Issue 5 April 2012

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 K.P.Balan

Dr.R.R.Bhat

message from our President

Dear readers,

Warm seasons greetings! I am happy to find the fifth issue of SFA newsletter following the New Year celebrations in India. The mid-April marks the first day of Hindu Solar calendar. It signifies the arrival of spring and the celebrations call for forgetting all animosity and revel in the feeling of friendship, brotherhood and revelry.

I find SFA centers at different parts of the nation conduct regular meetings and technical seminars, which is a positive sign of growth. It is essential that we, the failure analysts must keep ourselves updated of all information relevant to the field and I hope the newsletter serves this purpose. This reminds me of a quote by Benjamin Disraeli: As a general rule, the most successful man in life is the man who has the best information.

Best wishes to all the readers!

K.Tamil Mani
PRESIDENT, SFA

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

From the Desk of Editors

Seasons Greetings! You are glancing through the fifth issue of the Newsletter of Society for Failure Analysis (SFA). Our efforts to build the society have seen success during the past few months with inauguration of our local centres at various places. The successful conduct of workshops at Bangalore, Hyderabad and Kalpakkam is a welcome activity by the local centres.

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

We thank the authors for their contributions to the current issue.

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 tjk@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 (T.Jayakumar)
31-03-2012 (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: pjayapal59@yahoo.co.in; alternatively, post your application with draft to Dr Eswara Prasad, Regional Director, **RCMA,** CEMILAC, Kanchanbagh, Hyderabad, 5500 058*

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

I know of only one bird - the parrot - that talks; and it can't fly very high-**Wilbur Wright**

"

Inauguration of SFA centre at Chennai

The inaugural function of Chennai centre of Society for Failure Analysis (SFA) was conducted during 28th October, 2011 at 5.30 PM at Centre Lecture Theatre, IIT Madras. The chief guest of the function was Dr.A.Venugopala Reddy, Former Regional Director, RCMA, CEMILAC, Hyderabad. Dr. T. Jayakumar, Outstanding Scientist & Director, Metallurgy & Materials Group, IGCAR, Kalpakkam welcomed the gathering consisting of delegates of the workshop, conducted by the IIT, Madras on the subject of failure analyses. He also spoke a few words of introduction about the chief guest. The importance of forming the Society among the failure analysts was highlighted by Dr.N.Eswara Prasad, RD, RCMA, CEMILAC, Hyderabad who also emphasized the vibrant nature of the Chennai city in responding to newer activities. Prof.K.Prasad Rao, IIT, Madras emphasized the need for separate society and appealed to all the delegates to join SFA. Followed by this, the chief guest, Dr.A.V.Reddy delivered an excellent lecture covering the need for quality awareness in industrial practice. He also emphasized the point that the heat treatment stage as the most abused one in the industry. He also linked the origin of defects to poor design, abuse in maintenance or operation or process deficiency, and he further stressed that the current situation of lack of proper defect analysis in Indian industries is due to the urgency of meeting production targets. Finally he recommended the solution to the industry to follow the five commandments – composition, cleanliness, processing, quality assurance and maintenance. The lecture was followed by a brief address by Sri.Jayapal, the secretary of SFA, who mentioned the appeal of the president of SFA, Dr.K.Tamilmani, CE, CEMILAC (airworthiness) to the participants of the inaugural function with a proposal of exclusive offer of 50% reduction in SFA life membership. Dr.P.Parameswaran proposed a vote of thanks.

A well-informed mind is the best security against the contagion of folly and of vice. The vacant mind is ever on the watch for relief, and ready to plunge into error, to escape from the languor of idleness-**Ann Radcliffe**

Workshop on Failure Analysis
13 Sep 2011, HAL, Koraput

One day workshop on ***Failure Analysis*** was held at HAL, Koraput on 13 September 2011 by Aeronautical Society of India, Sunabeda chapter along with HAL, Koraput. & RCMA (KPT).

Dr K Tamilmani, Distinguished Scientist, Chief Executive (Airworthiness), CEMILAC, Bangalore graced the occasion as chief guest and formally inaugurated the chapter on Society for Failure Analysis (SFA). A soft copy of the coating compendium prepared by RCMA(KPT) was released on the occasion.

A total of 102 participants including twenty delegates from HAL, DGAQA, 3BRD, Chandigarh, DMRL, GTRE, NAL, IMMT Bhubaneswar, RCMA (MAT), and CEMILAC, Bangalore attended the workshop.

Shri Ashok Aseri, GM, Engine Division & Chairman AeSI, Sunabeda delivered the welcome address. Chief Guest Dr K Tamilmani, CE(A), CEMILAC, Bangalore delivered a talk on Aeronautics in India with emphasis on importance of failure analysis for improving the design. Plant visit and display of failed aero-engine components was organised for the delegates.

Following lectures were delivered followed by panel discussion:

1. Dr M Srinivas, Scientist-G, DMRL, Hyderabad:- Engineering Aspects of Failure Analysis
2. Dr SK Bhoumik, Scientist-G, NAL, Bangalore:- Failure Analysis: Balancing Theory & Practice
3. Dr BB Jha, IMMT, Bhubaneswar:- Failure Criteria Determination during Superplastic Deformation of Titanium alloy
4. Shri M Shambulingaiah, Scientist-F, GTRE, Bangalore:- Defect Investigation & Failure Analysis of LPTR Blades of KAVERI Engine.

Introspection of a Failure Analyst

Dr. K.P.Balan
Defence Metallurgical Research Laboratory
Hyderabad

Failure of an engineering component is a condition when it no longer is able to perform the desired function due to a breakage, fracture, crack, wear, corrosion, inaccuracies as regards dimensional or other parameters. In a large number of engineering failures, it has been noticed that unsuccessful or non-performance of an engineering system is due to failure of one or more components of the assembly. During preliminary examination, the system's manager is generally able to locate the component that is suspected to have caused the failure. Whenever there is a crack or fracture, telltale evidence is left on the failed component. In certain cases, when there is a rubbing action by the mating fracture surfaces or rubbing of the fracture surfaces by some other component, it amounts to loss of useful evidences for an analyst. In such a situation, a failure analyst has to resort to the available data and circumstantial evidences to draw a conclusion about the failure. A good failure analysis can be highly useful in understanding the cause of failure and also the methods to prevent occurrence of such failures in future.

Failure analysis is a combination of art and science. All material scientists or engineers cannot handle failure analysis as it needs certain amount of experience and skill to handle a case study. Since every failure is reported as a crisis, it is also expected to get an investigation carried out within a very short time. However, it should be borne in mind that a failure analysis cannot be performed with a magic wand. The analyst requires a certain amount of time to understand the background, collect suitable samples, make a variety of specimens for a large number of tests, interpret the test results and then come to a conclusion in order to pronounce the cause. Failure

analysis is based on sound metallurgical principles and authentic scientific evidences gathered through standard tests. The time frame demanded by the analyst should be considered to be genuine and must be provided for a job to be well handled. After all everyone involved in the case looks forward to the cause of failure and a suitable remedial measure in order to avoid future recurrence of the same.

'Neglect of metallurgy' has been the primary reason for a large number of failures of metallic components in our country. Most of the small and medium scale industries appoint mechanical engineers in all such fields of shop floor to look after the metallurgy related activities also, to optimize the man power requirements and for cost effectiveness; for example, a heat treatment shop. During the design and development of a system, for example, a weapon, ordinance or an aerospace vehicle, metallurgists or materials experts are seldom part of the team. When some component of the system fails, the management appoints an inquiry committee to look in to the matter. More often than not, this committee comprises of members from the design, manufacture and user. A metallurgist is not appointed, many a time, as one of the members in the inquiry committee to the management while his services are sought for investigation. It is made to believe by the inquiry committee to their management that a metallurgist is appointed to carry out a few metallurgical tests under their instruction. In a number of instances, the failure analysis report prepared by the analyst is not presented in its actual form by the inquiry committee to their management, whereas portions drawn out of it for convenience makes in to the final outcome of the inquiry committee report. During and after the course of investigation, the failure analyst is called to attend the deliberations of the inquiry committee only in the capacity of an 'invitee' and not as a member of the inquiry team only to seek clarifications on the failure analysis report. There are other instances where the engineers of the development team arrive at a cause of failure based on the operational error or breakage of some part of the system. Now they approach a metallurgical laboratory with a

We all have to decide for ourselves what constitutes failure, but the world is quite eager to give you a set of criteria if you let it-J. K. Rowling.

OLD ACADEMICS never die; they just lose their faculties

request for chemical analysis of the failed component and sometimes for a hardness check. The inquiry committee thinks that it knows the cause of failure and what more they want is a confirmation by a chemical analysis or hardness check. Even at this stage, the committee does not realize that what it requires is a failure analysis by an expert. What it also does not realize is that it needs to approach a materials consultant for a thorough failure analysis and appointment of a metallurgist for all future endeavors. This non-realization leads to failure after failure but fails to wake up any establishment to understand its basic fault- 'neglect of metallurgy'. The day this realization comes and metallurgists get the right place in engineering industries and engineering systems development team, the problem of premature failure would minimize to a large extent.

Another important aspect is the lack of awareness about 'metallurgy' as a branch of engineering. In India and especially in southern India, the awareness about metallurgy/ material science as an engineering course is hardly found with both parents/students and engineering colleges. This is evident from the fact that a handful of colleges are running an undergraduate engineering course in metallurgy/materials science. The feeble job prospect for metallurgy graduates also dictates the poor existence of this course or its popularity. Moreover, failure analysis is only an optional subject in post graduate course in metallurgy. Bodies like AICTE and UGC should spread awareness among universities and suggest them to run metallurgy/material science course in at least 10% of the engineering colleges affiliated to them. Policy makers must see to it that such engineering graduates find suitable jobs in government and public sector engineering industries and establishments.

Most of the failure analysts, who are largely metallurgists working in this

I can't give you a sure-formula for success, but I can give you a formula for failure: try to please everybody all the time-**Herbert Bayard Swope**

field, have entered it as a matter of chance. They then struggle to learn the subject and skill, and later gain expertise by practising it over a long period. The users always are benefited from the work of a failure analyst but the analyst or his work seldom enjoys the recognition for his effort.

It is high time that failure analysis departments are created both at state as well as at the central level by the respective governments under a relevant ministry. It must be made mandatory for all government and public sector establishments to address their failure cases to this department and get them analysed and also implement the remedial measures suggested by it. That alone will impart seriousness to this important field of work and bring glory to both the work and the personnel rendering this yeomen service to the nation.

About the author:

Dr. K.P.BALAN obtained his M.Tech. from IIT, Kharagpur and Ph.D from Banaras Hindu University, Varanasi in Metallurgical Engineering. He joined DMRL, Hyderabad in the year 1982 and since then has been working in the area of Failure Analysis. He has handled over 300 failure case studies pertaining to defence hardware, railways, thermal power stations, mines etc. He has been a member of renowned national committees that addressed failure cases of strategic importance. He has been a member of Materials Standardisation Sub Committee, under Directorate of Standardization, and Sectional committee on Microstructure and Heat Treatment, under Bureau of Indian Standards (BIS), for one decade. He is a member of Metallurgical Engineering Division Council, of BIS. He has about 50 publications to his credit in national and international journals on topics related to failure analysis and structure-property correlations in steels.

Success is not the result of spontaneous combustion. You must set yourself on fire. - **Reggie Leach**

FAILURE OF ALUMINIUM ALLOY ADAPTER IN FATIGUE TESTING

Vaishakhi Nandi, R. R. Bhat and I.N. Yatisha
Hindustan Aeronautics Limited (HAL), Bangalore

BACKGROUND INFORMATION

A broken part namely "Adapter" was forwarded to the laboratory for defect investigation. The adapter was a part of the fixture used for fatigue test assembly of a composite part "*Rescue Hoist Installation Beam*" of a military helicopter. The adapter was not meant to fail but was found cracked after completion of 5890 cycles during the fatigue test. The adapter was made of aluminium alloy of specification 3.1354. The adapter material was in T351 temper (heat-treat) condition. The adapter was fabricated through machining route from raw material stock.

OBSERVATIONS

Photograph of the as-received adapter that had failed during the fatigue test is shown in Fig.1. Failure had taken place at a location just above the change in section in the part. Close-up view of the failure location is given in Fig.2. The fillet radius at the change in section did not appear to be very sharp and was having sufficient radius/relief.

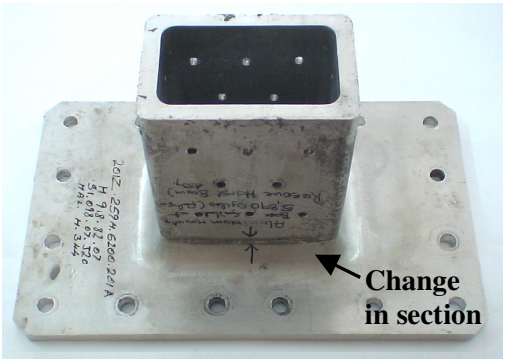


Fig.1: Photograph of the part adapter that had failed during the fatigue test

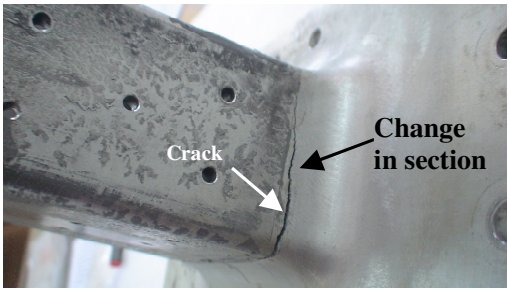


Figure 2: Close-up view of the failure location in the adapter

Chemical analysis

The chemistry of the adapter was analyzed by spectrometry (Table.1). The composition conformed to 3.1354 specification requirement.

Table 1
Chemical composition of the adaptor

Elements	Weight (%)	
	Observation	Requirement
Si	0.05	0.50 (max)
Fe	0.09	0.50 (max)
Cu	4.05	3.80-4.90
Mn	0.48	0.30-0.90
Mg	1.41	1.20-1.80
Cr	0.014	0.10 (max)
Zn	0.03	0.25 (max)
Ti	0.03	0.15 (max)
Al	Bal	Bal

Hardness Measurement

The hardness of the adapter was measured in Brinell Scale as per ASTM E 10 using 2.5 mm diameter ball and 62.5 kg load. The average hardness of the adapter material was about 127 HBW. This is higher than the minimum requirement of 110 HBW in T351 temper condition.

Microscopic examination

Sample was sectioned from the adapter at locations close to and away from the failure location for microscopic studies.

The sectioned samples were appropriately mounted, polished and etched for optical microscopic studies. 3.1354 is a wrought aluminium alloy specification. Hence, it is expected that the adapter shall reveal completely wrought microstructure.

However, microscopic examination revealed presence of remnant cast structure in the microstructure of the adapter material. Photomicrographs showing presence of remnant cast structure in the sample sectioned away from the failure are shown in Fig.3. The sample sectioned close to the failed location revealed significant level of cast/dendritic structure (Fig.4).

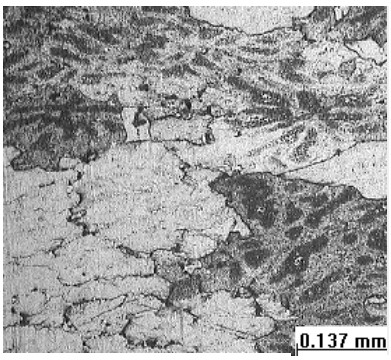


Fig.3.Remnant cast structure in the sample sectioned away from the failure

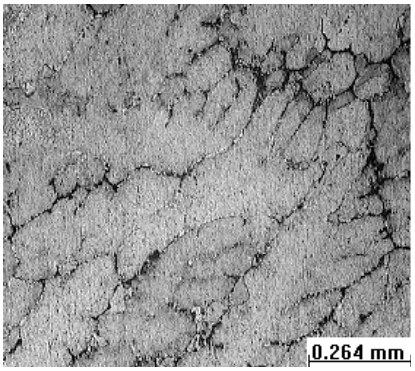


Fig.4: Significant level of cast structure in the sample sectioned close to the failure in the adapter.

Fractography

The fracture surface of the part was examined under stereo-binocular microscope. Macro examination revealed that major portion of the fracture surface showed fibrous features that is indicative of overload failure. However, careful examination revealed small areas on the fracture surface that showed features of fatigue failure like half moon zones. These areas were located close to the outer surface of the part. From the gross fractographic features, it appeared

that the fatigue failure had originated at multiple locations from the outer surface of the adapter. However, to confirm the mode and initiation of failure, the fracture surface of the adapter was examined under *Scanning Electron Microscope (SEM)*.

Scanning Electron Microscopy

Macro examination had revealed features of fatigue failure on the fracture surface at locations close to the outer surface of the adapter. Hence, the fracture surface close to the outer surface of the adapter was carefully examined under SEM. SEM analysis revealed presence of half moon zones at many locations on the fracture surface. Half moon zone is indicative of fatigue failure. SEM images showing half moon zone on the fracture surface at locations close to the outer surface of the adapter are given in Fig.6.

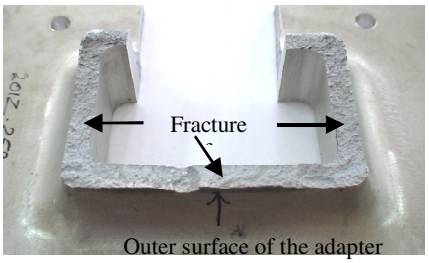


Fig. 5: Fracture surface obtained after opening the crack in the adapter

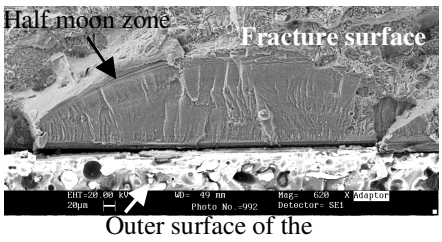


Fig.6: SEM images showing presence of half moon zones on the fracture surface at locations close to the adapter outer surface

The areas of the fracture surface showing half moon zones revealed presence of striations when examined under SEM at high magnifications. Striations are typical of fatigue failure. High magnification SEM images showing presence of fatigue striations on the fracture surface of the adapter are given in Fig.7.

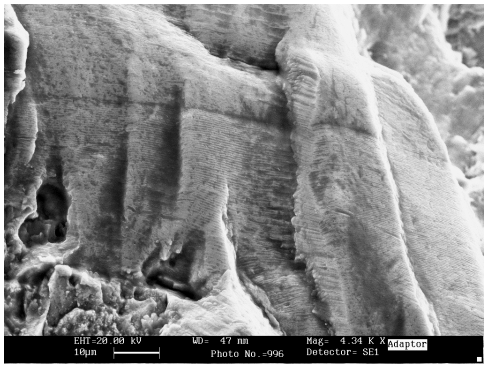


Fig.7: High magnification SEM images showing presence of fatigue striations on the fracture surface of the adapter

The half moon zones and orientation of the fatigue striations confirm the fact that small fatigue cracks had initiated at multiple locations from the outer surface of the adapter.

Rest of the fracture surface revealed dimpled features (Figure 8) that is indicative of overload failure and corresponds to the fast/final failure of the adapter.

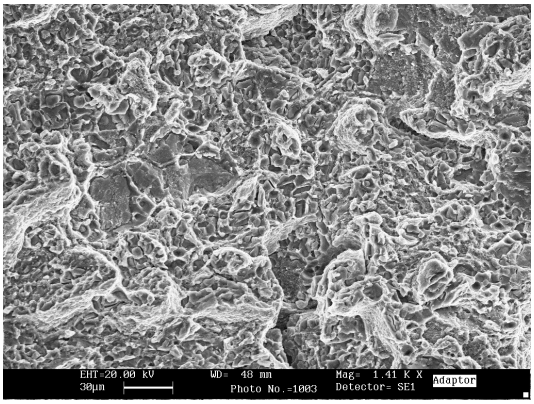


Fig. 8: High magnification SEM image showing presence of dimpled overload features on the fracture surface of the adapter

ANALYSIS OF TEST RESULTS

1. Chemistry of the adapter conformed to the specification 3.1354.
2. Average hardness of the adapter was about 127 HBW which is higher than the minimum requirement of 110 HBW in T351 temper condition.
3. The alloy, 3.1354 is a wrought aluminium alloy specification. Hence, it is expected that the adapter material shall revealed completely wrought microstructure. However, micro examination reveal presence of remnant cast structure in the adapter material. Further, at locations close to the failure, the adapter material revealed significant levels of dendritic (cell) structure.
4. The adapter was manufactured from the raw material stock by machining. The raw material used for machining was identified as the source of remnant cast structure in the adapter.
5. The presence of remnant cast structure in the raw material was attributed to insufficient working (viz. extrusion or rolling or forging) of the cast billet that was used to produce the raw material stock. Owing to insufficient working, the cast structure of the billet had not broken down completely. This had resulted in presence of remnant cast (dendritic) structure in the raw material stock that was used to manufacture the adapter.
6. The adapter had cracked at a location just above the change in section (radius) in the part. Fractographic studies revealed that failure in the adapter had

initiated in the form of small fatigue cracks originating at multiple locations from the outer surface of the part. Later, the component had fractured by overload (fast) failure.

7. In principle, for a given metallic material, completely worked structure is believed to have better dynamic properties especially fatigue when compared to that of cast structure. Hence, from the observations and with the available evidences, it looked apparent that the remnant cast (dendritic) structure observed in the adapter material has resulted in its premature failure during the fatigue test.

CONCLUSIONS

The failure of the adapter had initiated by multiple small fatigue cracks originating from the outer surface of the part. On further servicing of the component, it fractured by overload (fast) failure.

Remnant cast (dendritic) structure observed in the adapter material appears to have caused the unexpected failure of the adapter during fatigue test. The raw material stock used to manufacture the adapter was identified as the source of remnant cast structure.

Due to insufficient working, the cast structure of the billet had not completely broken down and had resulted in remnant cast structure in the raw material used to manufacture the adapter.

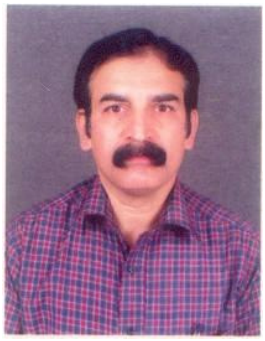
RECOMMENDATIONS

In order to obtain more homogeneous microstructure free from abnormalities like remnant cast structure in the part, it is recommended to manufacture the adapter by forging route rather than direct machining from raw material stock or ensure that the raw material used for machining is free from any cast structure

ACKNOWLEDGMENT

The authors express their sincere gratitude to Shri S.P. Singh, General Manager (Foundry & Forge Division) and Shri S. V. Suresh, Additional General Manager (Laboratory & Quality) for their constant encouragement and support in conducting failure analysis work in the laboratory and for permitting us to publish the case study.

About the authors



Dr R.Raghavendra Bhat took M.Tech. in Process Metallurgy in 1986 and followed with Ph.D. (Metallurgical Engg) in Thermomechanical treatment of spinodal Cu-Ni-Cr alloys in 1993. Starting his career as a Research Associate in Regional Research Laboratory, Trivandrum with a project on Secondary processing of Metal-matrix composites containing SiC_p and carbon fibre reinforcements, he further continued as a research fellow in the study of "Role of Al-Ti and Al-Ti-B master alloys in the grain refinement of Al and its alloys for defence applications" at I I T Kharagpur until 1995. His work culminated as an Indian Patent on the product. He executed the project on development of MMCs as Armour material during the period 1995 –2001 while working in the Materials Processing Division at National Metallurgical Laboratory, Jamshedpur. He moved to Central Materials & Processes Laboratory, F&F Division, HAL, Bangalore in 2001. He looks after mechanical testing and metallurgy sections responsible for process and service related investigation reports and finalization of report related to process & development, R&D projects, member of the team in the export projects from Rolls-Royce, MOOG, Honeywell Phoenix, Hamilton-Sundstrand USA, Turbomeca, France, Kaveri. He has published more than 50 papers in reputed Journals and presented equal number of papers in national seminars/conferences. He received "2011 Metallurgist of the Year Award" from Ministry of Steel, Govt of India on 14-11-2011 at Hyderabad. He is the Vice Chairman of IIM, Bangalore Chapter and Secretary, ASM International Bangalore Chapter.

Miss. Vaishakhi Nandi completed BE (metallurgy) from MS University of Baroda in 2000 and continued further with M Tech from IIT ,Bombay. She joined as Deputy Manager (Lab), Central Materials and Processes Laboratory, Foundry & Forge Division, Hindustan Aeronautics Limited (HAL), Bangalore in 2002. Since then she has been engaged in the following R &D work:

i) Failure Analysis of in-service and process failures of aeronautical & general engineering components.
ii) Metallurgical characterization of metallo-ceramic friction materials used in braking applications, shape memory alloy (NITINOL) ferrule rings and other aircraft spares as part of indigenization (development) activities.

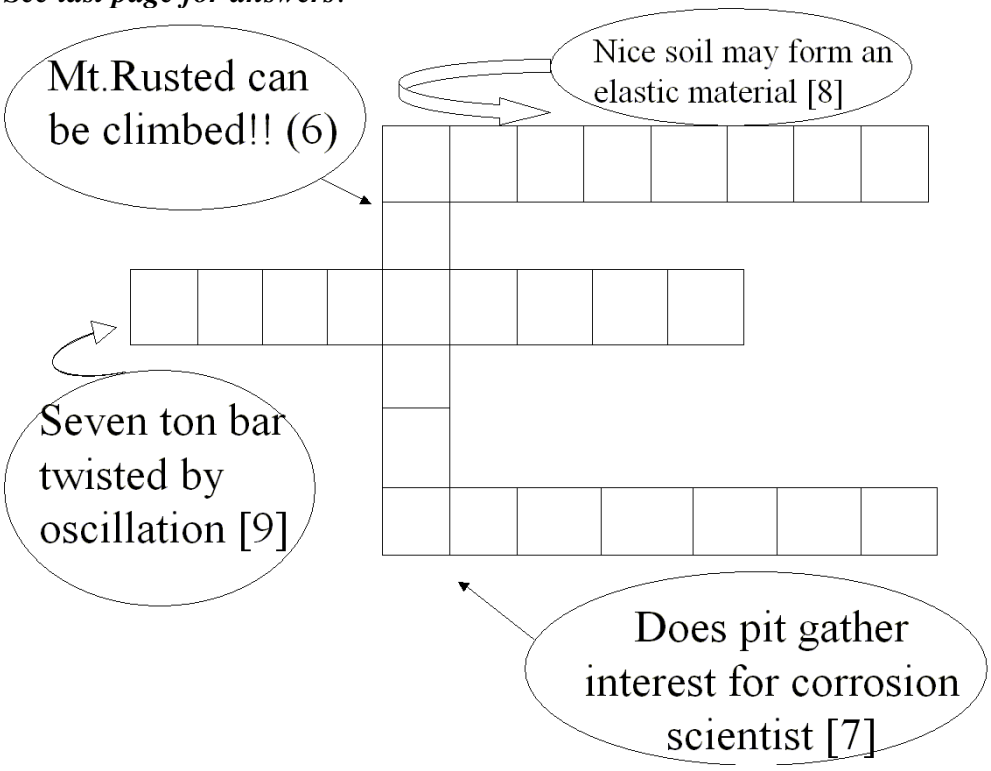
She is a recipient of the following awards/Recognitions

i) Received Young Metallurgists of the Year 2009 award from Ministry of Steels, Government of India in November 2009 during NMD-ATM 2009 held in Kolkata
ii) Received Women Achievers award from *Forum of Women in Public Sector* (WIPS) under the aegis of SCOPE during 21st National meet of WIPS at Chennai in February 2011.
iii) Received first prize for oral presentation of the technical paper "Case study on failure of Casing Ring of Integrated Dynamic System of a military helicopter" at NMD-ATM 2011 organized at Hyderabad in the November 2011

She has published more than 15 technical papers in well-known journals and presented more than 30 technical papers in various international and national conferences/seminars.

Cross word puzzle on failure analysis terminology

See last page for answers:



SFA organized clinic on Failure Analysis at IGCAR, Kalpakkam -22-24, Dec 2011

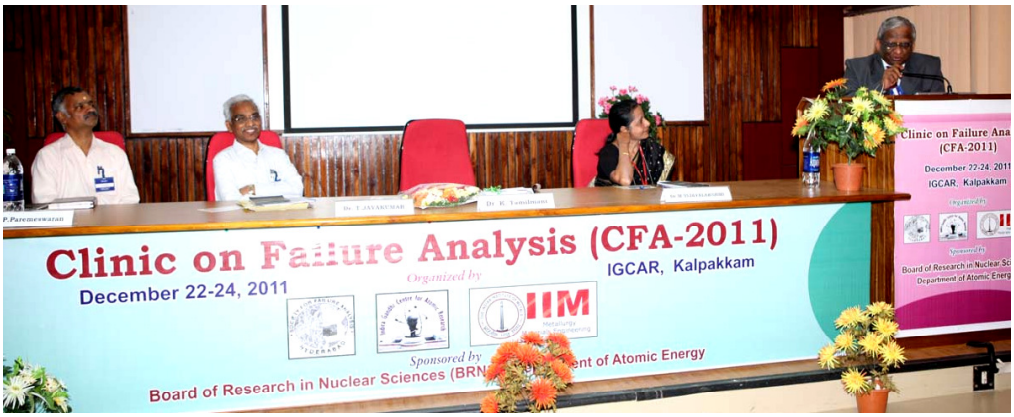
Society for Failure Analysis (SFA), Hyderabad conducted CFA-2011 at IGCAR, Kalpakkam during Dec.22-24, 2011. Dr.T.Jayakumar, Director, Metallurgy & Materials Group, IGCAR welcomed the gathering and briefly touched upon the importance of the subject for critical components of nuclear power plants. Followed by this, Dr M.Vijayalakshmi, Associate director, Physical metallurgy group introduced the details of the clinic and the program envisaged over the three days. Inaugurating the clinic, the chief guest, Dr.K.Tamilmani, chief executive, CEMILAC, Bangalore emphasized the need for failure analysis in every aspect of component certification for its worthiness, right from domestic appliances to aircraft industry. In a comprehensive lecture by Sri.K.V. Kasiviswanathan, Raja Ramanna fellow, IGCAR he has brought out three important aspects of failures- design issues, fabrication issues and service effects.

This was followed by a lecture on general methodology emphasizing design against failures by Prof Raghu Prakash, IIT Madras and Dr G Sasikala, IGCAR. On the later half of the day, Dr Sandeep Bhattacharya, Tata steels, Jamshedpur and Sri.N.G.Muraleedharan, formerly of IGCAR covered important service and fabrication related issues through several case studies from their experiences.

The second day was devoted to detailed analysis laying stress to finer aspects like the energetics involved in crack initiation and propagation, the monitoring methods and so on. Sri.A.K.Jha, VSSC, Trivandrum covered the importance of fine micro-cracks and deformation mechanisms and role of environment on failure initiation. Dr. Arbind Kumar, BARC, Mumbai covered NDT techniques to monitor propagation of micro-cracks. Dr A.Joseph, IGCAR introduced the simple and elegant NDT mode of metallography namely-insitu metallography in life estimation of engineering components.

The third day highlighted case studies of different industries like chemical, power plant and so on. While Dr Vivekanand Kain, BARC, Mumbai and Prof V.S.Raja, IIT, Bombay touched upon case studies related to chemical industries and corrosion, Dr. B.Venkatraman, DMRL, Hyderabad dealt with tribological failures in engineering systems. Dr.M.Vijayalakshmi, IGCAR introduced the need for using advanced techniques in failure analysis with a few examples of quantification adopted through fractal analysis of fracture surfaces. The clinic received a very good response with 55 outside participants from industries, research laboratories and academic institutions and 14 eminent specialists delivered the lectures. In addition, there was a poster session wherein a few participants presented their work, which was well received and appreciated by all.

The three days event ended with many good feedbacks from the participants, which included the conduct of regular clinic once in two years for updating the knowledge, appeal to SFA to help universities in introducing Failure analysis as elective and so on. Dr.P.Parameswaran, the convener, CFA-2011 summed up the event and proposed a vote of thanks.



**Inauguration of Clinic on Failure analysis by Dr.K.Tamilmani, Chief Executive, CEMILAC (Airworthiness), Bangalore;
from L-R seated are: Dr.P.Parameswaran, Convener, CFA-2011,
Dr.T.Jayakumar, Director, Metallurgy & Materials Group and
Dr. M.Vijayalakshmi, Associate director, Physical metallurgy group**

Society for Failure Analysis

Application Form

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

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Fax : 040-24341827
E-mail: rdrcma.mat@cemilac.drdo.in

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Books

La vintage métallurgie. 60 years of marriage of science to industry

414 pages, ISBN 97881-87053-70-8, published in 2011 by National Metallurgical Laboratory, Jamshedpur, India

Making, shaping of NML- review on l*a vintage metallurgie*

For India to be a developed independent nation, in addition to her deep-rooted cultural heritage and legacy, she needs to be economically independent and provide the highest quality of life to her citizens. The single largest factor that can bring about this change in the quality of life of her people is Science and Technology. The importance of Science & Technology in bringing about a social, economic and industrial transformation and development was realized very early by visionaries such as Pt. Jawaharlal Nehru, Sir Ramasami Mudaliar and the doyen of scientific industrial research, Dr. Shanti Swarup Bhatnagar. Even before her formal independence, these leaders conceived and set into motion the creation of a series of CSIR labs for nurturing scientific research and synergizing it with industrial needs. Prominent among the CSIR labs is the one dedicated for metallurgical engineering at Jamshedpur, that is, National Metallurgical Laboratory (NML). The efforts that went into the formation and the excellent growth of NML with international recognition over the last sixty years is brought out as a mammoth volume, titled: *'la vintage metallurgie'* which illustrates its glory and achievements.

The attractive feature in the narration of the story of making and shaping of NML is in the lucid and unique way the chapters are highlighted with rich metallurgical connotations of the R&D and technology. Beginning with the early stage of building the laboratory, the book discusses the nucleation of ideas and growth and recrystallisation of the laboratory in the subsequent pages. The visits of important personalities added as a composite alongwith the research pages makes it a catchy and colorful memoir and draws any reader's attention.

The contents make one to quickly comprehend and appreciate the outstanding contributions and achievements of NML, among which many are first of their kind in India. To mention a few: the ferroalloy production that helped medium level entrepreneurs, innovations such as the first baby blast furnace, the second largest creep facilities in Asia, indigenous technology for magnesium production, indigenously built continuous casting of Al alloys, development and commercialization of the direct reduction process of sponge iron making, the first experimental LD converter of India, development of Ni-free stainless steel, building indigenous testing equipments like residual stress measurements using ultrasonic probes and so on. Another aspect which deserves mention is the building of unique infrastructure such as the first X-ray Fluorescence (XRF) spectrometer in India, electron microscopes etc. very early. In its efforts to utilize and build technologies for the processing of indigenous resources such as the many beneficiation projects of iron, copper and uranium ores, the lab has contributed a lot to the minerals sector. Systematic studies on overheating and burning in hot forging of alloy steels, studying the liquid structures through some very innovative techniques and stabilization of austenite by hydrogen through extensive physical metallurgical studies are among the outstanding research contributions of NML.

Stress on futuristic technologies is evident from the programs such as the Polymetallic nodules from seabed and the low shaft furnace technology for use of non-coking coal for iron making. Many of the developments could see the light of the day through implementation at reduction process of sponge iron making, the first experimental LD converter of India, development of Ni-free stainless steel, building indigenous testing equipments like residual stress measurements using ultrasonic probes and so on.

Another aspect which deserves mention is the building of unique infrastructure such as the first X-ray Fluorescence (XRF) spectrometer in India, electron microscopes etc. very early. In its efforts to utilize and build technologies for the processing of indigenous resources such as the many beneficiation projects of iron, copper and uranium ores, the lab has contributed a lot to the minerals sector. Systematic studies on overheating and burning in hot forging of alloy steels, studying the liquid structures through some very innovative techniques and stabilization of austenite by hydrogen through extensive physical metallurgical studies are among the outstanding research contributions of NML.

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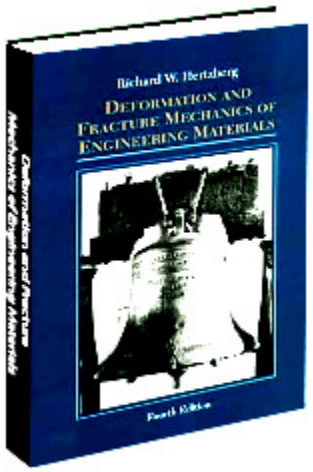
With its main lab located at Jamshedpur, it is currently having an extension unit at Chennai. Its regular updates in the form of NML technical journal reach many corners of India and also international institutes and laboratories, sowing seeds of inspiration in the minds of young researchers and professionals. No doubt the book instills the reader with pride and a firm belief in India as a nation and stimulates his mind with a spirit to contribute his might too. The book is a personal treasure for all metallurgical professionals and should find a place in every college/ university library.



Deformation and Fracture Mechanics of Engineering Materials, 4th Edition

Author: Richard W. Hertzberg

Updated to reflect recent developments in our understanding of deformation and fracture processes in structural materials. This completely revised reference includes new sections on isostress analysis, modulus of rupture, creep fracture micromechanisms.
Publisher: John Wiley & Sons, Inc
.
ISBN: 978-0-471-01214-6

Learning the proper steps for organizing a failure investigation ensures success. Failure investigations cross company functional boundaries and are an integral component of any design or manufacturing business operation. Well-organized and professionally conducted investigations are essential for solving manufacturing problems and assisting in redesigns. This book outlines a proven systematic approach to failure investigation. It explains the relationship between various failure sources (corrosion, for example) and the organization and conduct of the investigation. It provides a learning platform for engineers from all disciplines: materials, design, manufacturing, quality, and management. The examples in this book focus on the definition of and requirements for a professionally performed failure analysis of a physical object or structure. However, many of the concepts have much greater utility than for investigating the failure of physical objects. For example, the book provides guidance in areas such as learning how to define objectives, negotiating the scope of investigation, examining the physical evidence, and applying general problem-solving techniques.

Publisher: ASM International, 2005

Number of pages: 233

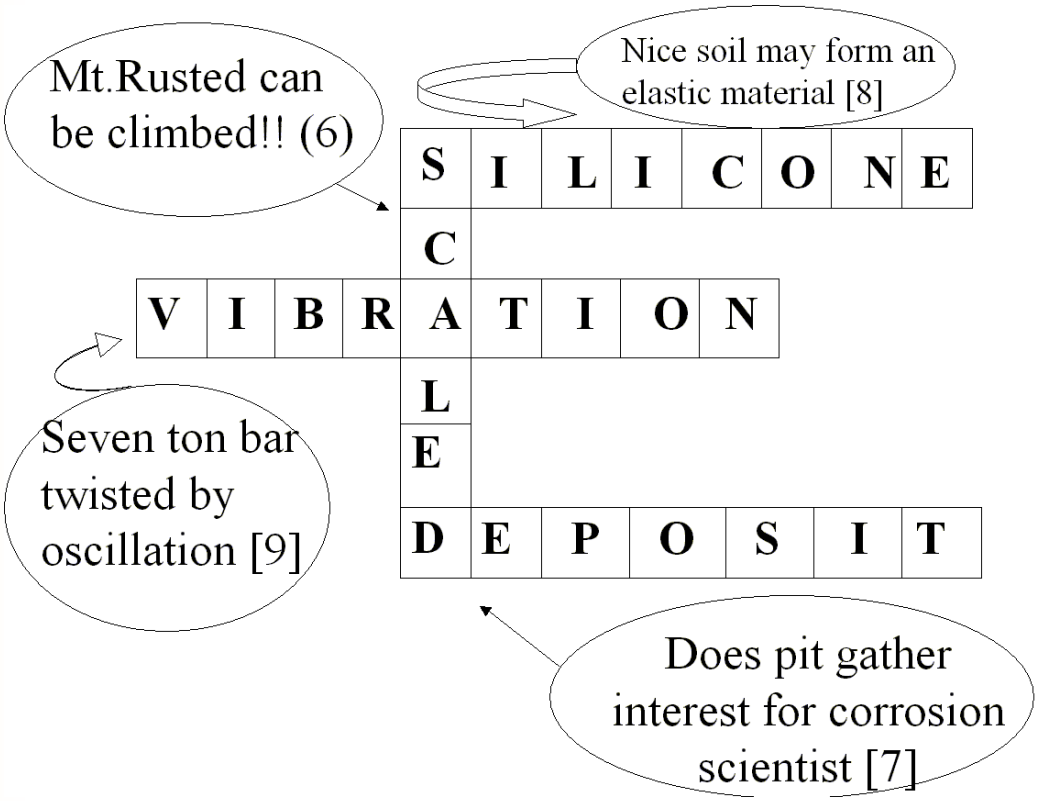
ISBN: 978-0-87170-811-3

Events in the pipeline

The 15th European Conference on Composite Materials takes place from 24th to 28th June 2012 in Venice, Italy. Please visit http://www.eccm15.org/ ;

19th International conference on Wear of materials:Portland, USA, 14-18. April, 2013. Submit your abstract before June 1, 2012.

Answers to the crossword:



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