

SFA Newsletter

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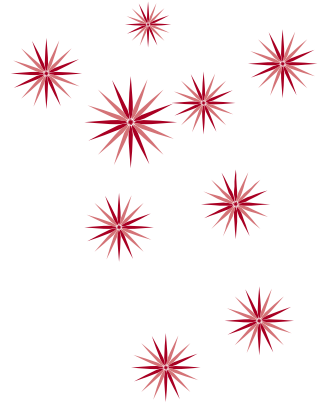
Welcome you all to join as members of SFA! Please find the membership form inside; kindly fill in and contact Secretary of SFA through email.

Experts and experiences

By

Dr Debashis Ghosh,
CMERI, Durgapur

Seasons Greetings!



Message from our President

Dear readers,

Warm greetings to all of you!

The month of May marks the peak of Indian summer when the temperatures start picking to the peak. However, the season is reversed by the end of the year as we witness cold with winter setting in our India. Secondly, the first day of May is dedicated to the work force of our Nation who are the wealth creators by sincerely working on the programmes like Make-in India, Aatm Nirbhar Bharat / Self Reliant India etc. enabling valuable and highly advanced product manufacturing for several subsystems and systems for various sectors. Finally, and definitely not the least, the May 4th was dedicated for the fire fighters' devoted service.

While welcoming the season, SFA cautions the readers to take care of failures that stem from heat and fire in these extreme weather conditions. Further, it is expected in these months, the cooling devices and sub-systems in major engineering systems are likely to fail; especially the Batteries. Hence, it is quite common that we observe power outages in hot weather as the transmission lines snap out due to excess heat. Thermal expansion of steel rails leading to buckling too cause failures, derailments and sometimes, major accidents. Historically the chemical fire that caused metallurgical failure at Flixborough, England in 1975 reminds us all grave dangers that such fires can lead to. It is, therefore essential to take care of engineering systems with regular maintenance and quality assurance. Let us be utmost vigilant. I take this opportunity to wish you all the very best with an emphasis to sustain our hard work with regular upkeep through following quote: "“When we change the way we communicate; we are sure to change the Society!”".

Best wishes

(N. Eswara Prasad)



Dr. N. Eswara Prasad,
FAPAM, FAeSI, FIIM, FInSIS
President, SFA

Best wishes to all the readers!

Edited by: Dr.P.Parameswaran & Dr Swati Biswas on Behalf of Society for Failure Analysis



From the Desk of Editors

Dear Readers:

Season's Greetings! You are glancing through the 25th issue of the Newsletter of Society for Failure Analysis (SFA).

SFA activities during the past one year at the chapters' level were constrained to online mode since March 2020 onwards. Covid-19 pandemic is currently on its second wave spreading around our nation bringing all our activities to a halt, but let us interact through online.

We had a sudden change in the leadership of SFA as our President, Dr. BPC Rao requested the Vice President, Dr. N Eswara Prasad, Outstanding Scientist and Director, DMSRDE, Kanpur to be the Interim President due to many some pressing assignments on hand. On behalf of all of you, we welcome Dr Prasad to do the honours and many may know that Dr. Prasad served SFA as Hon. Joint-Secretary (2009-2012), Secretary (2012-2015) and Vice-President (2015-To Date) to steer our activities in a diligent manner till a new president takes over.

During the last four months, our activities are few which include opening of new chapter at Kottayam, Kerala. Accordingly, the map is updated with the chapter. Also, you would find a

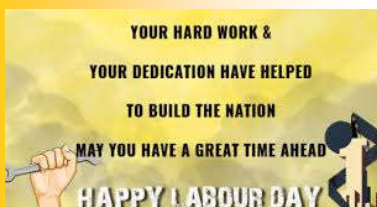
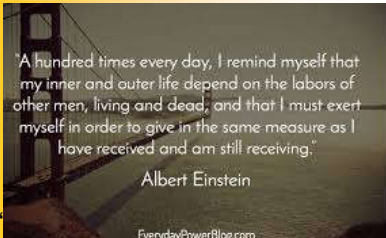
report on the inaugural which was completely an online event.

For the present issue, we solicited articles 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 Debashis, CMERI, Durgapur for sharing the knowledge gained from a case study and 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: param1961@gmail.com; alternatively, post your application with draft to Sri.B Jana, Treasurer, **RCMA**, CEMILAC, Kanchanbagh, Hyderabad, 500 058

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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.





Case study on Metallurgical investigation of Premature Pinion failure in a Helical Gear

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Abstract

A pinion in a helical gear has failed after 20 days of service in engineering industry, which processes grinding ball media. The failure has reduced production margin of the industry and failure was investigated. The pinion was made from EN24 steel supplied in hardened and tempered conditions. However, inclusion in steel have initiated fatigue crack and resulted in failure. EDX mapping evidenced that inclusion was oxide in nature. Metallography confirmed that steel contain tempered martensite structure along with oxide inclusions. It is recommended to select clean steel in gear applications to avoid similar kind of premature failure in near future..

Keywords: Helical gear; Fatigue; Metallography

Special gear like planetary gear have reported failure due to pitting and fatigue cracking in variety of services like aerospace and other earth moving equipments [1, 2]. Gears have experienced fatigue failures in attached shaft [3]. Procedure to analyze the failures especially on gears was reported by Robert [4]. In addition to service failures, the gear failure during manufacturing process was also reported [5]. Helical gears were often used in many industrial applications. The pinion is a critical component in helical gear for transmission of rotational to linear motion. In heavy engineering industries helical gears were often used for transmission of motion in machine for various engineering purposes and its appearance is shown in Fig 1 [6]. The pinion is component attached with helical gear was failed after twenty days of service and it was investigated to find out the root cause of failure. Material specification, geometry and assembly parameters of pinion were provided in Table1. The materials of construction of pinion and mating gear were 817M40 BS: 970/EN24 and IS2644 Grade 2 cast steel (CS 700),

in application of girth gear drive for grinding mill ball media. The EN24 steel grade is promising alloy used in material of construction of pinion. This material possesses excellent balance of strength, toughness and fatigue resistance in fluctuating load conditions for gear applications.

The pinion was manufactured by machining and supplied with applicable heat treated conditions. The close chemistry control and heat treatment process have lead pinion of tempered martensite structure. Similar grades obtained from clean steel were used in various applications like studs and bolts [6, 7]. The pinion failure has lead to temporary stoppage of machine which impact production losses of grinding mill. This study conducts metallurgical failure analysis of fractured pinion using various materials characterization techniques. Suitable recommendations to avoid such failure have been mentioned as countermeasures. The pitting in pinion often extent to repair by metal deposit like buttering of equivalent filler metals and finally machined according to dimensional drawing [4]. However, such methods eventually result in

Be like a
postage stamp.
Stick to one
thing until you
get there.

Dietrich Bonhoeffer

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Fig.1. Appearance of a typical bevel gear

Table.1. Technical Data of pinion

Geometric and assembly parameters of pinion	
Type	Helical
Tooth form	Full depth involutes
Number of teeth	21
Normal module	30
Helix angle	7°
Normal pressure angle	20°
Correction factor	0
Face width	650mm
Pinion outside diameter	694.73mm
Pinion rpm	151.9
Centre to centre distance between gear & pinion	3642.15mm
Motor power	2850kW
Number of teeth of mating gear	220

sudden failure due to inappropriate heat treatment and risk of nucleation of deposition defects. Therefore replacement of pinion was suggested after failure while root cause study understands the cause of failure.

2. Experimental Analysis

Visual inspection was conducted on failed pinion and photographs were documented. The chemical analysis was carried out using a portable

spectrometer (Model: Q4 TASMAN, Bruker, Germany) to estimate the weight percentage of the constituent elements present in the failed pinion sample. The hardness measurements of the metallographic specimens were also carried out using 10 kg load. Tensile test were performed to record the tensile strength and elongation. Metallographic specimens from the failed pinion sample were judiciously selected, sectioned, polished and etched as per the standard





ASTM E-3 2003 and ASTM E 407-2003. All the specimens were examined under optical Microscope for evaluating micro-structural characteristics. The fracture surface was examined using Field Emission Scanning Electron Microscope FESEM attached with Energy Dispersive X-ray analysis (EDX).

3. Results and discussion

The failed pinion sample showed flat and shiny appearance on both sides as shown in Fig 2a. The bottom fracture surface revealed presence of coarse beach marks emanated from a single point source point of fracture initiation, which appears dark Fig 2b. However, deep tool marks/rubbing marks were observed on one face as shown in Fig 2c. Visual examination revealed presence of flat and shiny appearance on side of the failed pinion (refer Fig 2a), whereas the other side has deep tool/rubbing marks (Fig 2c). The presence of deep rubbing/tool marks indicate severe abrasion on one side of the

pinion, which is often not favourable for gear pinion assembly and it might possibly occurred due to some misalignment in the assembly. The bottom fracture surface revealed coarse beach marks emanating from one single point, which appears dark in colour. The presence of beach marks clearly indicates fatigue failure. The chemical compositions are shown in Table 2. Chemical composition conforms to EN-24 Grade. The fracture surface was critically examined using Field Emission Scanning Electron Microscope FESEM. The striation marks are shown in Fig 3(a). The striation marks are very fine [fig 3(a)] further the surface crack origin is also shown in Fig 3(a). Energy Dispersive X-ray analysis was carried out to characterize the chemical constituent of the material near the crack origin and is shown in Fig 3(b). The X ray mapping Of different elements also

Table 2 Chemical composition of pinion

Element (wt %)	C	Si	S	P	Mn	Cr	Ni	Mo	Fe
Failed	0.436	0.226	<0.0005	<0.0071	0.697	1.087	1.747	0.269	bal
Specification*	0.44	0.35	0.04	0.035	0.70	1.40	1.70	0.35	bal

*Maximum

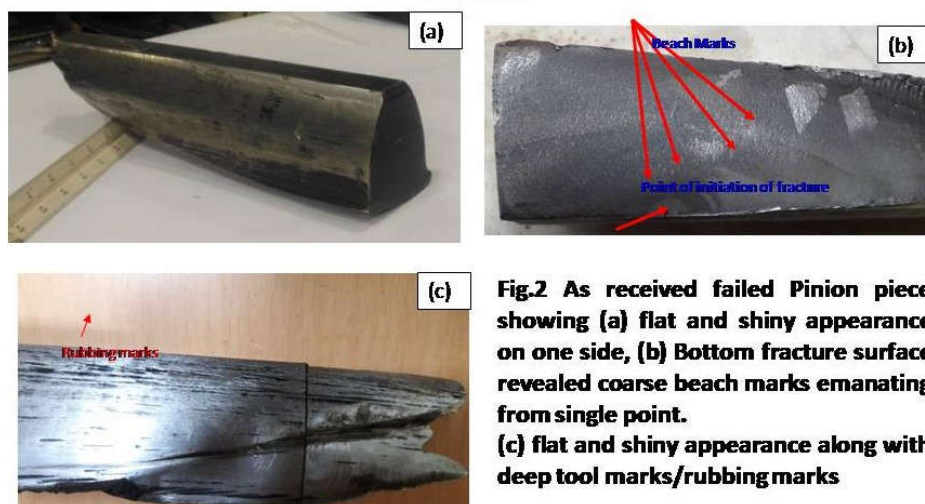


Fig.2 As received failed Pinion piece showing (a) flat and shiny appearance on one side, (b) Bottom fracture surface revealed coarse beach marks emanating from single point. (c) flat and shiny appearance along with deep tool marks/rubbing marks

**NO HUMAN
MASTERPIECE
HAS BEEN
CREATED
WITHOUT
GREAT LABOR.**
ANDRE GIDE





shows presence of oxygen with Fe, Ni and Cr(trace). Un-etched microstructure near the region from which fatigue fracture initiated reveals presence of fine and coarse inclusion (refer **Fig 4a&b**). Few large size inclusions are also observed. The inclusions are both elongated and globular in shape. Presence of large amount of inclusions is unfavourable in metallic material used in dynamic system. The etched microstructure reveals tempered

martensite structure, which is typical of EN-24 material used in Gear and Pinion assembly. Presence of elongated inclusion of 50 μ m can also be seen clearly under etched condition (refer **Fig 4c**). The mechanical characterization of the failed pinion was evaluated for hardness. The hardness of 305Hv at 10 Kg load) matches fairly well with that observed in EN-24 grade material. The tensile strength shows a decrease in materials strength

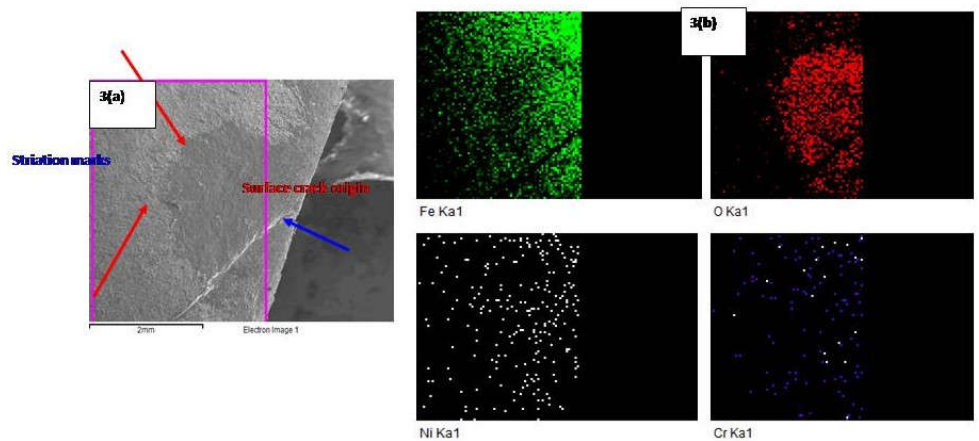


Fig 3: (a) SEM fractograph showing surface crack origin and striation marks adjacent to failure region.(b)EDX mapping on coarse striation marks showing presence of Oxygen with Fe, Ni and Cr(trace).

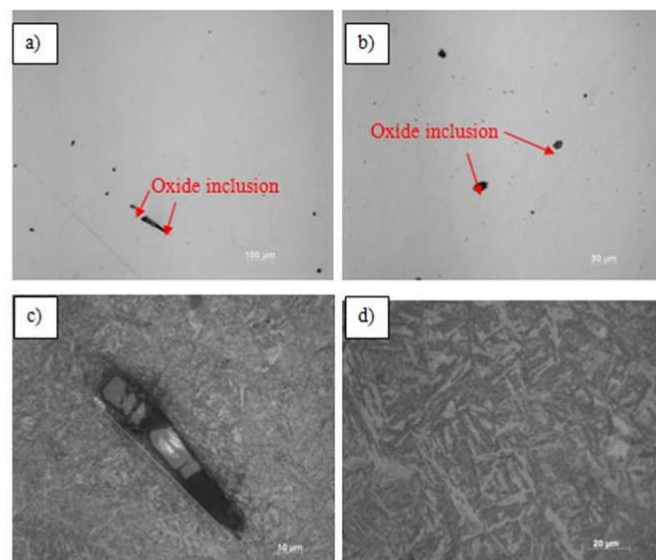


Fig. 4(a &b) Microstructure showing oxide inclusions in un-etched condition (c) oxide inclusions at higher magnification. (d) on etching, microstructure showing tempered martensite away from failure region.





(697 MPa) compared to 800-900 MPa range for EN-24 grade material. The lower strength values are possibly due to high amount of inclusions present. The fracture surface analysis using Scanning Electron Microscope reveals presence of coarse striation marks as shown in Fig 3(a) which corroborates the fact that failure occurred due to fatigue. The initiation point is also examined using EDX mapping analysis as shown in Fig 3(b) and it is found that the initiation point is an oxide inclusion. Presence of surface crack through the inclusion can also be seen. The oxide inclusion was sufficient to cause failure in such a short span of time in the system which resulted in significantly increases stress concentration for failure. Similar results were also obtained by other researchers [2-7,8]

Conclusions

Based on investigation carried out, the following conclusions can be drawn with respect to this failure of pinion.

The failure of the pinion is primarily due to fatigue. Metallographic evaluation indicated a significant distribution of nonmetallic inclusions near the fracture initiation site. From the observed results it can be inferred that material has inherent flaws in terms of its cleanliness (inclusion content). Therefore, it is recommended to give more stress on quality aspect of these classes of materials.

Acknowledgements

This work is financially supported by Technical Service Project (TSP No: 1125) from industry.

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Inauguration of Kottayam Chapter of SFA - online event by Amal Jyothi Engineering College, Kottayam

A new chapter of Society for Failure Analysis was inaugurated on 26/03/2021 through online platform at Kottayam, the central region of Kerala. Dr N Eswara Prasad, Outstanding Scientist and Director, DMSRDE, Kanpur and Vice President, SFA was the chief guest on this special occasion. During his inaugural talk, Dr N Eswara Prasad pointed out the importance of metallurgical failure analysis and how SFA can play a key role in bringing out the real causes of failures. He also expressed his best wishes for the growth of the chapter which has 60 active members at present. Dr. M. D. Mathew, Dr. S. V. S. Narayana Murty, Dr. P. Parameswaran and Dr. Z. V. Lakaparampil were the special invitees for the day. The event was attended by various scientists, faculties, students, research scholars etc. across the country. The program was organized by Department of Metallurgical and Materials Engineering, Amal Jyothi College of Engineering, Kerala.

The AD-HOC Committee for the chapter was selected with Dr. M. D. Mathew (Professor and Dean, Saintgits College of Engineering, Former Scientist and Head, Mechanical Metallurgy Division, IGCAR, Kalpakkam) as the Chairman, Dr. John Felix Kumar (Head of the Department, Department of MME, Amal Jyothi College of Engineering, Kerala) as the vice-chairman, Mr. Vishnu KC (Assistant Professor, Department of MME, Amal Jyothi College of

Engineering, Kerala) as secretary, and Mr. Tony Varghese (Assistant Professor, Department of ME, Amal Jyothi College of Engineering, Kerala) as the treasurer.

Dr. Joby Joseph (Professor, Department of ME, Mar Athanasius College of Engineering, Kothamangalam, Kerala), Mr. Jithin Devasia (Assistant Professor, Department of MME, Amal Jyothi College of Engineering, Kerala), Mr. Manu Harilal (Assistant Professor, Department of MME, Amal Jyothi College of Engineering, Kerala), Mr. Rajeev K Mohan (Assistant Professor, Department of ME, Mangalam College of Engineering, Kerala) and Mr. Rohit Raju (Student, Department of MME, Amal Jyothi College of Engineering, Kerala) were also selected as the Committee members. The inauguration of the chapter and constitution of the committee was followed by three technical talks on failure analysis. Dr. M. D. Mathew shared his vast experience on the mechanical behaviour of materials through his talk on “Mechanical Behaviour of Materials – A Pathway to Failure Analysis”. The theories of mechanical failures and the response of materials towards mechanical loading conditions were discussed in detail. The next talk was by Dr. S. V. S. Narayana Murty (Scientist 'SG' and Deputy Head, Material Characterization Division, Vikram Sarabhai Space Centre, ISRO) on “Metallurgical

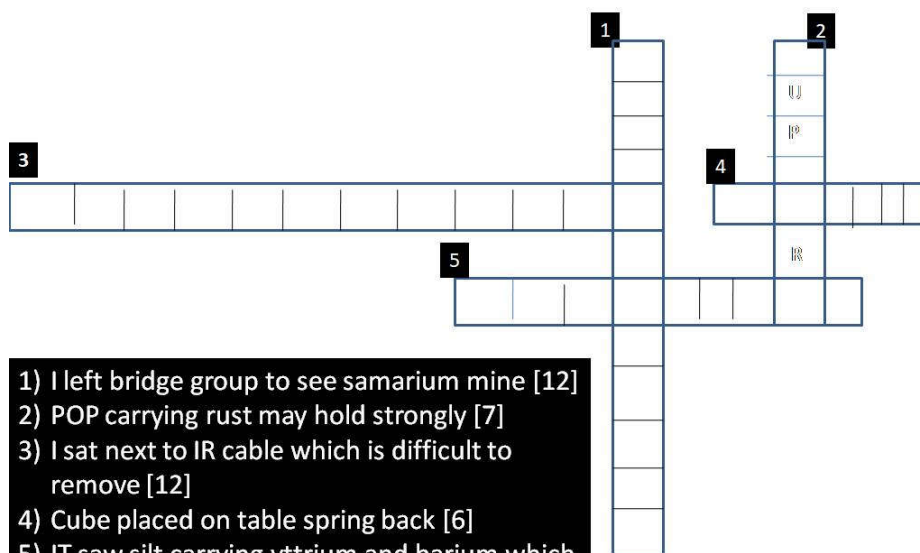




Failure Analysis of Aerospace Components: Musings of a Metallurgist”. Different case studies showcasing the metallurgical failures in space programmes were introduced to the participants. Dr. P. Parameswaran (Formerly Scientific officer/H & Head, Physical Metallurgy Division, Metallurgy & Materials Group, IGCAR, Kalpakkam and also Honorary Secretary, SFA) delivered the next talk on “Microstructure -means to understand engineering failures”. The methods to understand about failures by analysing the microstructure were discussed in detail.



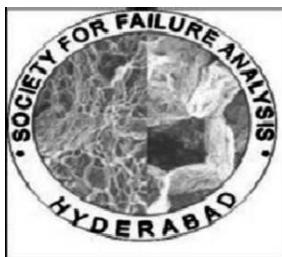
Dr N Eswara Prasad, Outstanding Scientist and Director, DMSRDE, Kanpur and Vice President, SFA pronouncing the opening of the chapter

**CROSSWORD**

- 1) I left bridge group to see samarium mine [12]
- 2) POP carrying rust may hold strongly [7]
- 3) I sat next to IR cable which is difficult to remove [12]
- 4) Cube placed on table spring back [6]
- 5) IT saw silt carrying yttrium and barium which provided strength against tremor often [9]

Answers See page 14





Society for Failure Analysis

Application Form

Society for Failure Analysis

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Hyderabad 550 058

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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)

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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

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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

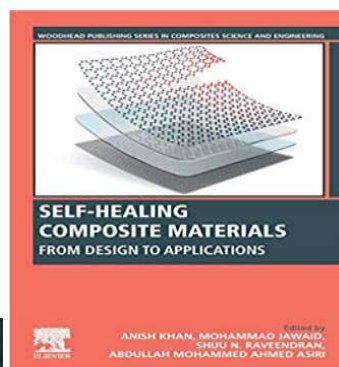
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Books

Self-Healing Composite Materials: From Design to Applications (Woodhead Publishing Series in Composites Science and Engineering) 2019

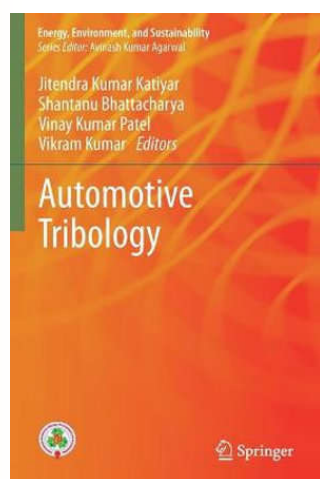
by [Anish Khan](#) (Editor), [Mohammad Jawaaid](#) (Editor), [Shiju N. Raveendran](#) (Editor), [Abdullah Mohammed Ahmed Asiri](#) (Editor)



Self-Healing Composite Materials: From Designs to Applications provides a unique resource on self-healing composites for materials scientists and engineers in academia, as well as researchers involved in the aerospace, automotive, wind-generation, construction, consumer goods and marine industries. There is a huge demand for self-healing composites that respond to their environment like living matter. Unlike other composites, self-healing composites are combined with carbon materials and resins to form a recoverable composite material.

Automotive Tribology

This book presents a comprehensive study of all important aspects of tribology. It covers issues and their remedies adopted by researchers working on automobile systems. The book is broadly divided into three sections, viz. (i) new materials for automotive applications, (ii) new lubricants for automotive applications, and (iii) impact of surface morphologies for automotive applications. The rationale for this division is to provide a comprehensive and categorical review of the developments in automotive tribology. The book covers tribological aspects of engines, and also discusses influence of new materials, such as natural fibers, metal foam materials, natural fiber reinforced polymer composites, carbon fiber/silicon nitride polymer composites and aluminium matrix composites. The book also looks at grease lubrication, effectiveness and sustainability of solid/liquid additives in lubrication, and usage of biolubricants. In the last section the book focuses on brake pad materials, shot peening method, surface texturing, magnetic rheological fluid for smart automobile brake and clutch systems, and application of tribology in automobile systems. This book will be of interest to students, researchers, and professionals from the automotive industry.





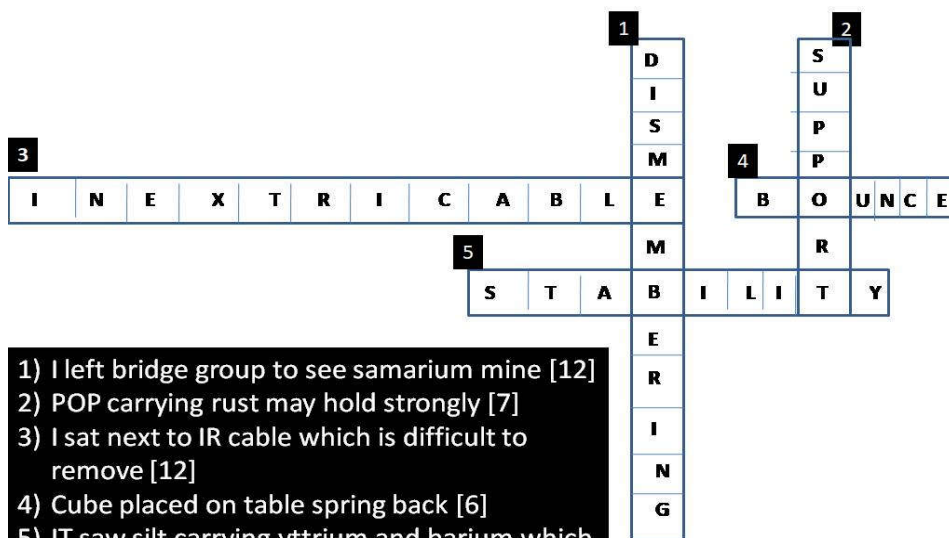
Events in the pipeline



December:

A month of lights, snow, coziness, and feasts; time to make amends and tie up loose ends; finish what you started and make your wishes come true."

Answers to the crossword:



- 1) I left bridge group to see samarium mine [12]
- 2) POP carrying rust may hold strongly [7]
- 3) I sat next to IR cable which is difficult to remove [12]
- 4) Cube placed on table spring back [6]
- 5) IT saw silt carrying yttrium and barium which provided strength against tremors often[9]





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