Issue 24 January 2021

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.Sujatha, Principal Scientist, NAL, Bangalore

Message from our President

Dear readers,

Happy New Year2021! Warm season's greetings! I am happy to find the 24th issue of SFA newsletter getting launched out coinciding with the New Year! Every New Year brings us hope signaling us that we can begin again and emerge positive in the year ahead! Let us begin the year saying that we are not too old to set new goals and dreams.

With this optimism in mind, in the year 2021 that is ahead, we shall make it more meaningful with our commitment to the business we are involved in. While we should be grateful for what we have accomplished but we need not be satisfied. Therefore, setting higher goals, we believe on our skill and ability and working further which would bear fruits if we sustain the same or improved vigour. However, we may experience a fall, and at that time, we should think that we are just coming to terms and accepting a situation. It helps us look to the future and create expansive, evolving realities. Let us promise to leave behind the negativity and vow not to let the difficulties affect us in starting the New Year on a positive note.

While I extend hearty New Year Wishes to You and your near & dear ones and also pray to Almighty for yours Prosperity, Peace, and all Happiness, I recollect the quote:"Tomorrow is the first blank page of a 365 page book. Let us write a good one in the year ahead!"

Best wishes to all the readers!

B P C Rao
PRESIDENT, SFA

Dr. B P C Rao
President, SFA

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

From the Desk of Editors

Dear Readers:

A very Happy New year 2021 and Season's Greetings! You are glancing through the 24th issue of the Newsletter of Society for Failure Analysis (SFA).

SFA activities are during the past one year at the chapters level was constrained to online mode since March 2020 onwards, Covid-19 pandemic started spreading around our nation bringing all our activities to ahalt initially and it took some time to restore our interactions but through online.

We had an opportunity to exchange and interact with Failure Analysis Society of ASM, again through online for a possible interaction or joint-organisation of events in the future. However, we could not realise much as we had to indefinitely postpone our planned event-NCFA 2020.

SFA newsletter was released once during September 2020.

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 Dr.Sujatha, Senior Principal Scientist, CSIR-NAL, Bangalore for her excellent contribution "failure analysis of a condenser tubes of a captive power plant", which you would find 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. Therefore, as always, your views and comments, mailed to param1961@gmail.com are welcome. We wish you all success free of failures and a joyful life!

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

Kalpakkam

31-01-2021 (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:param@igcar.gov.in; alternatively, post your application with draft to Sri.B Jana, Treasurer, ***RCMA,*** *CEMILAC, Kanchanbagh, Hyderabad, 500 058*

Aims and Objectives of Society for Failure Analysis

The aims and objectives of the Society shall be:

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

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

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

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

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

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

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

To cooperate with other professional bodies having similar objectives.

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

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

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

Failure analysis of surface condenser tubes of a captive power plant

M. Madan, K. Raghavendra and M. Sujata*

Materials Science Division, National Aerospace Laboratories, Council of Scientific and Industrial Research (CSIR), Bangalore 560017, INDIA

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Abstract

This article deals with failure analysis of admiralty brass tubes of a surface condenser used in a captive power plant of a petrochemical industry. The failure was witnessed in the form of leaks from the tubes involving perforations and cracking. The mode of failure was identified as dezincification of brass tubes by corrosion because of presence of chloride ions in the cooling water beyond the permissible limit. A detailed analysis of the failure is presented and recommendations to prevent similar failures are suggested.

Keywords: surface condenser; admiralty brass tubes; perforations; dezincification

1. Introduction

Failures in pipelines/tubes in petrochemical industries are common and they result in leaks of process fluids, water and steam leading to unplanned shut down of plants. Among the various types of failures encountered in petrochemical industries, corrosion and environment assisted failures are widespread and they account for more than 50% of the total failures [1]. Corrosion in metals/alloys results from several factors, and the interacting chemical species in the environment to which the metals/alloys are exposed to play a dominant role. Depending on the environmental conditions, corrosion can occur in various forms, namely, uniform corrosion, pitting corrosion, galvanic corrosion, stress corrosion cracking etc. [2-3,4-6].

This article deals with failure in a surface condenser unit of a captive power plant of a petrochemical industry. The tubes of the condenser were made of admiralty brass of nominal composition 70.4Cu-28.4Zn-1.2Sn (wt.%). While majority of the corrosion related failures in brass are associated with dezincification, stress corrosion cracking, erosion-corrosion and corrosion fatigue, dezincification is reported to be more common mechanism of failure in condenser brass tubes [7-10].

2. Investigation of failure

2.1. Background

Repeated incidences of leaks were observed in the condenser unit of a power plant of a petrochemical industry. The condenser unit was used to condense the low-pressure steam from steam turbines and subsequently, the condensate collected in the hot well was pumped out to the de-aerator using condensate extraction pumps. A total of 5560 tubes of length 5.8 m each were used in the condenser and the tubes were made of admiralty brass. The operating parameters of the condenser are given in Table 1. Subsequent to the incidents of leaks, eddy current testing and hydro testing revealed that there were damages to a large number of tubes involving cracking, perforations and reduction in tube-wall thickness.

2.2. Laboratory observations

A typical damaged condenser tube with a perforation is shown in Fig.1(a).

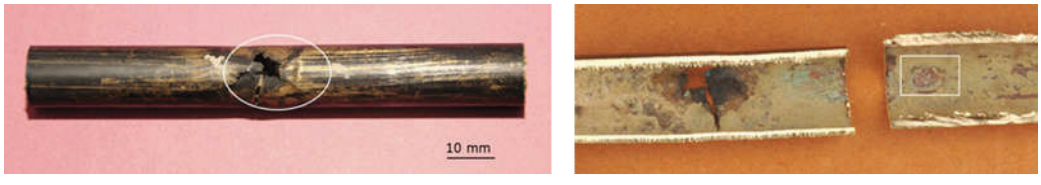
The tube sample was sectioned longitudinally for examination of the inside surface. Figure 1(b) shows inside surface of the tube at the perforated region. The outside surface was unaffected but the inside surface was covered with a thick layer of scale/corrosion products. Examination revealed that the perforation in the tube occurred because of localized corrosion on inside surface (Fig.2(a)).

Surrounding the perforation, the tube surface had reddish brown colour and porous, brittle appearance. The surface also contained patches of greenish deposits. Because of thinning of the tube-wall at the affected region, there was generation of cracks in the tube. Apart from the perforation, inside surface of the tube had innumerable number of deep corrosion pits and a typical one is shown in Fig.2(b) and Fig.3(a). The surface of the pit was covered with greenish and/or brownish powdery material. In-situ composition analysis showed that in the surrounding regions of the perforation and inside the corrosion pits, the tube material was depleted in Zn and contained substantial quantity of corroding element such as Cl. The corrosion products contained mainly copper oxide and copper chloride (Fig.3(b) and Table 2). Microstructural examination confirmed that corrosion was associated with chloride attack along the grain boundaries as well as loss of zinc from the tube material (Fig.4 and Table 3).

The tube material showed twinned grains of α brass and possessed hardness in the range 97-121 HV0.5. It conformed to the specification (Table 2) and there were no metallurgical abnormalities that could have resulted in the failure.

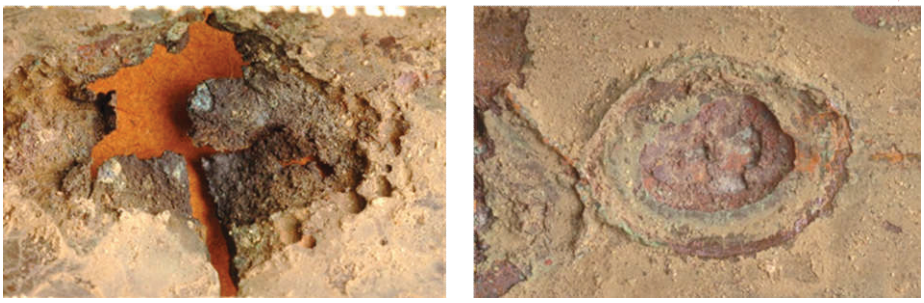
Table 1: Operating parameters of the surface condenser

	Operating conditions	Design specification
Shell side (Service: Turbine exhaust steam)		
Temperature (^{0} C)	46	100
Pressure (kg/cm^2)	0.1	1.1
Tube side (Service: Cooling water)		
Temperature (^{0} C)	42	80
Pressure (kg/cm^2)	4.5	5.0
Cooling water parameters		
pH	7.9	-
Composition	Chlorides: 1243.8 ppm Phosphate: 14 ppm	-



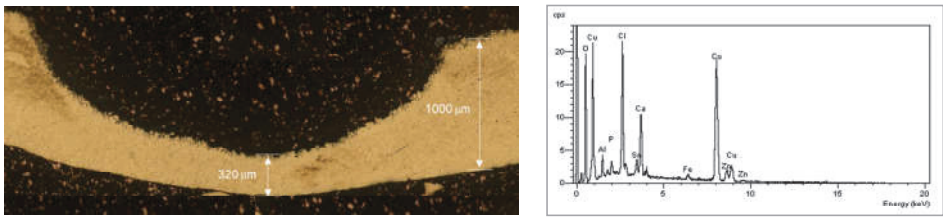
(a) (b)

Figure 1: (a) Sample of a surface condenser tube having a perforation (encircled), and (b) water-side surface of the condenser tube at damaged region



(a) (b)

Figure 2 (a) Magnified view of the perforation on the water-side surface, and (b) a corrosion pit in the region marked in Fig.1(b)

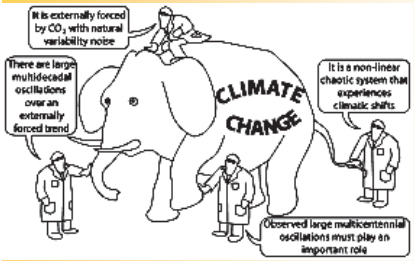


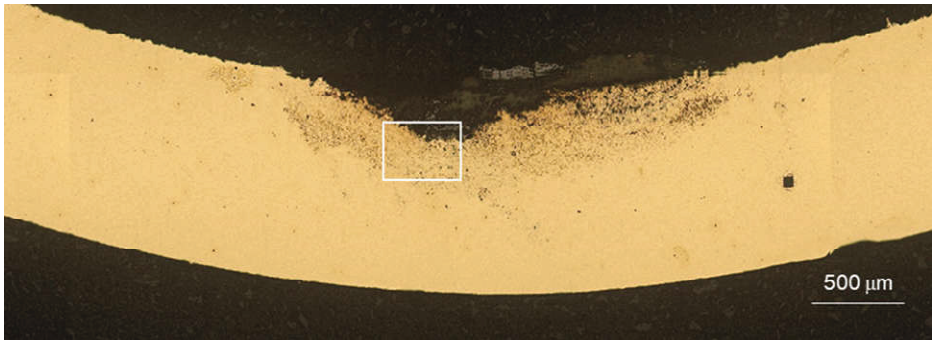
(a) (b)

Figure 3: (a) Optical micrograph of the transverse section of the tube at a typical pit shown in Fig.2(b); note no damage to the outer surface of the tube, and (b) energy dispersive X-ray spectrum recorded at the corroded region shown in Fig.2(a).

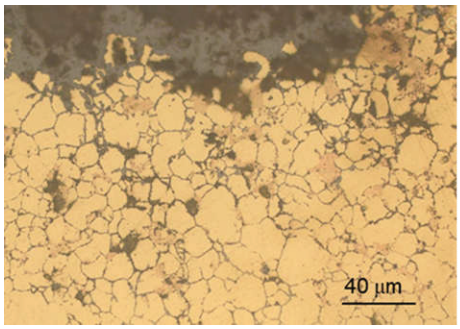
Table 2: Semi-quantitative chemical analysis of the tube material and, corrosion products inside a typical pit and adjacent to perforated region

Element	Composition, wt.%			
	Specification	Tube material	Inside the pit	Adjacent to perforated region
O	-	-	31.3	27.4
Al	-	-	0.3	1.6
Si	-	-	0.8	0.3
P	-	-	1.3	0.9
Cl	-	-	12.5	8.8
Ca	-	-	-	4.5
Fe	-	-	0.8	0.8
Cu	70.0 – 73.0	70.4	48.2	47.0
Sn	0.9 – 1.2	1.2	3.6	3.3
Zn	Remainder	28.4	1.2	5.4

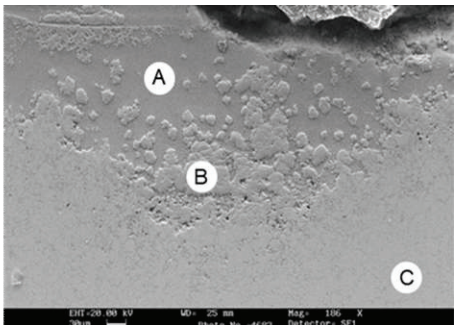




(a)



(a)



(b)

Figure 4: Micrographs (unetched) of transverse section of the tube showing (a) corrosion pit and copper chloride (dark grey region) on the pit surface, (b) chloride attack along the grain boundaries, and (c) secondary electron image of the region marked in (a)

Table 3: Semi-quantitative chemical analysis of the tube material adjacent to a pit (Fig.4(c))

Location	Composition, wt.%					
	Cu	Zn	Sn	P	Cl	O
Region-A	60.0	1.1	2.3	0.4	26.2	10.0
Region-B	81.1	-	-	-	4.8	14.1
Region-C	70.4	28.4	1.2	-	-	-

2.3. Discussion

Investigation showed that failure in the condenser tubes was associated with corrosion on the water-side surface. Corrosion occurred in localized regions leading to formation of pits of varying depths. In some cases, the loss of material resulted in puncturing of the tube leading to leakage of water during service. The progressive loss of material by corrosion led to thinning of the tube-wall as well as generation of multiple cracks. In some locations, the cracks progressed circumferentially in the tubes.

From the evidences, it was apparent that the failure in the condenser tubes was associated with degradation of material due to dezincification in localized regions. Dezincification of brass is a process in which Zn is selectively leached out leaving

behind patches of reddish-brown porous Cu and Cu oxide layer. This porous copper layer is depleted in mechanical strength and it is continuously removed from the tube surface by the flowing water. Once the Cu-layer is removed, fresh metal surface gets exposed to corroding element and the dezincification process continues. As a result, the affected regions penetrate deep into the tube-wall leading to formation of punctures/holes [2-3, 7].

The factors that affect dezincification in brass are alloy composition and water chemistry. Brasses with 15-30% Zn are known to be susceptible to dezincification in marine as well as fresh water environments [7-10]. As far as water chemistry is concerned, dealloying or dezincification is mainly promoted by ammonia containing solutions, sodium nitrite solutions, and dilute acidic solutions. Dezincification is also a frequent failure mechanism in brass tubes handling water contaminated with chloride ions [3,7]. In the failed condenser tubes, the affected regions showed presence of high amount of Cl inside the corrosion pits as well as in the corrosion products. The source of Cl could only be the cooling water in this case. There are generally two accepted theories on the mechanism of dezincification in brass, namely, singular mechanism and dual mechanism. However, under certain conditions, singular mechanism is operative when cooling water contains chloride ions [7]. Although both Cu and Zn react with chloride ions, the reactivity of Zn with chloride ions is higher than that of Cu. Also, solubility of zinc chloride is significantly higher in water than that of copper chloride. As a result, leaching of Zn preferentially takes place from brass in chloride ions containing water leaving behind copper chloride deposit which often appears as greenish colour dehydrate on the tube surface.

3. Conclusions and Recommendations

The failure in the surface condenser tubes was a result of loss of material from the water-side surface by corrosion. Dezincification of brass was the mechanism by which the failure occurred. Evidences suggested that high concentration of chloride ions in cooling water was responsible for the failure.

It was recommended that the surface condenser tubes be replaced by new ones since the damages were very severe in nature and beyond repair. To prevent recurrence of similar failures, cooling water sample analysis on regular intervals, and maintenance of chloride and ammonia contents in the boiler water within the specified limit were suggested.

Acknowledgements

The work reported in this article was financially supported by CSIR-National Aerospace Laboratories, Bangalore, India vide Project No. M-1-298.

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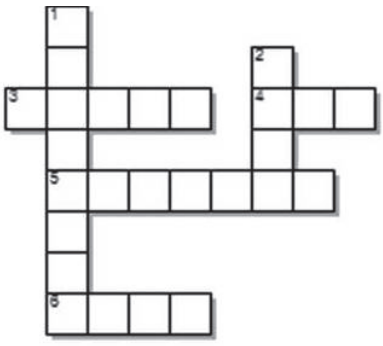
Cross word puzzle involving terminology of structural failures



1D) Batsman added good runs with an action of removing tenacious pitch
2D & 4 A) Pitch of 4th day looks good for spin
3A) unexpected turn of ball by this nature of patches on ground
5A) Polishing to improve shininess of ball
6A) batsman seeing bouncer bite his teeth

See page 20 for answers:

Experiences in Engineering Failure Analysis

SFA, Chennai Chapter alongwith IIM,Kalpakkam organised online half day theme meeting on Experiences in Engineering Failure Analysis on 28th January 2021 in coincidence with the superannuation of Dr..P.Parameswaran, Head, PMD, IGCAR, Kalpakkam who has been serving as Honaray Secretary of SFA taking care of its activities overall in India in coordination with Chapters and also as Vice Chairman of Chennai Chapter. The theme meeting was attended online across the country by many and by local IGCAR scientists, engineers and scholars.

The presentations by Dr S A Krishnan brought out the important aspects

Sri P K Parida, Scientist at PMD brought a lucid case study of failure that occurred in tube making of ODS alloy. The experience gained was useful further when the 18CR ODS tube was recently made.

The presentations by Dr S A Krishnan brought out the important aspects

The plastic collapse and fracture type of failure modes in AISI type 316LN stainless steel pipe subjected to four point bend loading have been discussed. The eXtended-FEM predictions based on continuum fracture parameters obtained from specimen level experiments have been demonstrated for fracture prediction in pipes.

A close agreement between prediction and experiments have shown that the proposed coupled experimental-numerical methodology could be extended to other components.

The talk by Sri Surya Prakash of Kuwait Oil Company brought out leakage incidence and how choice of a higher grade steel instead of what is recommended would cause a leak as the heat treatment procedures are different when welding is involved for high alloy steels.

Shree S. Surya Prakash made a presentation on Crack on HAZ of Welding Joint in Crude Flowline.It brought out a case of mix up of materials during the construction phase of a facility and it's deliterous effect during service of the plant. The subject case detailed on a crack on Haz of a welding joint that has occurred after 11 years in dry sour crude service.

The welding joint during the construction phase was done joining a API 5L Gr B standard spool to a non standard low alloy steel spool. This mix up led to leaving behind lack of fusion at the root coupled with Hydrogen gas entrapped in the solidified weld spool.

The two phenomena caused a crack to initiate and subsequent HIC in martensitic phase on Haz of non standard grade aided the crack to propagate through thickness over time leading to loss in containment and resulting in production loss coupled with HSE issues.

It was recommended to have standard colour code for different materials and close control on PMI in all incoming materials during any project stage

Prof Raghu V Prakash , IITMadras brought out the importance of measuring striations spacing through microscopy and

quantification of the blocks of cycles to understand fatigue loading and subsequent modelling.

The last presentation was by Dr.Parameswaran who brought out the evolution in microstructure when engineering materials are exposed to temperature, stress and radiation and explained how a possible microstructural parameter –either a change in chemistry or incidence of lave phases or defects like formation of voids could be employed to understand and monitor the degradation of a component like wrapper in a fast breeder reactor. He also emphasized that a similar exercise could do good to understand the state of the material when it is exposed in laboratory simulated aggressive environment which represent a reactor condition.

Finally vote of thanks was proposed by Dr S A Krishnan, Secretary, SFA Chennai chapter.

Dr Shaju K Albert, Director, Metallurgy & Materials Group handing over IGCAR memento to Dr.Parameswaran on the occasion of his superannuation from IGCAR

Dr B P C Rao, President, SFA and Direcotr, FRFCF, IGCAR handing over a memento to Dr.Parameswaran on the occasion of his superannuation from IGCAR

Society for Failure Analysis

Application Form

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

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

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

1. **Name in Block Letters**

   First Middle Last
2. **Date of birth**
3. **Father's Name/ Husband's Name**
4. **Present Occupation /Designation and office address:** | **Phone:** **Mobile:** **Fax:** **Email:**
5. **Academic & Professional Qualifications**:
6. **Home address:** | Phone: Mobile: Fax: E-mail

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

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

Name	Membership No.	Signature

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

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

10. **Name of the Chapter you intend to be attached**_____
    (Please refer to Chapters' list)
11. **Subscription details:**
    Payment should be made by cheque / DD favoring **"Society for Failure Analysis"**, payable at Hyderabad. Outstation cheques not accepted.

Amount Rs. Cheque / D.D. No Dated

Bank Name Branch

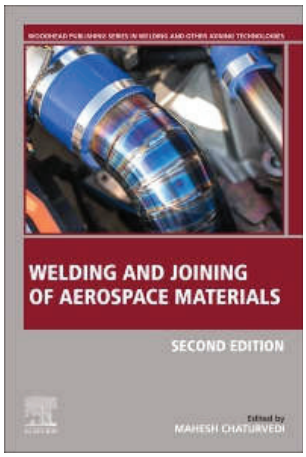
Category	Amount Payable		
	Admission Fee (One time)	Yearly Subscription	Total on joining
Student Member	NIL	Rs 200	Rs.200/-
Life Member	NIL	Rs 2000	Rs.2000/-

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



Welding and Joining of Aerospace Materials

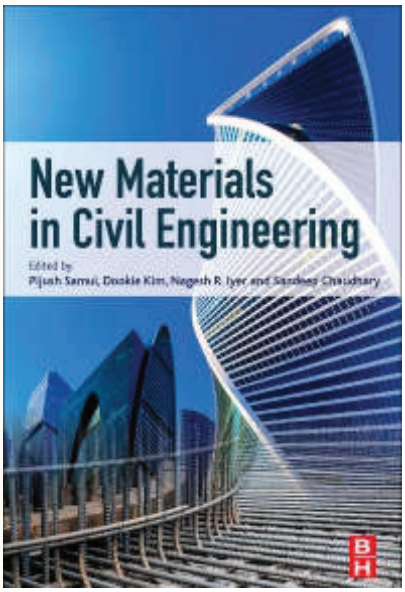
2nd Edition

Editors: Mahesh Chaturvedi

Imprint: Woodhead Publishing

Published Date: 1st July 2020

Page Count: 560



New Materials in Civil Engineering
1st Edition
Editors: Pijush Samui Dookie Kim Nagesh Iyer Sandeep Chaudhary
Imprint: Butterworth-Heinemann
Published Date: 23rd July 2020
New Materials in Civil Engineering provides engineers and scientists with the tools and methods needed to meet the challenge of designing and constructing more resilient and sustainable infrastructures. This book is a valuable guide to the properties, selection criteria, products, applications, lifecycle and recyclability of advanced materials. It presents an A-to-Z approach to all types of materials, highlighting their key performance properties, principal characteristics and applications. Traditional materials covered include concrete, soil, steel, timber, fly ash, geosynthetic, fiber-reinforced concrete, smart materials, carbon fiber and reinforced polymers. In addition, the book covers nanotechnology and biotechnology in the development of new materials.
No. of pages: 1104
Language: English

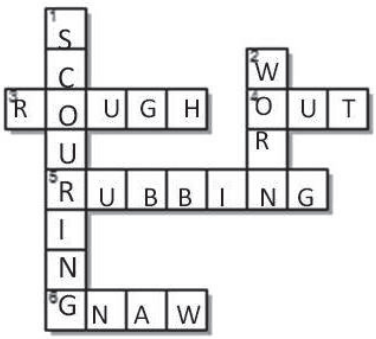
Events in the pipeline

8th International Conference on Creep, Fatigue & Creep-Fatigue Interaction: 24-27 August, 2021, Hotel Radisson Blu Resort Temple Bay, Mamallapuram, Tamil Nadu

Scope of the Conference

The challenges involved in addressing the growing global energy demands with reduced greenhouse emissions have to be met by advanced fission and fusion nuclear reactor systems and fossil-fired ultra supercritical power plants, all of which involve complex technologies and operating environments that raise new challenges for materials development and understanding of their mechanical behaviour. Performance of materials under creep, fatigue and combined creep-fatigue loadings is of utmost concern in the design, operation and reliability of high temperature components.. CF-8 aims to bring together experts working in the areas of creep, fatigue and creep-fatigue interaction, development of high temperature creep and fatigue resistant materials and life assessment so as to facilitate mutual interaction and exchange of knowledge and experience.

Answers to the crossword:



1D) Batsman added good runs with an action of removing tenacious pitch
2D & 4 A) Pitch of 4th day looks good for spin
3A) unexpected turn of ball by this nature of patches on ground
5A) Polishing to improve shininess of ball
6A) batsman seeing bouncer bite his teeth

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