Issue 8

May 2013

SFA Newsletter

About SFA

Objectives

Local centers

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:

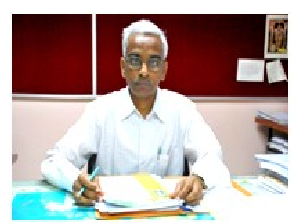
- Dr.Balaraju, NAL Bangalore
- Dr. Ashok Roy NML, Jamshedpur

Warm Greetings!

Message from our President

Dear readers,

I wish you all very warm greetings as I take the responsibility of presidentship for the SFA. I thank the council for giving this responsibility. Indeed, it is a challenging one as the founder president Dr.A.Venugopala Reddy and immediate past president Dr.K.Tamilmani have laid the strong foundation and the society has sprouted well and branched off wide and far. The vision of our society is to see the future of Indian engineering industries without any premature failures and associated losses- human as well as money. Integrating the people engaged in the failure analysis is important that allow disseminating the information and the knowledge gained through failure analysis, to avoid recurrence of failures. I would like to see realization of our efforts successfully. Current newsletter is found interesting to read and I thank the editors among whom Dr.M.G.Pujar of IGCAR is taking this responsibility from this issue. I request all readers to send their feedback to the editors. It is generally said that: “One benefit of summer is that each day we have more light to read by”.



Best wishes to all the readers!

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

From the Desk of Editors

Warm greetings! We are happy to present you the eighth issue of the Newsletter of Society for Failure Analysis (SFA). We express our Greetings to Dr.T.Jayakumar on taking over as the president of SFA who has been striving hard to build the society since its inception, alongwith the past presidents over the last six years.

"

Among the efforts taken to build the society over the last three years, with several activities by our local centres at various places, including bringing out Newsletter, organizing workshops among engineering students alongwith various other professional bodies are some of them. Dr Jayakumar has been instrumental in planning and sustaining the newsletters for the last seven issues which are available in our web site.

We have solicited articles from experts in the important area of life extension methods- such as surface engineering and life assessment methodologies.

We thank the authors for their contributions which are worth their efforts.

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 pujar@igcar.gov.in or param@igcar.gov.in are welcome. We wish you all free from failures and a joyful life!

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

Kalpakkam (M G Pujar)
31-05-2013 (P .Parameswaran)
Editors

*We encourage you to join the society, Kindly fill up the application form (enclosed at the end of the newsletter) and contact secretary:, post your application with draft to Dr.N.Eswara Prasad, Regional Director, **RCMA,** CEMILAC, Kanchanbagh, Hyderabad, 500 058*

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About the society

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.

Know your local centers

Surface Engineering and its Role in Preventing Early Failures

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Introduction

Surface modification has a long history, dating back to 850 B.C., when it was more of an art than science. It has come a long way to mature as an established scientific discipline since then and has diversified into many techniques, thereby acquiring the ability to ensure functioning of surface modifications under a variety of aggressive conditions.

A vast majority of engineering components degrade/fail in service due to surface related phenomena, namely, wear, corrosion and fatigue. This has lead to the development of an interdisciplinary field of study referred to as surface engineering that aims at developing innovative techniques for superior material performance. It starts with the definition of functional requirements of the surface, to guarantee certain performance of the component, identification of the failure mechanism and choice of the appropriate material for the component and surface modification process which will ensure economics of processing and conservation of raw materials/environment, in addition to extending the life of the component.

The basic idea in surface engineering is to use lean (often cheaper) materials as substrates and rare or strategically important (often expensive) materials as coatings. In such an approach, one can hope for a synergism of the surface and substrate. According to Bell [1], surface engineering may be defined as "the design of surface and substrate together as a system, to give a cost-effective performance enhancement of which neither is capable on its own". To impart specific surface properties such as resistance to wear, corrosion, abrasion and oxidation, coatings are generally being used. Although numerous coating methods like physical vapour deposition (PVD), chemical vapour deposition (CVD), etc., are available, electro and electroless plating processes have received considerable attention and are extensively used because they are versatile, economical, scalable and their process methodologies can be easily tailored to meet the property requirements. Among these, the electroless plating is being extensively used in modifying the surface of various materials, in terms of metals, semiconductors and non-conductors. It has several advantages over similar electrochemical methods such as more uniform coating thickness, less porosity, absence of power supply and electrical contacts, ability to deposit on non-metals.

A couple of illustrative examples are discussed below in the usage of electroless plating in preventing surface related failures.

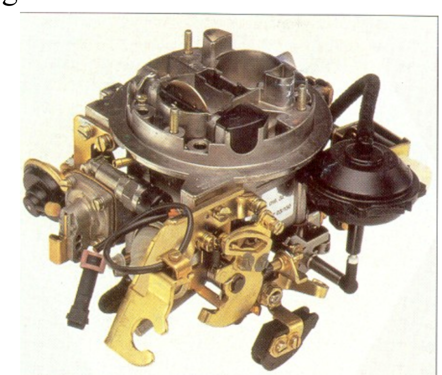

Fig. 1 Electroless nickel resolved corrosion problems on carburetors using ethanol fuel

Automobile sector

South America, especially in Brazil, a decision was made in 1976 to switch from gasoline to alcohol (ethanol) as fuel [2]. Enormous cost advantages were correctly predicted in Brazil, as alcohol could be produced from local sugar-cane, whereas gasoline required imported oil. A major problem occurred during the introduction of alcohol fuel.

Hydrated alcohol, passing through the carburetor at high temperatures, produced corrosive conditions that severely corroded the zinc diecast components. These corrosion products plugged the narrow channels and orifices in the carburetor but this problem was able to be resolved with the application of electroless nickel deposit (Fig. 1).

In some commercial and military aircraft, compressor case components are required to be protected from corrosive atmospheres and erosive particles [3] at temperatures of 425°C. For many years, two coating systems have been used extensively. The first was electrodeposited Ni/Cd alloy and thermally sprayed aluminide coatings. Both coating systems have suffered with non-uniform coating thickness especially at the leading and trailing edges of airfoils. The uniform thickness and corrosion and erosion resistance of electroless nickel offered an alternative to these two traditional processes and it has been used very successfully in engine compressor components. Apart from this, the deposit, typically 5 to 9 microns thick, exhibited excellent corrosion resistance in this environment and of equal important was the thickness uniformity, which was mandatory for simplifying assembly and optimizing carburetor performance part from this, the use of electroless nickel to provide corrosion and erosion protection to the airfoil surfaces and wear resistance to the trunnions (Fig. 2). High phosphorus electroless nickel outperformed both Ni/Cd and thermally sprayed aluminide coatings.

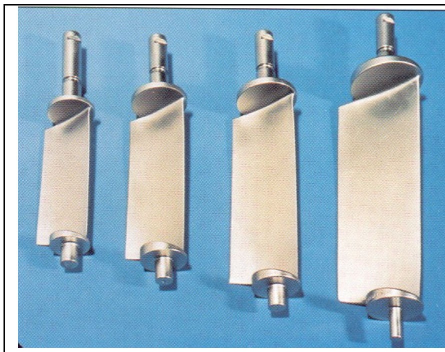

Fig. 2 High phosphorus deposits on variable vanes and trunions have provided performance and cost advantages

“A failure teaches you that something can’t be done—that way.” – Thomas Edison

Electronic sector

Heat sinks are devices used to cool semiconductor components during operation. They are required to have good thermal conductivity and so copper or aluminium is usually the materials of choice.

They are also required to dissipate heat efficiently and this is achieved by maximizing surface area by the use of fins (Fig. 3).

The design entails deep recesses and to protect such parts from corrosion and to provide them with a hard, durable coating capable of being soldered or brazed, they are often plated with electroless nickel [4, 5].

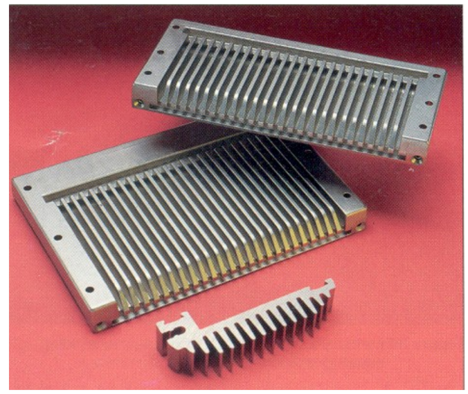

Fig. 3 Electroless nickel provides a hard, durable coating with good solderability on heat sinks

Some of the examples available in the literature discussed above are relevant to improve the corrosion, wear and abrasion resistance of components used for various applications to prevent failures by adopting surface engineering. It can also be applied to achieve other applications.

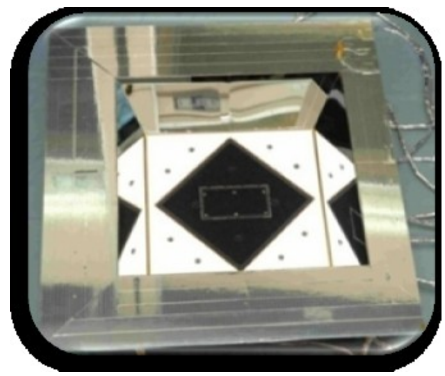

Fig. 4 Highly polishable coatings for passive radiative coolers of satellites

The INSAT class of satellites employ a passive radiative cooler for maintaining the temperature of IR detector at 105 K. The mirrors for this application should have a diffuse reflectivity of $< 0.05\%$ and specular reflectivity $> 99.95\%$. The total reflectivity should be about 85%.

The choice of aluminium is vital because of its light weight and high strength. Due to its poor scratch resistance, it cannot be polished to yield low diffuse reflectance surface. Obviously the surface has to be engineered to produce such a smooth finish, especially on aluminium. Multilayer coating system containing nanocrystalline nickel coating to obtain a polishable surface with an overlay of aluminium deposited by PVD. Aluminium mirrors suitable for passive radiative coolers were made and employed in various INSAT series of satellites (Fig. 4).

Conclusions

Surface engineering plays an important role in modifying the surface to enhance one or more surface properties apart from improving the total efficiency of the product. Among the various coating methods, electroless nickel plating method is widely used for various applications. The examples discussed in this report clearly show that surface modification has tremendous potential in preventing early failure/degradation of engineering component. Apart from improving the abrasion, wear and corrosion resistance of the substrate and coating system, this method also finds suitable in achieving required optical properties.

Acknowledgements

The author thanks Mr. Shyam Chetty, Director, NAL, Council of Scientific and Industrial Research (CSIR), Bengaluru for giving permission to publish this work. The author also expresses sincere thanks to Dr.C.Anandan, Head, Surface Engineering Division for his kind support and encouragement.

References

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2. A. Zanini, "Nickel", Nickel Development Institute (NiDI) March 1987 Publication.
3. F. Brindisi, "The use of electroless nickel in the aerospace industry – An Overview", S.W. Ontario Branch AESF Springfest Symposium, Kitchener, Ontario, April 1997.
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Uncertainty in Damage Assessment and Remaining Life Prediction of Engineering material

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Background

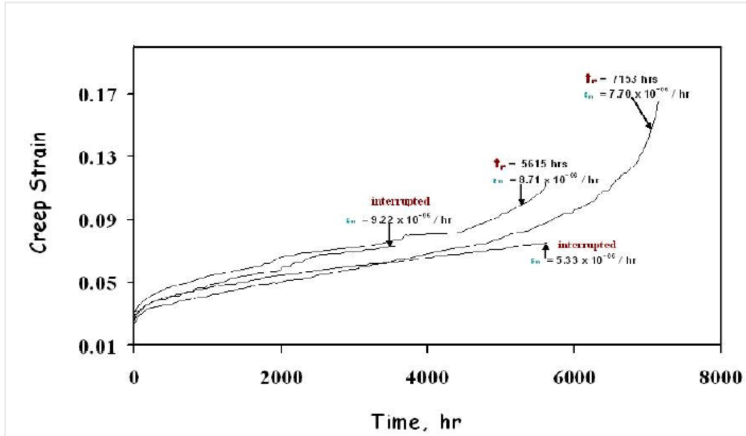
Life assessment study of aged components in power plants is of considerable interest since some of the components operate in aggressive environment beyond the design life. Most of these components operate at elevated temperature. In order to estimate the remaining life, an assessment is required for the accumulated damage. The damage that occurs during creep consists of changes in microstructure, rearrangement of dislocations and the development of voids and microcracks on grain boundaries leading to fracture.

Creep tests conducted on engineering materials at a given stress and temperature exhibit considerable scatter in creep strain with time and time to failure data. This is often attributed to material variability. The uncertainty observed in creep deformation and time to failure plays a significant role in the assessment of damage and remaining life prediction of engineering components. To predict and characterize the variation in the evolution of creep damage, most of the approaches are deterministic in nature which provide a basis for the evolution of damage as a measure of the loss of load bearing capacity of the material. The damage parameter is assumed to have an initial value of 0 and reaches a limiting value of 1 when failure occurs. This imposes severe limitations as it cannot predict any intermediate states of damage accumulation. An evolutionary probabilistic model is required for creep damage prediction which takes into account the evolution of damage as a function of time.

On the other hand, remaining life assessment (RLA) of a component is predicted from creep rupture data using a temperature-time parametric method such as the Larson–Miller Parameter (LMP) method. Usually, remaining life is predicted from extrapolation of stress v/s LMP plot without incorporating the uncertainty involved in calculation of LMP values. Uncertainty involved in calculating LMP values is gaining more and more importance because it is a function of rupture time. The placing of confidence bounds around any failure time prediction requires knowledge of the failure time distribution. **Uncertainty in RLA and Damage assessment**

The scatter observed in creep deformation and time to failure (Fig.1(a,b)) is of considerable technological importance because it makes the task of making accurate lifetime predictions of high temperature components quite challenging. Creep fracture topography of SS 304 LN specimens tested under identical conditions (600^{o}C /220 MPa), as observed in Fig. 2(a,b), shows that it is of different nature and type. In the case of Fig.(2a), it was predominantly intergranular type revealing the existence of clear grain facets while in the case of Fig.(2b), predominant transgranular features with the presence of flat dimples. Fig.3 reveals the nature and shape of creep cavities of SS 304 LN specimens for different rupture times even under identical test conditions (600^{o}C/220 MPa): (a) ‘w’ type and (b) ‘r’ type. Fractographs of crept specimens of 17 yrs service exposed P-22 grade of steel used in main steam pipe of boiler, tested under identical conditions (550ºC/145 MPa) show: a brittle failure (Fig.4a) and a quasi cleavage failure with river pattern marking in the cleavage facet (Fig.4b).

TEM bright field images of these specimens show subgrain formation and thickening of subgrain boundaries (Fig. 5a); optical microstructure of crept specimens at 550^{o}C/145 MPa exhibits (b) ferritic bainitic structure with coarsened carbides along the ferrite grain boundaries, (c) ferritic bainitic structure with carbide-free zone near ferrite grain boundaries. The microstructural evidences of fractured samples indicated that the micromechanism of deformation



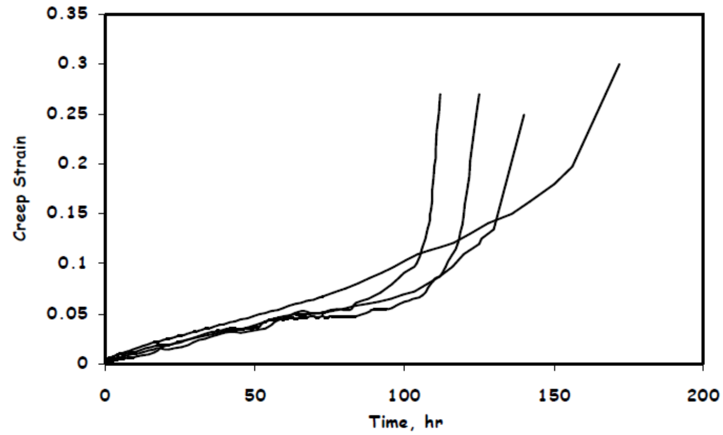


Fig.1 Scatter observed in experimental creep curves of (a) SS 304 LN at 600ºC/220 MPa and (b) 17 yrs service exposed P-22 grade of steel used in main steam pipe of boiler at 550ºC/145 MPa.

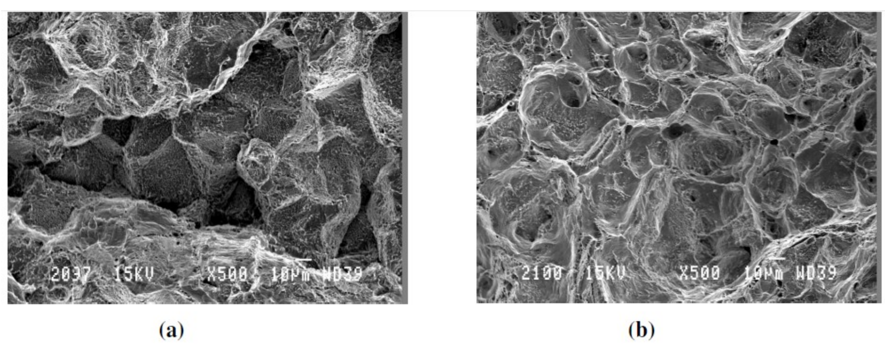


Fig.2.SS 304LN (600ºC/220 MPa) exhibiting different modes of fracture: (a) intergranular (tr =7153 hrs) and (b) transgranular (tr =5615 hrs).

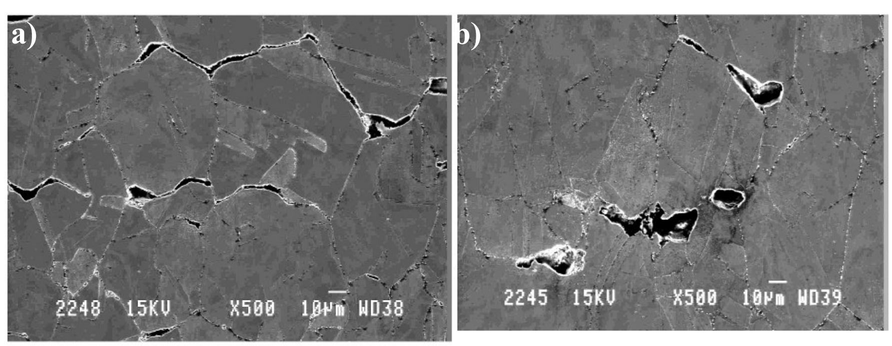
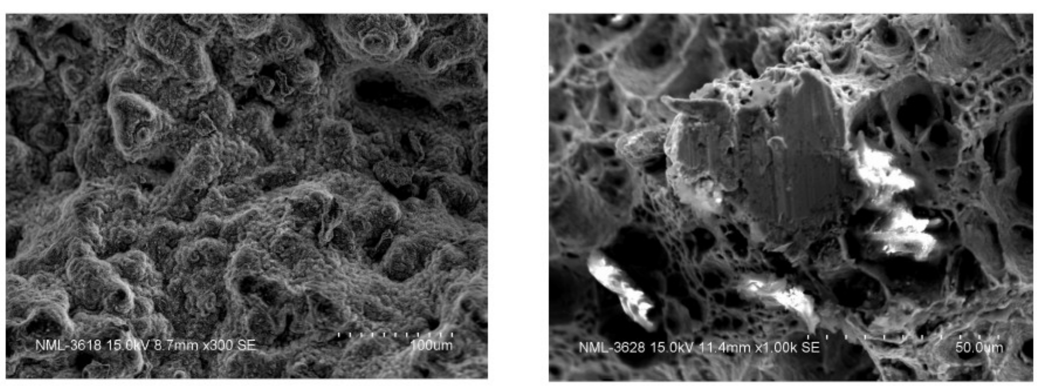


Fig.3. SS 304LN (600ºC/220 MPa) exhibits (a) numerous ‘w’ type cavities (b) ‘r’type creep cavities.

experienced by these samples may be of different nature. Possibly, as a result of this variation in microstructure, there is a substantial amount of scatter, both in the creep response and in the creep rupture failure times. The Weibull distribution function frequently provides a reasonable fit to the probability distributions of life times that have been obtained from stress rupture tests. Some aspects of variability in life time can be assessed and accounted for. But the probability distributions of damage as it evolves during tests that are related to the strength and stiffness properties could not be reasonably represented by Weibull distribution in many cases. For instance, one cannot incorporate the initial damage distribution. Another approach is to assume an evolutionary probabilistic damage model which takes into account the evolution of damage as a function of time, as shown in Fig. 6(a,b). For the purpose of remaining life assessment from creep rupture data, an approach, called the time-temperature parameter, is often used to combine time and temperature into one expression. Therefore, all the data obtained at various stresses and temperatures can be condensed to a narrow band, resulting in a so-called “master curve” that is generally used to represent its creep rupture property. Various kinds of expressions were introduced in order to best fit the data; the Larson–Miller parameter was among the most commonly used methods. Because of uncertainty factors in materials and

Twenty years from now, you will be more disappointed by the things you didn’t do than by the ones you did. So throw off the bowlines. Sail away from the safe harbor. Catch the trade winds in your sails. Explore. Dream. Discover. - Mark Twain



(a) (b)

Fig.4.Fractograph of crept specimens of 17 yrs service exposed P-22 grade of steel used in main steam pipe of boiler at 550°C/145 MPa: (a) a brittle failure and (b) a quasicleavage failure with river pattern marking in the cleavage facet.

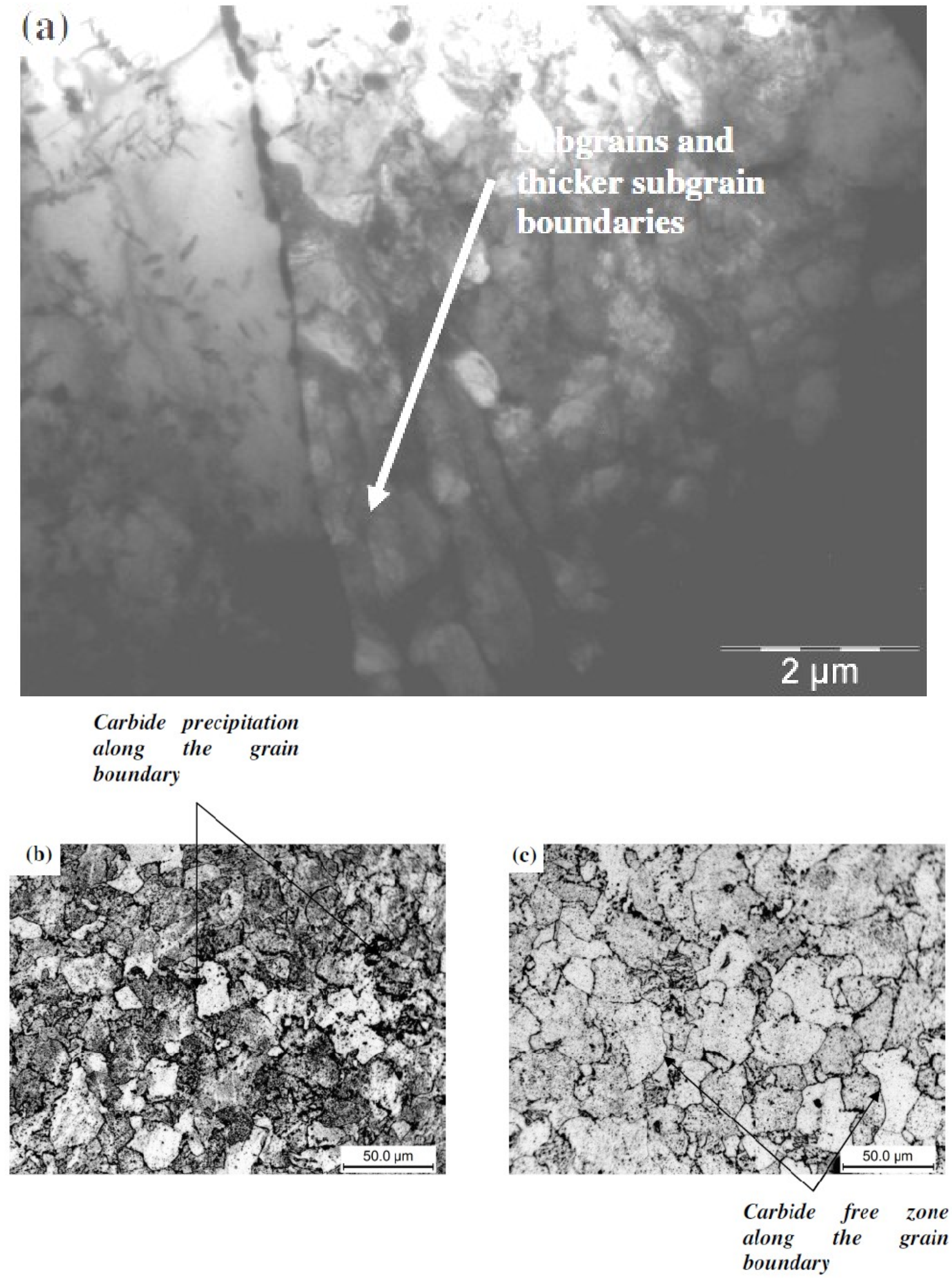


Fig. 5 (a) TEM bright field micrographs showing subgrain formation and thickening of subgrain boundaries; Optical microstructures of crept specimens at 550°C/145 MPa showing (b) ferritic bainitic structure with coarsened carbides along the ferrite grain boundaries and (c) ferritic bainitic structure with carbide free zone near ferrite grain boundaries of 17 yrs service exposed P-22 grade of steel used in main steam pipe of boiler.

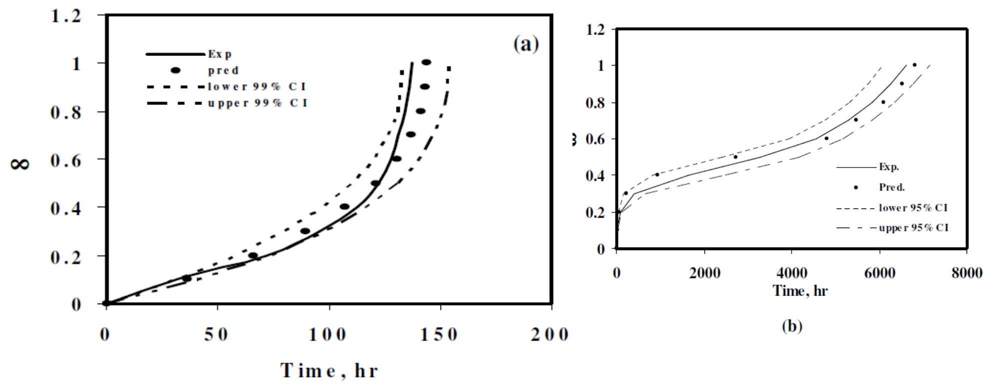


Fig.6 Experimental and predicted values of mean time to reach a specific damage state with 99% confidence interval (CI) for (a) 17 yrs service exposed P-22 grade of steel used in main steam pipe of boiler at 550°C/145 MPa and (b) SS 304 LN at 600 ºC/220 MPa.

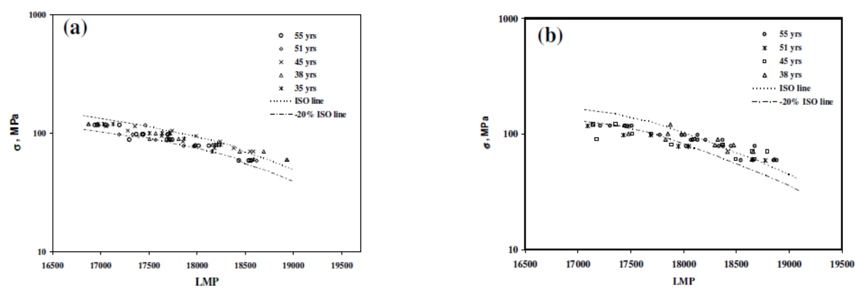


Fig.7 Stress rupture plot at various shut down for a 55 yrs service exposed: (a) CCU reactor and (b) FPU column material of a petrochemical industry.

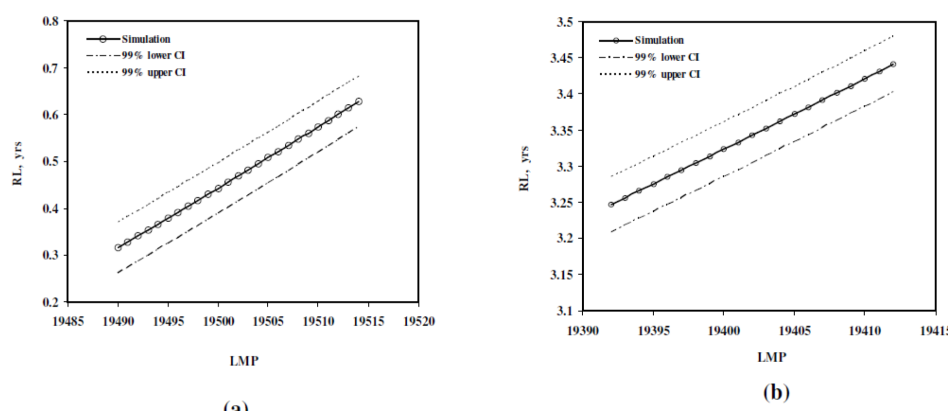


Fig.8. Plot shows the effect of variation in LMP on remaining life calculation for a 55 yrs service exposed : (a) CCU reactor and (b) FPU column material of a petrochemical industry.

experimental conditions, creep rupture data generally exhibits dispersity, as shown in Fig. 7(a,b) for 55 years of service exposed reactor and column materials of a petrochemical industry, where the experimental data distributes scattering around the master curve in stress time-temperature plot. In usual practice, remaining life is predicted from extrapolation of stress v/s LMP plot without incorporating the uncertainty involved in calculation of LMP values. Calculation of LMP values has uncertainty due to its dependence on rupture time of creep specimens. Variability of normalized creep damage can be well approximated with the aid of Weibull distribution. Creep damage in terms of probability of failure and LMP can be expressed as:

$$\omega = a(a_0 + a_1 LMP + a_2 LMP^2)\left(\left(-\ln(1-P_f\right)\right)^{\frac{1}{b}} \quad (1)$$

$$\omega = \frac{t}{t + t_r} \quad (2)$$

where a_0, a_1, a_2 are material constant; **a, b** are Weibull parameter and $\mathbf{P_f}$ is probability of failure.

The effect of variations in the Larson–Miller Parameter value on remaining life is shown in Fig.8(a,b).It has been well documented that stress rupture tests always reveals scatter in rupture data. To incorporate data scatter band in stress rupture tests, Monte Carlo simulation has been carried out where LMP value is varied between ISO mean line and ISO(-20%). Corresponding to each LMP value, remaining life and normalized creep damage was calculated using Eq.(1) and Eq.(2). Variability of normalized creep damage for reactor and column materials is well approximated with the aid of Weibull distribution as shown in Fig.9(a,b). It is observed that the distributions shift towards the higher range of damage with increase in service exposure time. Remaining life of reactor and column materials after 55 yrs of service exposure with relative confidence interval (CI) are reported in Table 1.

Table 1 RLA of 55 years service exposed CCU reactor and FPU column material with 99 % confidence limit

Component	Temp. °C	RL, yrs	Confidence Interval (CI)	Lower CI	Upper CI
CCU reactor	515	2.4	99 %	2.33	2.48
	520	0.47		0.42	0.52
FPU column	515	4.78	99 %	4.73	4.83
	520	3.34		3.3	3.38

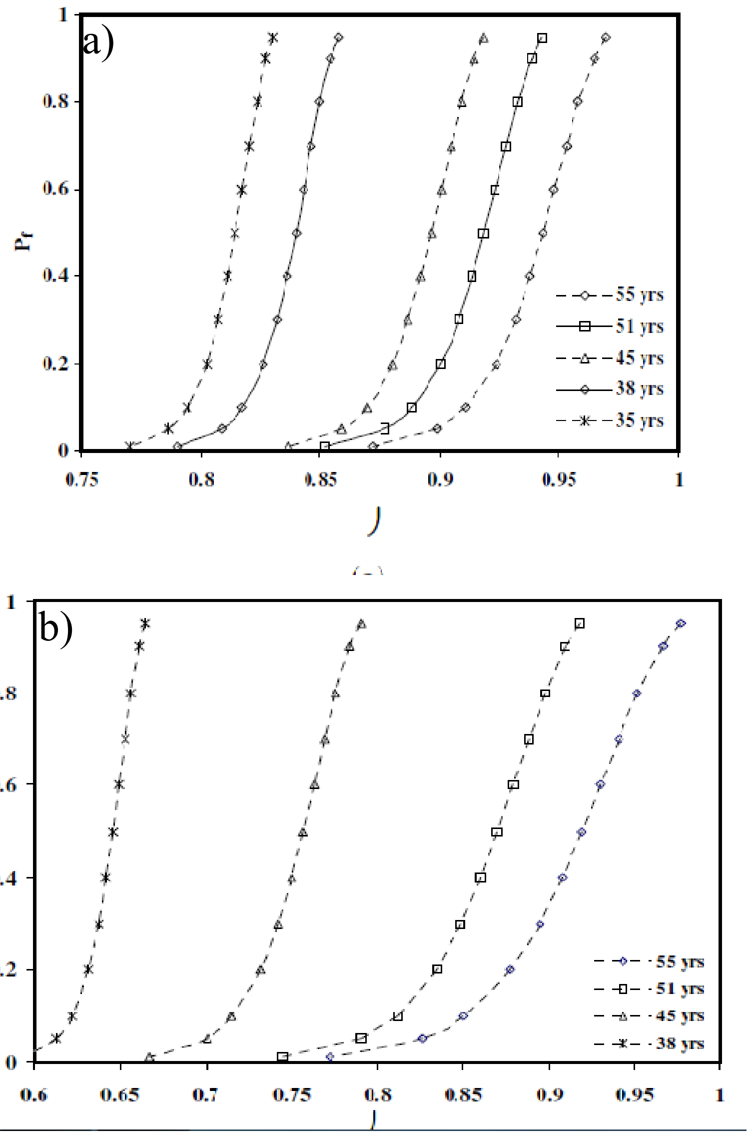


Fig. 9 Creep damage distribution for various shut down of a 55 yrs service exposed: (a) CCU reactor (b) FPU column material of a petrochemical industry.

Do not follow where the path may lead. Go instead where there is no path and leave a trail—Muriel Strode, writer.

Conclusions

- The microstructural evidences from fractured samples indicated that the micromechanism of deformation experienced by these samples may be of different nature. Possibly, as a result of this variation in microstructure, there is a substantial amount of scatter, both in the creep response and in the creep rupture failure times.
- Normalized creep damage can be well-approximated with Weibull Distribution. It is observed that the distributions shift towards the higher range of damage with increase in service exposure time.

Acknowledgements

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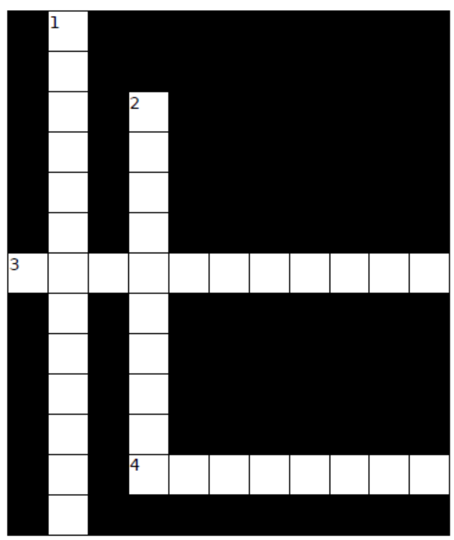
Cross word on failure analysis terminologies



	Across		Down
3	action on solid results in a defect	1	I M for no act on nation that causes dirt
4	yielded solid ends in free mode	2	improper and complicated design, misleading

Society for Failure Analysis

Application Form

Society for Failure Analysis
C/O Centre for Military Airworthiness & certification, RCMA (Materials)
Hyderabad500 058

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

Affix a passport size photograph

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** ☐

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8. **Endorsement by SFA Member**

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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

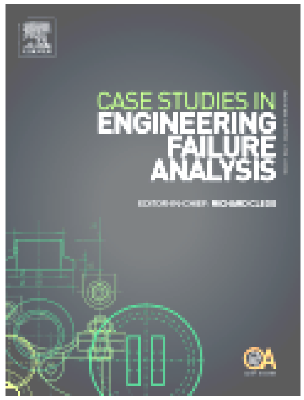
Category	Amount Payable		
	Admission Fee (One time)	Yearly Subscription	Total on joining
Member	Rs.50	Rs.200 (annual)	Rs.250/-
Life Member	Rs.50	Rs.1500	Rs.1550/-

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			

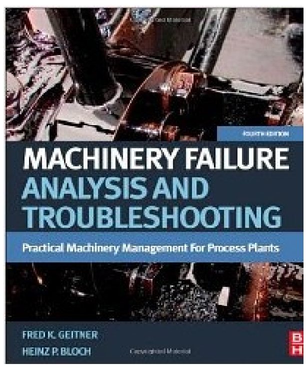
Books/ new journals



New Journal

Case Studies in Engineering Failure Analysis provides a forum for the rapid publication of short,structured Case Studies in **Engineering Failure Analysis** and related Short Communications, and will provide an essential compendium of case studies for practitioners in the field of engineering failure analysis.

Case Studies in Engineering Failure Analysis is an open access journal. If articles are accepted for publication, authors are requested to pay an Article Processing Fee of USD 500 (GBP 320, EURO 400, JPY 39,000) per article (exclusive of UK VAT at 20% which will be charged by Elsevier Ltd). Following payment of this fee, the article is made freely available to all on www.sciencedirect.com.



Machinery Failure Analysis and Troubleshooting: Practical Machinery Management for Process Plants

Heinz P. Bloch, Fred K. Geitner

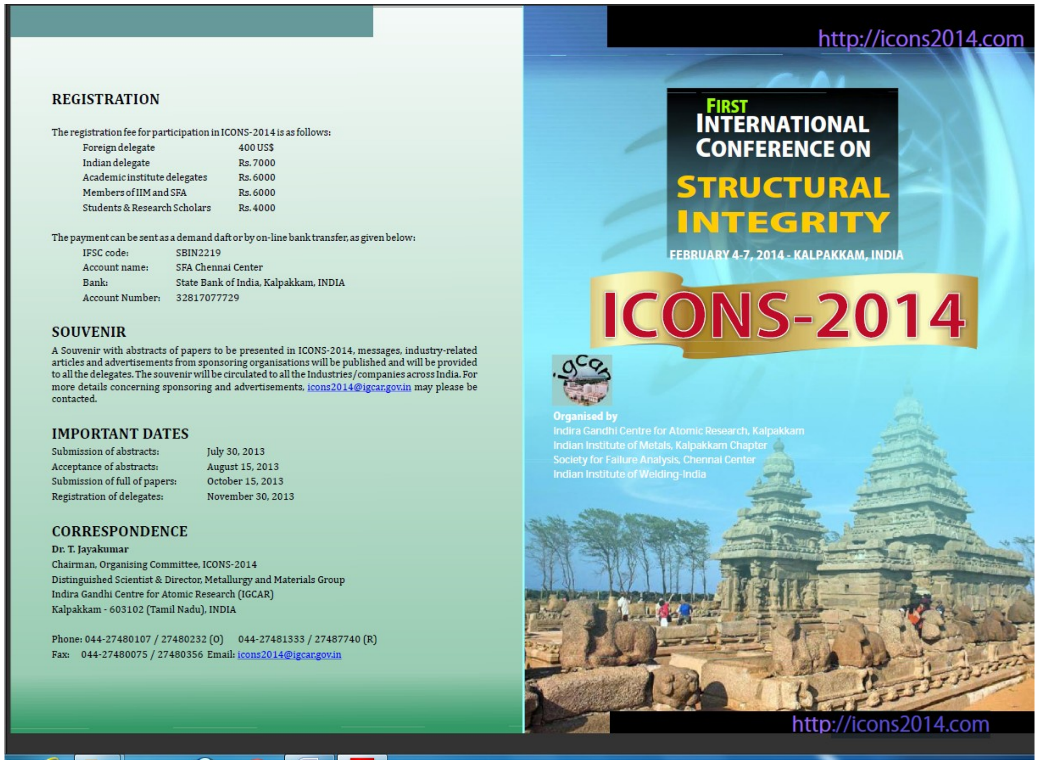
Publication Date: Aug 2012

- Provides detailed, complete and accurate information on anticipating risk of component failure and avoiding equipment downtime

Answer to Cross word

	1 C									
	O									
	N		2 M							
	T		I							
	A		S							
	M		A							
3 D	I	S	L	O	C	A	T	I	O	N
	N		I							
	A		G							
	T		N							
	I		E							
	O		4 D	E	F	O	R	M	E	D
	N									

Events in the pipeline



REGISTRATION

The registration fee for participation in ICONS-2014 is as follows:

Foreign delegate	400 US$
Indian delegate	Rs. 7000
Academic institute delegates	Rs. 6000
Members of IIM and SFA	Rs. 6000
Students & Research Scholars	Rs. 4000

The payment can be sent as a demand daft or by on-line bank transfer, as given below:

IFSC code:	SBIN2219
Account name:	SFA Chennai Center
Bank:	State Bank of India, Kalpakkam, INDIA
Account Number:	32817077729

SOUVENIR

A Souvenir with abstracts of papers to be presented in ICONS-2014, messages, industry-related articles and advertisements from sponsoring organisations will be published and will be provided to all the delegates. The souvenir will be circulated to all the Industries/companies across India. For more details concerning sponsoring and advertisements, icons2014@igcar.gov.in may please be contacted.

IMPORTANT DATES

Submission of abstracts:	July 30, 2013
Acceptance of abstracts:	August 15, 2013
Submission of full of papers:	October 15, 2013
Registration of delegates:	November 30, 2013

CORRESPONDENCE

Dr. T. Jayakumar
Chairman, Organising Committee, ICONS-2014
Distinguished Scientist & Director, Metallurgy and Materials Group
Indira Gandhi Centre for Atomic Research (IGCAR)
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Fax: 044-27480075 / 27480356 Email: icons2014@igcar.gov.in

Plan of SFA events* for the current year (2013-14)

SFA seminar- Professionalism in Failure Analysis
New Delhi July 16th 2013

Inauguration of SFA chapter Warangal July 19th 2013

Inauguration of SFA chapter Comibatore July/Aug, 2013

Inauguration of SFA chapter Jamshedpur Aug.30, 2013

National Conf On Failure Analysis (NCFA) Oct. 2013

Two day workshop on failure analysis of materials (FAMM)
Bangalore Jan 27,28, 2014

Two day workshop on failure analysis of materials (FAMM)
Hyderabad Jan 29,30, 2014

Special lecture on Antique silver by
Dr. R J H Wanhill, The Netherlands Feb, 2014

***The exact dates would be added as and when the program gets finalized;**

IPFA 2013 will be devoted to the fundamental understanding of the physical mechanisms of semiconductor device failures and issues related to semiconductor device reliability, yield and performance, especially those related to advanced process technologies. The Technical Programme Committee is inviting papers related, but not limited to, the following areas:

- Sample Preparation, Metrology and Material Characterization
- Advanced Failure Analysis Techniques
- Die-Level / Package-Level Failure Analysis Case Study & Failure Mechanisms
- Product Reliability Evaluation and Approaches
- Novel Device Reliability and Failure Mechanisms
- Novel Gate Stack/Dielectrics and FEOL Reliability and Failure Mechanisms
- Advanced Interconnects and BEOL Reliability and Failure Mechanisms

We are on the Web ! Please visit www.sfaindia.org

ASME Gas Turbine Chapter of India, supported by ASME International Gas Turbine Institute (IGTI), announces the **ASME 2013 Gas Turbine India Conference** in **Bangalore, Karnataka, India** on December 5-6, 2013 at the **CSIR-National Aerospace Laboratories**

To

From
Society for Failure Analysis (SFA)
C/O Centre for Military Airworthiness & Certification, RCMA (Materials)
Kanchanbagh
Hyderabad-500058