicrograph of the defect location in etched condition captured using optical microscope that appeared as HDI in radiography. Figure 2a shows the SEM image of these defects/particles.

SEM-EDX analysis revealed that the *(HDI)* defects observed in the FSW sample in radiography were large Al_2Cu aluminium-copper particles and results of EDX analysis of these particles are

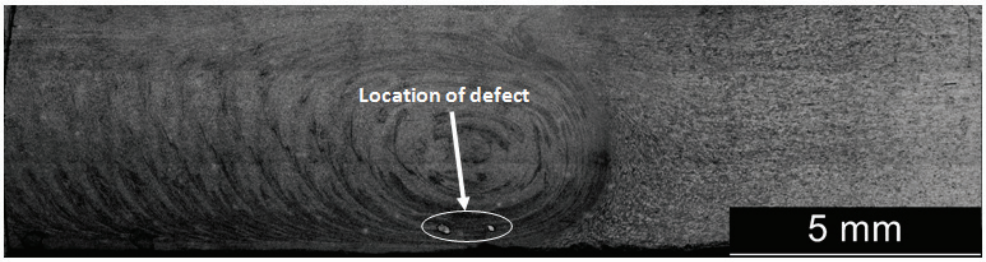


Figure 1: Photomicrographs showing the defects in the forwarded FSW sample that appeared as HDI in radiography. [Etchant: Kellars]

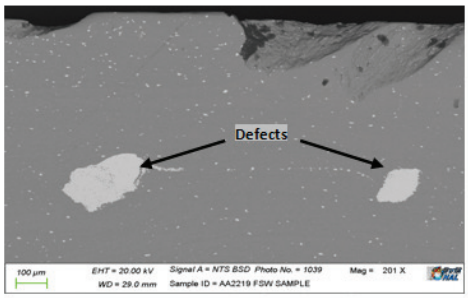
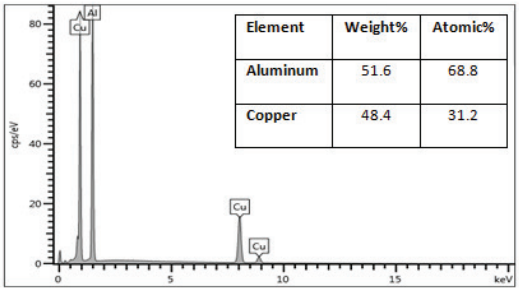


Figure 2a: SEM image showing the defects in the welded sample



Element	Weight%	Atomic%
Aluminum	51.6	68.8
Copper	48.4	31.2

Figure 2b: Result of EDX analysis of defects (labelled in Figure 2a) in the welded sample

depicted in Figure 2b.

In most friction stir welded parts, large θ particles, some of them exceeding 100 µm were observed compared to the normal θ particles of only about 10-15 µm in length in both base metal and the weld; that is the stir zone or nugget.

The large θ particles are likely to have formed during FSW from agglomeration of fractured θ particles and the smaller ones of the θ particles in the work piece. These agglomerated particles were often found around the pin at the end of welding. This suggests the possible retention of agglomerated θ particles by the intense plastic deformation associated with the movement of the material around the pin and friction heating. However, there is no apparent correlation exists between the extent of agglomeration of θ particles with the welding parameters.

Conclusion:

High density inclusions observed in radiography of the FSW sample of AA 2219 alloy are the agglomeration of Aluminium-Copper (Al_2Cu) particles as established through SEM/EDX analysis.

References:

1. Mondolfo, L.F, Aluminium Alloys Structure and Properties, 1976, Butterworth, p717-857.
2. G. Cao and S. Kou, Friction Stir Welding of 2219 Aluminium: Behaviour of θ (Al_2Cu) particles, Welding Journal, January 2005, p 1-s to 7-s.

APPROACH FOR CERTIFICATION OF ALUMINUM ALLOY EXTRUSION DEVELOPMENT FOR AIRBRONE APPLICATION

Pradeesh Kumar, Shirish S Kale
Scientist, RCMA (F&F-FOL), CEMILAC, DRDO

This article highlights about the certification procedure adopted byRCMA(F&F-FOL), CEMILAC for the indigenous developed aluminium alloy in the form of millform (extrusion) for aircraft and missile structural applications. For structural application the desired properties are strength, fatigue, fracture toughness and stress corrosion cracking (SCC) resistance.

In India the scenario is such that there is limited aircraft and aero-engine manufacturingestablishment which offers limited order quantity but on the other hand there are numerous alloy making establishments which has enormous capacity to produce the alloy both in the public and private sectors and also augment their capacity to cater to future needs of aeronautical industries.

ALLOY DEVELOPMENT

AA2219-T8511 is the aluminum alloy developed by a consortium of research establishments and public sector undertakings within India for self-reliance purpose.

The Composition of the alloy is as follows in Table-1:

Beginning of any alloy development process will be through as cast products (Ingot metallurgical route i.e. thermally processed as-cast ingots. Millforms products like extrusion, plates, sheets and bars are generally made through metal forming route. This is in fact nothing but processing the as-cast ingots alloy thermally and mechanically, which finds variety of application in civilian and military aeronautical applications.

In wrought alloy production, the process steps usually followed are as follows: Melting and Casting -Homogenization- Scalping, and Ultrasonic testing - Hot working by extrusion - Solution treatment and Quenching - Cold Stretching- Artificial ageing (single / multi-step) depending upon the material specification.

Table-1: Composition Comparison between Specification and Observed Value.

COMPOSITION		
ELEMENT	As Per AMS 4162D Spec	
	MIN	MAX
Silicon		0.20
Iron		0.30
Copper	5.8	6.8
Manganese	0.20	0.4
Magnesium		0.02
Zinc		0.10
Titanium	0.02	0.10
Vanadium	0.05	0.15
Zirconium	0.10	0.25
Other Elements, each		0.05
Other Elements, total		0.15
Aluminum		Balance

ALLOY MANUFACTURING TECHNIQUE

Melting and Casting

Aluminum alloy is melted in a reverberatory type oil fired melting furnace. Melting charge constitutes are 99.8% virgin aluminum and internally generated scrap of the same alloy. Other alloy additions includes pure manganese, Al-Cu(50%-50%) master alloy, aluminumzirconium(5%) and aluminum-vanadium Al-V(5%) master alloy are charged to achieve the desired chemical composition as per the specifications. Molten metal mixing and degasing is done with Argon gas purging. Chemical composition of the bath is ensured as per specification before ingot casting. The furnace is shown in fig.1

Casting of molten metal to 400mm diameter Mouldis done in a semi-continuous direct chilled vertical casting machine. Around eight such castings are made out of molds of length 3m as shown in fig.2.

Homogenization & Scalping

Threemeters long cast ingot are homogenized in an electrical resistance furnace and scalped (machined) into suitable lengths to feed the extrusion machine. These machine ingots are tested ultrasonically to the requirements of AMS specification 2360 of grade 'A' of 2mm FBH.

Extrusion

Extrusion is processed from a 6500Ton direct hydraulic extrusion machine using a 400mm pre-heated cast ingot produced from direct chill vertical casting machine. The extruded or ram speed is maintained at 0.8 to 1.2 mm/sec and the extrusion ratio of 17:1. The extruded bars are generally of length of five meters and usually they will cut to minimum length of one meter.

Solution Treatment, Control Stretching & Tempering

Extruded bars are solution treated at 520+ 5° C with a specified soaking time in a tubular furnace and quenched in water in pit at

Fig.1: Reverberatory furnace for melting Aluminum alloy

Fig. 2: Direct Vertical Chill Casting Machine

Fig. 3: Direct Extrusion Machine

Fig. 4: Tubular For Solution Treatment

ambient temperature. Solution treated is control stretched to achieve permanent set of 2-3% in a stretching machine. Further these control stretched bars were subjected to ageing treatment at 190° C for 12 hours.

ALLOY TEST PROGRAM

Once the alloy, for development is chosen by the developer in consultation with user, further the test program is finalised by the consortium of defence establishment consisting of developing laboratory, public sector undertaking and certification agencies. The testing responsibilities are shared between the manufacturer and developing agency under the eagle eyes of certification agency. In general the properties are tested for the initial as-cast product and subsequent form (extrusion) and test includes like ultrasonic, Macro & Microstructure examination and visual examination apart from chemistry for the cast product. In the case of extrusions, ultrasonically qualified extrusions were evaluated for test like mechanical, microstructure, stress corrosion cracking (SCC), exfoliation and weldability studies. A number of material lots and specimens (3 No's) are sampled to provide confidence in the consistency and reproducibility of the properties.

Fig. 5: Extrusion bars after extrusion

Summary

The test results of the extrusions for both the sizes are meeting the test schedule approved by RCMA (F&F-FOL). Based on this satisfactory test results the RCMA (F&F-FOL) issued a provisional certificate to defence research laboratory for use in missile applications.

Table 2: The Results for such sizes of extrusion are tabulates as shown:

AA 2219-T8511		As Specified in AMS 4162D Specification	EXTRUSION BARS				
			40 mm Dia		85 mm Dia		
PROPERTIES (Units)			MELT 1	MELT 2	MELT 1	MELT 2	MELT 3
Hardness HBW/10/500		123	116.3	114.3	116.6	120	120
TENSILE at RT (MPa,min ,%) Longidutional direction	0.2% P S	290	368	354	350	361	362
	UTS	400	455	437	359	442	446
	ELN	6	9.82	10.28	11	11	11
TENSILE at -40 °C(MPa, min, %) Longidutional direction	0.2% P S	Not specified	316	331	351	349	342
	UTS		414	428	440	441	437
	ELN		11	11	6	8.5	10
TENSILE at 150°C(MPa,min ,%) Longitudinal direction	0.2% P S	Not specified	283	274	279	254	253
	UTS		324	318	325	300	285
	ELN		25	22	25	18	22
TENSILE at 250°C (MPa,min ,%) Longidutional direction	0.2% P S	Not specified	143	153	171	156	163
	UTS		154	161	180	165	175
	ELN		20	19	16	18	20
Fracture toughness Mpa√m			21	20	24.28	22	22.43
Fatigue 3 specimen at 3 specified stress levels corresponding to S N curve	Stress MPa		Cycles	Cycles	Cycles	Cycles	Cycles
	385		1600	1800	1600	1700	800
	255		13700	37300	64000	24000	16600
	70		82800	37400	11000000	2240000	236000
Stress corrosion cracking at 90% of YS Mpa as per ASTM G34		No Failure	No Failure	No Failure	No Failure	No Failure	No Failure
Exfoliation Corrosion		EA	EB	EB	EB	EB	EB
Weldability weld efficiency WE %		0.5-0.75	0.55	0.57	0.63	0.6	0.54

Proceedings of the one day programme conducted by Society for Failure Analysis (SFA), Tiruchirappalli chapter on 03rd November 2017 and Inauguration of SFA Chapter, Sangli

A one day programme was organised at Sangli by SFA Tiruchirappalli Chapter in association with ***Delta Metallurgical laboratory and Services, Sangli, Maharashtra***. the topic being "**ESSENTIAL ASPECTS OF METALLURGY IN INDUSTRIAL APPLICATIONS"** on 03rd November 2017.The venue was Hotel Ambassador, Sangli.

In the inaugural function Sri. **S.G.Kulkarni**, Quality Manager, Delta Metallurgical Laboratory and Services, Sangli, Maharashtra welcomed the President, the chief Guest and the participants. Sri. **Abhinandan Admuthe**, Technical Manager, Delta Metallurgical Laboratory and Services, Sangli, Maharashtra detailed about the one day programme and its impact on industrial organisations. The President Sri **Sanjay Jadhav, Technical Director, Jsons Group of Foundries, Sangli** explained the need to have such programmes and seminars. He talked about the technical knowledge gained by such interaction and knowledge sharing.

This was followed by the address of the chief guest Dr R.Vaideeswaran, Chairman, SFA Tiruchirappalli Chapter and SM(Rtd) BHEL, Tiruchirappalli, who briefed about SFA, its origin, its activities in various Chapters and the details of the one day programme with an impact on industries especially the foundries. He highlighted the need

Society for Failure Analysis (SFA), Sangli Chapter
Executive Committee

Chairman: Mr.Abhinandan B Admuthe, Technical manager, Delta Met. Lab & services
Secretary: Mr.S.G.Kulkarni, Quality Manager, Delta Metallurgical Lab
Treasurer: Mr.Ketan Chougule, Dy Technical manager, Delta Met.lab and Services

Executive Committee Members:

1. Mr.Sanjay Jadhav, Technical Director, Jsons Group of Foundries, Sangli
2. Mrs.Vrushali A Admuthe Proprietor, Delta Metallurgical Lab
3. Mr.Amar Dandekar, Director, Omkar Foundries, Sangli
4. Mr.S.A.Bothe, Casting Consultant, KEPL
5. Mr.Ravi Nakil, Director, The Sky Industries, Ichalkanaji

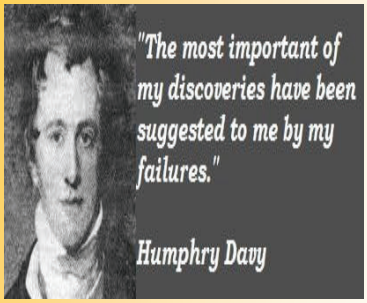
to know the root cause of failure in industrial components and the importance of Quality of the material or product.

*The chief guest inaugurated the **SFA, Sangli Chapter** with Sri **Abhinandan Admuthe** as Chairman, Sri. **S.G.Kulkarni** as the Secretary and **Mrs. Admuthe** as Treasurer of SFA chapter. It was welcomed by the participants who showed their eagerness to join the SFA Chapter, Sangli. A vote of thanks was proposed by S.G.Kulkarni.*

The morning session began with Fe-C phase diagram, basic Metallurgy principles and heat treatment of alloys and castings, covered by Sri **Abhinanadan Admuthe** of **Delta** Metallurgical Lab and at the end gave an exercise to participants of how to calculate CR ratio from ferrite ranges. Then **Dr.R.Vaideeswaran**, Chairman, SFA Tiruchirappalli chapter dealt with failure analysis, its importance, approach and case studies related to fabrication, welding and corrosion.

After lunch, Sri, **S.A.Bothe**, Casting Development and Foundry Consultant, Kirloskar Ebara Pumps Limited, Sangli talked about the failure in castings in shop floor practices. Then the next lecture by **Dr. R.Vaideeswaran** detailed about the problems and failures in oil field and petroleum industries and their solutions. He detailed about the importance of cooling rates in HT, sub zero toughness, temper embrittlement, PREN and CPT encountered in Stainless steel, Duplex SS and super Duplex SS castings. He also gave case studies related to Duplex SS castings, Impellers, pumps and shafts. The final session on case studies in Heat Treatment was taken by **Sri. Abhinandan Admuthe** of Delta Metallurgical Lab.

The programme was attended by nearly 30 participants drawn from various engineering industries and foundries in Sangli, Kolhapur and other nearby places.



Failure Investigation for Upcoming Engineers

S. Surya Prakash Senior Engineer Oil and gas sector, Kuwait
sri.surya59@gmail.com

In the recently held FAME 2017 the emphasis on experience gained from failure investigation was emphatically stressed and rightly so. The experienced and senior speakers spoke words of wisdom in this subject which I was happily listening and absorbing. Couples with my two plus decades of my experience in failure investigation I wish to pen down a few lines on the interesting subject which I sincerely hope will be useful as a sort of guideline for new engineers to take up failure investigation in a pragmatic approach.

The very first step in failure investigation is to visit the site of failure at the very earliest. On site the failed piece is to be observed in "as is where is condition". This is very important as tell tale signs of failure untouched needs to be observed and recorded in photos and in writing. In this step one needs to collect deposits as near to the failed area as possible. These deposits contain important information on what type of process went on like if it is low temperature electrochemical corrosion the type of corrodents that went into damaging the equipment.

The second step is doing on site portable chemical analysis and hardness measurements of the failed component and the adjacent sound component. This needs to be carried out by the investigator himself to be sure of the metallurgical condition of the failed piece. In this step care should be taken to clean the areas but not to dilute the tell tale signs of the failure region.

The third step is to perform on site NDT examinations which is usually liquid penetrant test. This test should performed keeping in view to identify the maximum area of damage. For example if it's a crack this test should reveal and to end of the crack. If X-ray or radiography can be carried out without disturbing the set up same rule applies.

The fourth and most important step is to select the samples for cutting out and sending it for laboratory testing. The samples should be identified by the principal investigator himself such that the damaged areas are not touched. For example it's a perforation the sample needs to be cut such that perforation and the visually observed damaged areas are untouched. If it's a crack the end to end of the crack are untouched while cutting. Please note that cutting the samples out shall be done using cold cutting method only so that chemistry of deposits and metallurgical condition of parent metal remains as original. If not cutting must be applied then cutting shall be at a minimum distance of 300mm from the damage area on all sides.

The fifth step is to transport the failed pieces to the laboratory in a safe manner so that damaged surfaces are not distorted in any way to alter the tell tale signs of failure.

The sixth step is to list down the tests to be carried out on the samples. The tests should be listed and planned keeping in view the type of damage seen, the position of damage relative to installation areas like welding areas, fasteners, flange joints etc soft example if a crack is away but still nearby a welding joint then one should think of conducting a microstructure study on HAZ and in the area containing a portion of crack. The microstructure reveals the extent of

HAZ region, if the crack region contains any anomalies like hard phases, soft phases, microfissures, inclusions etc. This will tell us if the crack is microstructure affected. Additionally micro hardness on microstructure can tell us presence or absence if hard phases or soft phases. In a case of HIC I found that a hard secondary phase existed near the crack and upfront of the crack an inclusion (soft phase) existed. The hard phase is a path of least resistance to the crack and the soft phase changed the contour of the crack upfront.

Sometimes conducting Ultimate Tensile Strength(UTS) of the material can throw up an important finding. In one such case I had conducted this test to prove that carbon steel and low alloy steel were welded together instead of welding two carbon steel spools. This was important because asset owners were not satisfied with microstructure differences. This led to an important modification in the Standard Operating Procedure (SOP) of inwards good inspection in a project. This is one major advantage of a thorough failure investigation. When the failure occurs in a part involved in process that involves high flow of gas it's a good guide to conduct impact test because temperature can drop to ductile – brittle transition temperatures. It's important to note that such tests are not required for all types of failures. In my over thirty failure investigations I have conducted mechanical test possibly for about 20% of the cases which however does not undermine the importance of mechanical tests.

When failure occurs in sour atmosphere then it's imperative to conduct buckets hardness tests both on welded portion including HAZ region and on base material. In sour atmospheres it's also important to know the H_2S gas composition in vapid and in liquid phase using Henry law. The partial pressure of H2S is more important than the total volume of H_2S in the environment. In such cases look for tell tale signs of hydrogen damage types like hydrogen induced cracking, SOHIC, SSC etc. It's however not necessary that these damages should occur in sour atmosphere as it had happened in one such case I had conducted. The sour atmosphere corroded the pipe preferably near the welding joint so deep without any hydrogen damage, that the process internal pressure ruptured the pipe along the corroded portion. To know such fine details we use SEM with EDS. SEM gives us an insight into the type of fractures like ductile, brittle, fatigue etc and EDS gives us presence of corrosion products.

Literature survey is a step that begins right from the observation of failure on site. Also note that though the article is written as a sequence it's not necessary to follow the sequence, except step one which is mandatory in all failure cases.

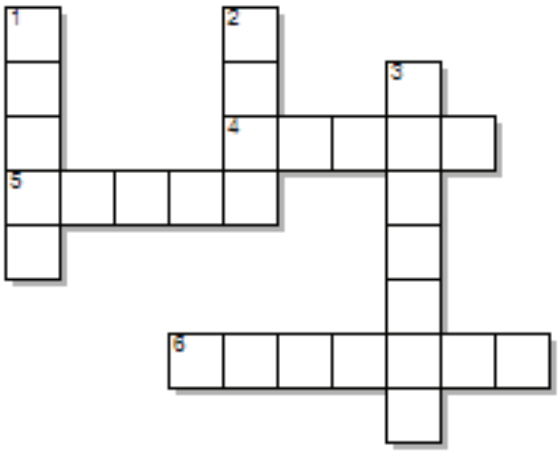
Experience is a must in conducting failure investigation. Hence top management in any corporate needs to put it as a standard practice in their respective companies, that in any failure investigation the experienced engineers should involve appropriately new engineers so that the baton is passed down the generations. There is no substitute for experience especially on failure investigation.

The final step is report writing. The report should have various sections so that thought process is smooth and easy to grasp. The higher management would be interested in

executive summary of the case and pragmatic recommendations. The report should contain these sections and be written in a crisp manner. Photos and sketches should be appropriately pasted in the report (not in the end of report) and should be referred to in the text with appropriate numbering system.

Concluding this article I wish to reiterate the thought expresses in FAME 2017 by many speakers that Failure Investigation is an interdisciplinary subject and hence needs to be conducted in a thorough manner.

Cross word puzzle on failure analysis terminology



Across:

4) Pepsi developed failures in ingot stage [5]
5) Masse join together [5]
6) Lodge adhered to Governing Council in allotment [7]

Down:

1) rubs tea on steel while forging may develop defect [5]
2) forging made by pals developed discontinuities [4]
3) Process in which material lost through orifice in container [7]

See page 17 for answers:

Society for Failure Analysis

Application Form

Society for Failure Analysis
C/O Centre for Military Airworthiness & certification, RCMA (Materials)
Hyderabad550 058

Phone: 040-24340750; 24348377;
Fax : 040-24341827
E-mail: rdrcma.mat@cemilac.drdo.in

Please √ applicable **member** ☐ **Life Member** ☐

1. **Name in Block Letters**

   First Middle Last

2. **Date of birth**
3. **Father's Name/ Husband's Name**

4	**Present Occupation /Designation and office address:**	**Phone:** **Mobile:** **Fax:** **Email:**

5 **Academic & Professional Qualifications**:

6	**Home address:**	Phone: Mobile: Fax: E-mail

6. **Address for correspondence:** **office** ☐ **Home** ☐

7. **Professional Experience**:
8. **Endorsement by SFA Member**

Name	Membership No.	Signature

9. **Primary Field of Interest: (please mark 1,2,3 in the in order of preference**)

Strategic ☐	**Power** ☐	**Foundry** ☐	**Welding** ☐	**Heavy industry** ☐	**transport** ☐
Design & Failures ☐	**Quality control** ☐	**Petrochemical** ☐	**Consultancy / services** ☐	**Materials and manufacturing**	**Education** ☐

10. **Name of the Chapter you intend to be attached**_____
    (Please refer to Chapters' list)
11. **Subscription details:**

Payment should be made by cheque / DD favoring **"Society for Failure Analysis"**, payable at Hyderabad. Outstation cheques not accepted.

Amount Rs. Cheque / D.D. No Dated

Bank Name Branch

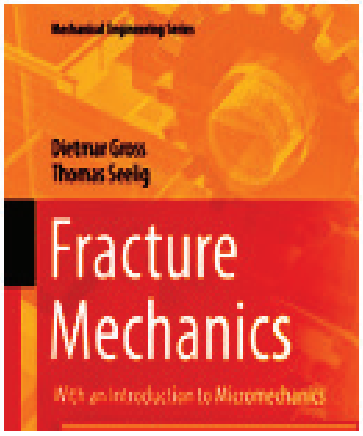
Category	Amount Payable		
	Admission Fee (One time)	Yearly Subscription	Total on joining
Member	Rs 100	Rs 250 (annual)	Rs.350/-
Life Member	Rs 100	Rs 2000	Rs.2100/-

12 **Declaration by the applicant**

If elected, I agree to accept to pay the prescribed yearly subscription, to abide by the Articles of Association of the Society and to promote its aims and objects.
Signature of the Applicant

13.	**Office Use Only**					
	Membership No.		Date of Enrolment		Chapter	
	Amount Paid (Rs)		Receipt No. / Date			

Books

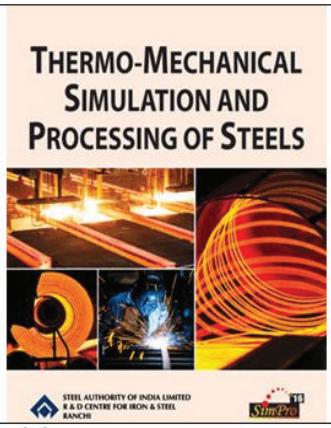


Fracture Mechanics

With an Introduction to Micromechanics

Authors: Gross, Dietmar, Seelig, Thomas

This textbook primarily focuses on the mechanical description of fracture process. However, material specific aspects are also discussed. A major part of the book is devoted to linear elastic and elastic-plastic fracture mechanics. Further subjects are creep fracture, dynamic fracture mechanics, damage mechanics, probabilistic fracture mechanics, failure of thin films and fracture of piezoelectric materials. The book also contains an extensive introduction into micromechanics. Self-contained, well-illustrated and with further reading suggestions, this text serves as a graduate-level text and reference.



Thermo-Mechanical Simulation and Processing of Steels SIMPRO 16

Steel Authority of India Limited, Jha, Saxena, Srikanth, Deva, Karmakar, Nageswaran, Baskiyar

Book Preview

9789385919862 2016 652pp 7.5 x 9.5" HB

Publisher: Viva Books

MRP: Rs. 2995.00

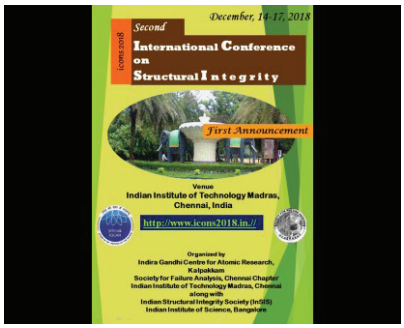
Price after 20% discount= Rs2396

BUY ONLINE

Events in the pipeline

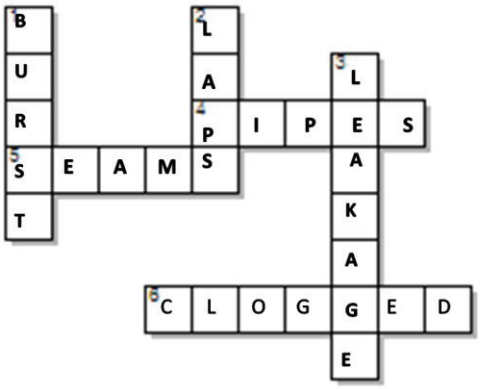
7th International Conference on Fracture Fatigue and Wear, 9-10 July 2018, Ghent University, Belgium

Welcome to the website for the seventh international conference on Fracture, Fatigue and Wear (FFW 2018), which will be held in the city of Ghent, Belgium.



ICONS-2018 will be the second in a series of International Conferences on Structural Integrity being held during **December 14-17, 2018 at IIT Madras**. The conference aims to bring together the multi-disciplinary community of engineers, scientists, academicians, industry experts, plant managers and regulatory personnel to discuss the recent trends and future directions in structural integrity: http://web.iitm.ac.in/icons2018/

Answers to the crossword:



Across:
4) Pepsi developed failures in ingot stage [5]
5) Masse join together [5]
6) Lodge adhered to Governing Council in allotment [7]
Down:
1) rubs tea on steel while forging may develop defect [5]
2) forging made by pals developed discontinuities [4]
3) Process in which material lost through orifice in container [7]

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