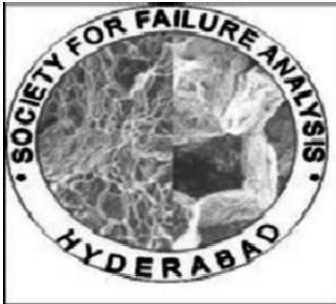




SFA Newsletter

Seasons Greetings!

[About SFA](#)

[Objectives](#)

[Local chapters](#)

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 Patnaik, GTRE, Bengaluru



Message from our President

Dear readers,

Warm greetings to all of you!

The current issue has emerged out when we celebrate the May day in appreciation of the excellent contributions of our labour force who are the creators and their hard work see things in three dimension. The skill they have at their hands is what a labourer acquires over a period of time by being persistent, determined to achieve excellence and readiness to cooperate with fellow workers. He would have good hand, eye and body coordination to do a skilled job. He would also follow safety rules and reduce material wastage and timely delivery of product. All these help us to contribute for our mission in engineering enterprises and therefore, it is our sincere wishes to the labourers on the advent of May 1st every year!

At this juncture we also observe shortage of skilled labour in every engineering domain which calls for systematic training to make them keep pace with technological advancements.

I sincerely wish that the members and readers appreciate the importance of above and share their thought as feedback and contribute in building our nation with a strong skilled labour force.

I recall the words of Pele, the Brazilian footballer: "Success is no accident. It is hard work, perseverance, learning, studying, sacrifice and most of all love of what you are doing..."

Wish you all the best!

Madhusudhan Reddy
President, SFA



Dr.G.M.Reddy
President, SFA



From the Desk of Editors

Dear Readers:

Season's Greetings! You are glancing through the 27th issue of the Newsletter of Society for Failure Analysis (SFA). The issue coincides with the advent of summer season in India. We would face failures due to heating up of large number of electronic components that form automation of many types of equipment-be it in home or in industrial environment. Since prevention is better than cure, it is better to keep our maintenance team working ahead of the impending outages or in the worst case, any calamity.

This issue hails the workers of engineering industries in particular, being May month. Since the summer has began, workers employed outdoor should take care of heat illness (including heat stroke, heat exhaustion, cramps, and fatigue) and our sincere efforts to provide necessary rest hours to them would prevent any serious issue.

Our Chapters are planning activities in the months ahead and we may have briefings soon on them in next issue onwards.

For the present issue, we solicited articles from experts of our country who had worked on many case histories and domain areas of relevance to improved efficiency and energy saving which is again an indirect way of prevention of failures or extension of life of

components. In this respect, we thank the author, Dr. B.V.A.Patnaik, GTRE, Bengaluru for sharing the knowledge highlighting the importance of Prognostics and health management (PHM) which has emerged as essential approach for preventing catastrophic failure and increasing system availability by reducing downtime, extending maintenance cycles. We hope you would find the article quite useful and interesting.

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; pl write them to us on param1961@gmail.com & Visit our web site for your comments/suggestions or any queries: www.sfaindia.org

P. Parameswaran &
Swati Biswas
Editors

We encourage you to join the society, kindly fill up the application form (enclosed at the end of the newsletter) and contact secretary: Dr Chandan Mondal, DMRL, Hyd; alternatively, post your application with draft to Sri.B Jana, Treasurer, RCMA, CEMILAC, Kanchanbagh, Hyderabad, 500 058

No work is insignificant. All labour that uplifts humanity has dignity. They should be undertaken with painstaking excellence.
-Martin Luther King Jr



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 Dr. V.K. Saraswat, DRDO, New Delhi
 Dr. G. Malakondaiah, DRDO, New Delhi
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Editors of Newsletter:

Dr.P.Parameswaran, formerly of IGCAR, Kalpakkam
 Dr.Swati Biswas, GTRE, Bengaluru

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.





Failure Modes of Aero-engine components

BVA Patnaik

Gas Turbine Research Establishment
Defence Research & Development
Bengaluru

e_mail: patnaikkbva.gtre@gov.in

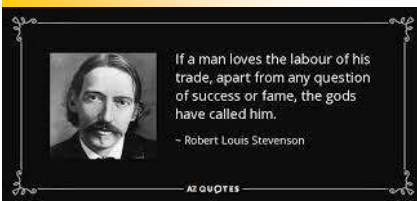
Structural integrity of a Gas Turbine Engine of Fighter or Civil aircraft is the ability of **structure/system** to perform its intended function without failure under all operating conditions for a specified life. **Life and safety together define Structural integrity.** Achieving very high specific workout put as a means of producing large thrust with minimum possible size of Gas turbine aero engine was the target of aero thermodynamic engineers for a long time. This required development of high pressure ratio compressors and development of Turbines which can withstand Turbine Entry Temperatures of the order of 1900K. The evolution of Titanium alloys as a replacement to steels and development of high temperature super alloys have brought tremendous advantage of designing the aerodynamic flow paths required besides meeting long life requirements.

During the process of generating thrusts of different magnitudes as per the mission requirements the critical parts undergo various failure modes. Some of these failure modes are associated with the safety and some are associated with the life of the parts. All the parts below the flow path are classified as cold parts. The flow path parts ahead of combustion chamber are also classified as cold parts. The Flow path parts from Combustor onwards are classified as hot parts. In the present scenario generally the life

requirements of cold parts is twice the life requirement of hot parts either in terms of Mission hours or TACs (Total accumulated cycles). The components whose failure can not be contained leading to loss of human life, loss of engine are classified as Class1 critical parts. The components whose failure cause mission abortion but do not endanger the life of personnel and does not cause catastrophic failure of engine are classified as Class2. The remaining parts which do not cause loss of either of them are classified as Class3 components.

Life of critical parts in the fighter aircraft engine is limited. The life capability of critical parts is governed by Low cycle fatigue due to start stop modes which is the main Failure mode for all Discs, shafts and Casings. In case of Turbine discs in addition to Low cycle fatigue, stress rupture also plays an important role due to very stresses and moderately high temperatures in the disc rim locations. Therefore the life critical locations in turbine discs can be bore or rim depending on the interaction mechanisms. Even in compressor discs there can be different critical locations based on the local stress state but not due to Fatigue and stress rupture interaction. Life of shafts is dictated by torsional fatigue and casing lives are dictated by cyclic pressure and temperatures.

In case of Flow path





components like compressor blades the life governing factor is still Low Cycle Fatigue. In case of Turbine vanes and combustor the life is dictated by thermal fatigue due to transient operations taking place during takeoff, landing and intermediate slams and chops, and creep phenomena due to sustained operation at elevated temperatures and stresses. The turbine rotor blades however are governed by Low cycle fatigue and Creep interaction for their life in terms of effective hours or cycles. Oxidation due to high temperature environment also is detrimental to the turbine blade life. To control this oxidation resistance coatings are used and to reduce the blade metal temperatures cooling techniques along with thermal barrier coatings are also used. Therefore a turbine blade experiences many of these failure modes. The combination of extreme mechanical and high temperatures experienced by these components often result in significant amounts of plasticity and cyclic time dependent plasticity which makes the structural analysis and life prediction a challenging job.

In a nut shell the life of critical part is governed either by cyclic life (LCF, Thermal Fatigue) or due to combination of creep & fatigue interaction as the case may be. The life thus established can be utilised provided an important mechanism called High cycle fatigue is not life consuming. All flow path components (Blades and vanes) are susceptible for High cycles fatigue due to flow perturbation frequencies matching with component natural frequencies and engine operating frequency orders. These potential resonances at lower orders can be identified at the

design stage and avoided if possible. In case it is not possible to eliminate these resonances it has to be substantiated during engine testing that the vibratory stresses are well within allowable limits so that theoretical infinite HCF life is assured. Assessment of allowable amplitudes is a tricky issue as the resonance modes can be uniaxial or multi axial in nature. While these mechanical resonances can be handled by avoiding the dwell times or minimising the vibratory stresses there are some aeroelastic phenomena like flutter that can cause exponential pile up of amplitudes should one encounter such a phenomenon. Such a phenomenon calls for design modification to eliminate the very phenomenon.

Fig.1 Shows the schematic describing HCF, LCF and Creep. Fig.2 represents typical stress distribution in Disc sector governing LCF and stress rupture capability. Fig.3 shows relative stress distributions in uniaxial and multiaxial fatigue modes under HCF. Fig.4 shows representative temperature and stress distribution depicting the creep accumulation process.

Subsequent to the design and life prediction equally important is to assess the residual life due to operational usage in order to ensure safe and economic exploitation. The life of critical components of the engine is declared based on the flight envelope consisting of various mission cycles and the corresponding operating environment of the component & failure modes.



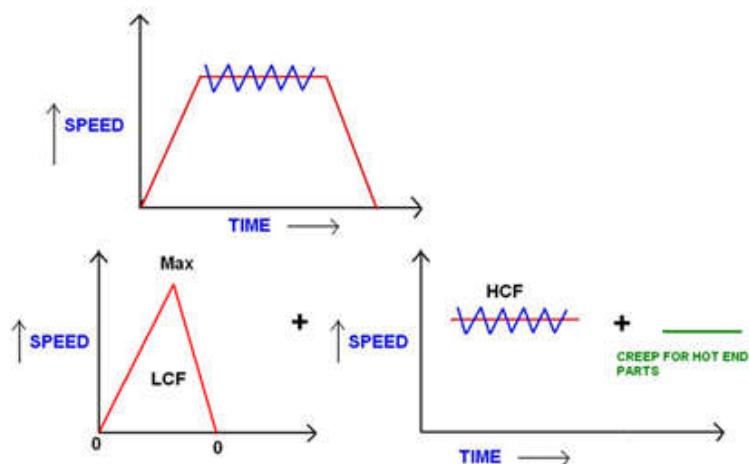
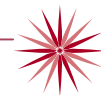


Fig.1. Schematic describing HCF, LCF and Creep loading during engine operation

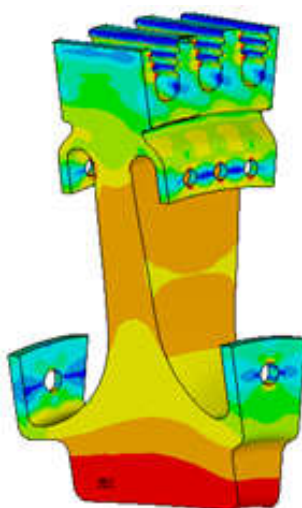


Fig.2. Typical stress distribution in Disc sector governing LCF and stress rupture

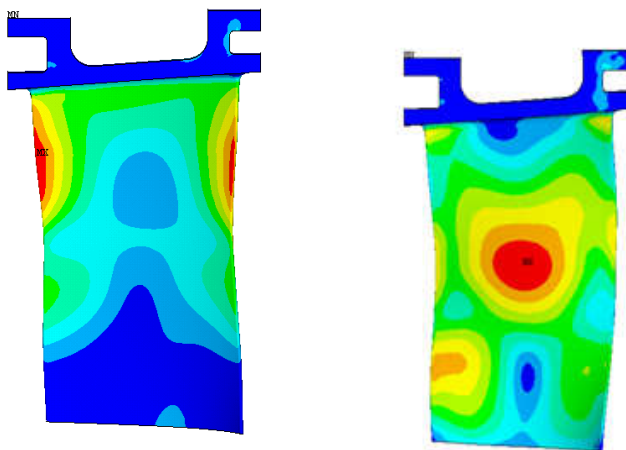


Fig.3. relative stress distributions under HCF in a blade (left) in uni-axial and (right) multi-axial fatigue modes



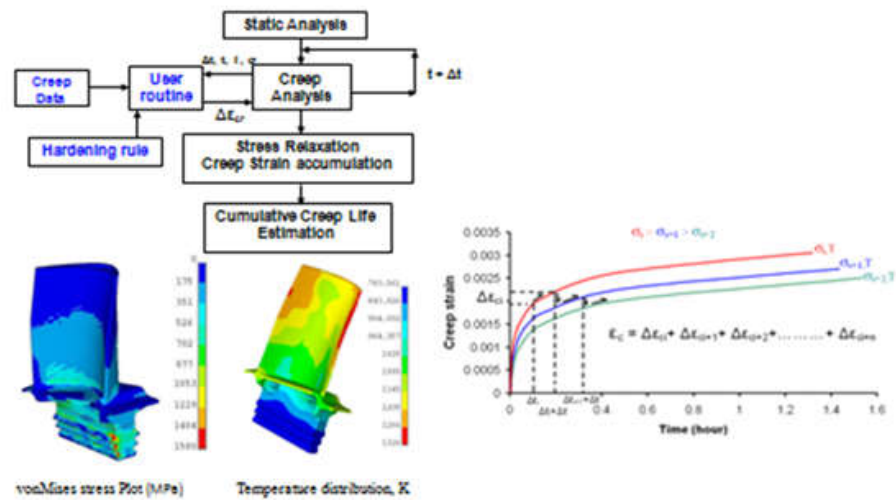


Fig.4. Representative temperature and stress distribution depicting the creep accumulation process in a blade

Subsequent to the design and life prediction equally important is to assess the residual life due to operational usage in order to ensure safe and economic exploitation. The life of critical components of the engine is declared based on the flight envelope consisting of various mission cycles and the corresponding operating environment of the component & failure modes.

The Low cycle fatigue life is declared in terms number of 0-Max-0 cycles. This fatigue life can always be correlated to equivalent damage cycles with respect to actual mission profile by summing up the damages due to minor sub cycles and the major cycle of the mission profile. The life of the cold parts is dictated by Low Cycle Fatigue behavior with respect to mission cycle whereas the components for which the operating temperatures are high (hot parts) the life is dictated by combination of Creep & thermal fatigue.

So far the failure modes governing the life capabilities is discussed. Apart from this, there are some failure modes which can lead to instantaneous failures in discs and shafts due over speeding for some reason. To safe guard against such eventualities the gross stresses are controlled in critical parts. There are some failure modes that cause a very high instantaneous strain rates due to foreign object damage. It requires exhaustive material characterisation and structural simulation techniques to ensure the integrity considering life and safety driven failure modes.

In order to ensure that the components in service have not exhausted the equivalent declared safe life, it is essential to assess the damages incurred in these components during engine operation. The cyclic exchange rate for the mission profiles in terms of





flight hours are generally defined for typical fighter aircraft by apportioning speed excursion ranges in to predominant speed ranges. However more accurate damage consumptions are to be evaluated so that life potential of the critical components is exploited very effectively. Diagnostics, Prognostics play vital role in ensuring integrity and economic life exploitation (Including life extension) of the fighter aircraft engine.

Conclusions:

The aero engine critical parts experience various failure modes from life and safety considerations during the course of mission exploitations.

The prediction of the same requires exhaustive material characterisation and structural simulation techniques and development of predictive health management.

-----XXX-----





Sustaining Society for Failure Analysis –some viewpoints

Dr. B.P.C.Rao

Former President, Society for Failure Analysis



SFA started its activities with a vision and mission to spread the importance of materials engineers in every aspect of the process of design, manufacturing, and service life. The interaction among the designers, production engineers and plant operating personnel is almost well established in engineering industries and to a finer extent with service engineers as their inputs are essential in smooth & safe running the systems for a stipulated intended period. Therefore, to establish the necessary linkages, SFA started various technical programs such as clinics, training programs to emphasize the essential knowledge of engineering failure analysis per se, conferences to share the experience on failure analysis and awareness workshops for young engineers as well as budding scientists. Since its inception, SFA has made it a policy to nurture membership with one time subscription which is again quite nominal. This allowed an easy step to join SFA for many, especially young & practicing engineers and Chapters have been established and developed over a period of time.

Our predecessors took SFA to a higher visible level with reasonable membership with sustenance of activities and the mantle of the Presidentship changes every three years so that the future teams take a note and further improve the activities and in subsequent years and introduce novel programs for future committees by giving special emphasis to the on-going as well as expected trends.

During the three years, 2018 to 2021, three different activities were

organised : (i) for engineers through experts, (ii) by the engineers for sharing their knowledge and (iii) of the engineers for discussing newer ideas and R &D areas which would help in understanding the service evolution of systems. The efforts paved way for developing SFA Chapters, improving its membership further. They can be grouped into the following:

- Membership drive-methods and establishing Chapters for network
- Workshops for young engineers- experts sharing experience with the youth
- National conferences on relevant domain areas -
- International conferences- on relevant themes and organising them as series
- Newsletter and web page for information dissemination
- Identifying excellence and awarding engineers and scientists engaged in the profession.

As a part of spreading SFA's





mission, Chapters were opened at various places. During the period 2018 to 2020, Chapters at Bhopal and Kottayam emerged. SFA always encourages and exhibit readiness to interact with other professional bodies to spread its wings. Therefore, as & when opportunity knocks the door, SFA organised events with other professional bodies like Indian Institute of Metals, Institution of Engineers, Indian Society for NDE, Indian Institute of Welding and so on. These events were regularly updated to SFA members through e-newsletter and web page. Further, special discount in registration fee was given to SFA Members to ensure their participation and gain from the proceedings.

Organising conferences at national and international levels is an important activity of any professional body and SFA started its events in this line with a series conference ICONS –International Conference on Structural Integrity - which was initiated in 2014 and then repeated by our team during 2018 in a vociferous manner. Comparing it with the 2014 conference proceedings edition, ICONS-2018 drew many engineering disciplines to participate in the event and in particular, civil engineers with their research work. Around 135 full-length manuscripts were received for publication. Out of which 112 articles were selected after peer-review by experts in the various topics. Among these, 14 papers were published in the Journal of Italian Group of Fracture (Frattura ed Integrità Strutturale) and about 71 were included in the Springer Nature “Lecture Notes in Mechanical Engineering”. The remaining 27 papers were published as CD proceedings.

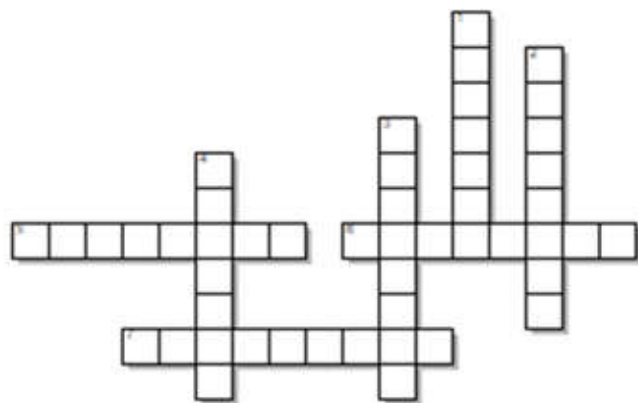
In the national level, our efforts to repeat the event- NCFA which was earlier held in 2006 and could not be conducted, but got postponed due to emergence of pandemic COVID during 2020. Of course, regular workshops for the young engineers were conducted. One among them is Clinic on Failure Analysis which is again a series event. During 2019, the event was held in Anna University, Chennai which helped many students to join and take home the essentials of the domain knowledge. Regular annual bridge course for engineering students & scholars is being sustained with the support of NDE Division, IGCAR, Kalpakkam which was held as a commemoration of late Dr Baldev Raj, former Director, IGCAR and Former President, Indian Society for NDE.

SFA continues to take guidance and support of our past Presidents, especially Dr. Venugopal Reddy, Dr. Tamilmani, Dr. Jayakumar and put every effort to ensure their participation in all important events of SFA. We recently gave a fitting farewell to Sri P Jayapal, President of SFA during 2015 to 2017 when he superannuated from the service at CEMILAC, Bengaluru as we recollected and thanked his contributions to strengthen the Society further with several important activities, in particular, identification of excellence through awards.





CROSSWORD



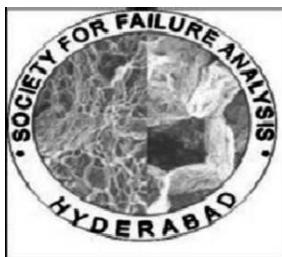
Across:

- 5) We, five, sat on floor to witness show as crowd was exuberant [8]
 6) I bend my leg and got injured causing blood come out [8]
 7) I G crashed to complete his duty [9]

Down:

- 1) Age old lake developed opening for water to ooze out [7]
 2) No use if fluorine cylinder develops leak [8]
 3) Fifty age old slip causing wastage [8]
 4) Lease given for Rare Earth may lose our rights [7]

Answers See page 15



Society for Failure Analysis

Application Form

Society for Failure Analysis

C/O Centre for Military Airworthiness & certification, RCMA (Materials)
Hyderabad 550 058

Phone: 040-24340750; 24348377;

Fax : 040-24341827

E-mail: rdcma.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
Student Member	NIL	Rs 200	Rs.200/-
Life Member	NIL	Rs 2000	Rs.2000/-

12 Declaration by the applicant

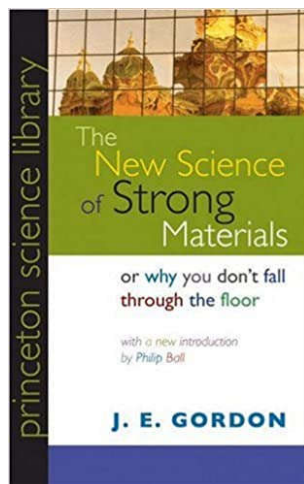
If elected, I agree to accept to pay the prescribed yearly subscription, to abide by the Articles of Association of the Society and to promote its aims and objects.

Signature of the Applicant

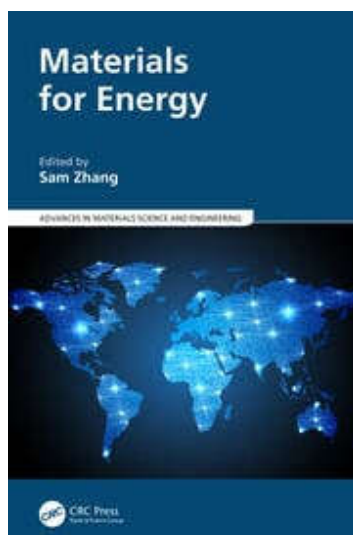
13.	Office Use Only				
	Membership No.		Date of Enrolment		Chapter
	Amount Paid (Rs)		Receipt No. / Date		



Books



J. E. Gordon's classic introduction to the properties of materials used in engineering answers some fascinating and fundamental questions about how the structural world around us works. Gordon focuses on so-called strong materials--such as metals, wood, ceramics, glass, and bone--explaining in engaging and accessible terms the unique physical and chemical basis for their inherent structural qualities. He also shows how an in-depth understanding of these materials' intrinsic strengths--and weaknesses--guides our engineering choices, allowing us to build the structures that support our society. This work is an enduring example of first-rate scientific communication. Philip Ball's introduction describes Gordon's career and the impact of his innovations in materials research, while also discussing how the field has evolved since Gordon wrote this enduring example of first-rate scientific communication.



Materials for Energy offers a comprehensive overview of the latest developments in materials for efficient and sustainable energy applications, including energy conversion, storage, and smart applications.

Discusses a wide range of material types, such as nanomaterials, carbonaceous electrocatalysts and electrolytes, thin films, phase change materials, 2D energy materials, triboelectric materials, and membrane materials

Describes applications that include flexible energy storage devices, sensors, energy storage batteries, fuel and solar cells, photocatalytic wastewater treatment, and more

Highlights current developments in energy conversion, storage, and applications from a materials angle.





Events in the pipeline

International Conference on Fracture, Damage and Plasticity of Engineering Materials ICFDPEM in November 2022 in Jerusalem

The International Research Conference is a federated organization dedicated to bringing together a significant number of diverse scholarly events for presentation within the conference program. Events will run over a span of time during the conference depending on the number and length of the presentations. With its high quality, it provides an exceptional value for students, academics and industry researchers.

International Conference on Fracture, Damage and Plasticity of Engineering Materials aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Fracture, Damage and Plasticity of Engineering Materials. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Fracture, Damage and Plasticity of Engineering Materials.

<https://waset.org/fracture-damage-and-plasticity-of-engineering-materials-conference-in-november-2022-in-jerusalem>

ICMPEM 2022: 16. International Conference on Mechanical Properties of Engineering Materials

December 09-10, 2022 in London, United Kingdom

Aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Mechanical Properties of Engineering Materials. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Mechanical Properties of Engineering Materials. For details:

[International Conference on Mechanical Properties of Materials \(ICMPM\) \(waset.org\)](https://waset.org/International-Conference-on-Mechanical-Properties-of-Materials-ICMPM)

14th International Conf on Materials Processing and Characterisation, 24-26, March 2023, GRIET, Hyderabad

The role of manufacturing in the country's economy and societal development has long been established through their wealth creation activities. To deepen and broaden our knowledge of materials and to increase innovation and responsiveness to ever-increasing international needs, more in-depth studies of functionally graded materials/ tailor-made materials are needed at present. The objective of this conference is to bring together experts from academic institutions, industries and research organizations and professional engineers for sharing of knowledge, expertise and experience in the emerging trends related to advanced materials processing, and characterization.

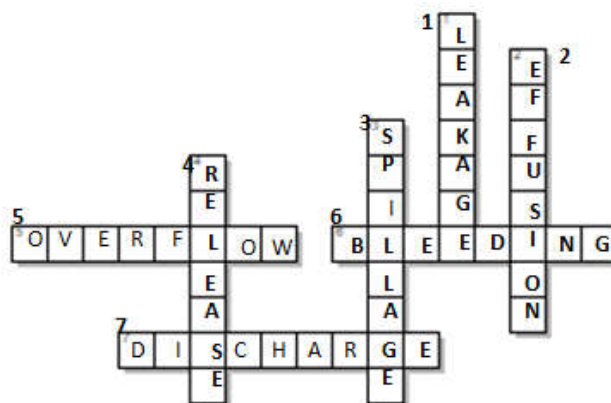
For details see the following link:

https://www.icmpc.com/call_for_papers.php





Answers to the crossword:



Across:

- 5) We, five, sat on floor to witness show as crowd was exuberant [8]
 6) I bend my leg and got injured causing blood come out [8]
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To



From
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 C/O Centre for Military Airworthiness &
 Certification, RCMA (Materials),
 Kanchanbagh
 Hyderabad-550058