



Investigation on Heat Exchanger Pipe Failure

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Abstract Convection heat exchangers are commonly used for heat transfer in high-temperature furnaces and processes. Pipes from U-bundles of a convection section of a MIDREX direct reduction ironmaking unit heater which carries reducing gas have been investigated for failure analysis. Repeated failures had occurred at a specific location. Samples of the failed pipe were subjected to microscopic and metallographic characterization. Inner diameter erosion and metal dust, carbides, oxides, and carbon were found at the failure location. Optical microscope revealed severe carburization on the inner surface that was in contact with heat exchanger gas. Coarse carbides at the grain boundaries accelerated the wear and corrosion by intergranular cracking. The reducing gas composition (with CO), dust composition (with carbides), and exposed temperatures (> 400 °C) confirmed that metal dusting is the cause of the failure. The high-temperature corrosion of steel is caused by hydrocarbon gases which form thermodynamically metastable carbides of the base metal. Such failures can be avoided by maintaining the pipe surface temperatures below 400 °C or using pipes manufactured from high-temperature-resistant steels.

Keywords Convection heat exchanger · Corrosion · Metal dusting

Background

JSW Steel has a 1.2 million ton per annum (Mtpa) direct reducing iron (DRI) plant based on the MIDREX process at its Vijayanagar, India works. It utilizes Corex gas to produce hot DRI for subsequent use in an electric arc furnace. Corex is a smelting reduction process which produces molten hot metal and generates high caloric export gas. In the DRI process, the Corex export gas and recirculated top gas from the MIDREX shaft furnace are mixed and compressed and subjected to a process to remove CO₂. The gas is then heated to the required process temperature in a convective heat exchanger. This heated gas is then used for the direct reduction of iron ore pellets in the MIDREX shaft furnace. The convective heat exchanger where the gas is heated is a cross-flow, unfinned tubular heat exchanger system where the reducing gas consisting primarily of CO and H₂ (54% CO, 30% H₂, 6% CO₂, 2% H₂O, and 1.5% CH₄) at 1.5 bar pressure is heated from 40 to 460 °C. The heat exchanger is a box-shaped chamber with a burner and combustion chamber at one side and an exhaust line on the other side. The heated air flows through four U-shaped tube bundles as shown in Fig. 1. The gas to these tube bundles is supplied by interconnected headers. Several grades of steel are used in different bundles based on its distance from the burner and combustion chamber and the exposed temperature. Puncturing and thinning of these heat exchanger tubes have been reported primarily in bundles 2 and 3. The failed steel tubes are of ASTM-A335-P11 grade having wt.% as 0.012% C, 0.45% Mn, 0.4% Si, 1.25% Cr, 0.5% Mo with the initial thickness of 4.4 mm. These pipes were designed for long life, and such premature failures are an unexpected phenomenon that has not been previously reported. Erosion problems on the outside of tubes resulting from impingement of wet, high-velocity gases such as

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Heat Exchanger Failure Investigation Report

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Heat Exchanger Failure Investigation Report:

Heat Exchanger Failure Austin Mwana, 2018-06-11 Academic Paper from the year 2018 in the subject Engineering Metal Engineering Metal Processing Metal Structure grade B Robert Gordon University Aberdeen course Oil and Gas Engineering language English abstract As a Corrosion Expert this report centred around the failure investigation of a shell and tube heat exchanger due to corrosion mechanisms The different types of corrosion its effect resulting to the failure and possible solutions and recommendations were submitted to the client for further action The report also sheds light on the alloys used for the design and better alternatives to be used to prevent future degradation of the shell and tube heat exchangers

Heat exchanger failure investigation report Ataliba Miguel, 2014-03-10 Technical Report from the year 2013 in the subject Materials Science grade B Robert Gordon University Aberdeen course MSc Oil and Gas Engineering language English abstract A high pressure gas cooler located in an offshore platform have been operating for more than 10 years Throughout that period the gas cooler have been subjected to several tube failures the failures have caused gas leak from the tube side Several materials upgrades have been used to contain the tube failure The last choice was to use a more corrosion resistant material Hastelloy C22 Crevice corrosion has been reported as the primary failure mechanism The tube and tube plate joined surfaces have been exposed to high temperature which is relatively higher than the critical crevice temperature of Hastelloy C22 There was a poor heat transfer between the shell side fluid and tube side due to a small heat transfer area and low fluid velocity in the affected zone Stress corrosion and fatigue corrosion accounted for the secondary failure mechanism which ultimately caused a crack in the tubes Other possible reason identified to cause crevice corrosion was the mechanical rolling expansion technique Oftentimes it creates rear crevices on the tubes with enough geometry to develop crevice chemistry Mitigation methods such as hydraulic expansion technique heat treatment for residual stresses and baffle design enhancements have been proposed in this report Key words shell and tube heat exchanger failure Hastelloy C22 material tube failure localized corrosion crevice corrosion internal pitting corrosion Interior, Environment, and

Related Agencies Appropriations for 2018 United States. Congress. House. Committee on Appropriations. Subcommittee on Interior, Environment, and Related Agencies, 2017 **DP**, 1962 **Scientific and Technical Aerospace Reports**, 1995

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assessment and structural damping evaluation using this model *Process Safety for Engineers* CCPS (Center for Chemical Process Safety),2022-04-12 Process Safety for Engineers Familiarizes an engineer new to process safety with the concept of process safety management In this significantly revised second edition of Process Safety for Engineers An Introduction CCPS delivers a comprehensive book showing how Process Safety concepts are used to reduce operational risks Students new engineers and others new to process safety will benefit from this book In this updated edition each chapter begins with a detailed incident case study provides steps that help address issues and contains problem sets which can be assigned to students The second edition covers Process Safety including an overview of CCPS Risk Based Process Safety Hazards specifically fire and explosion reactive chemical and toxicity Design considerations for hazard control including Hazard Identification and Risk Analysis Management of operational risk including management of change In addition the book presents how Process Safety performance is monitored and sustained The associated online resources are linked to the latest online CCPS resources and lectures **Guidelines for Process Safety Knowledge Management** CCPS (Center for Chemical Process Safety),2024-03-12 Use this guideline to develop an effective Process Safety Knowledge Management system When managing the risks of hazardous materials and energies a well developed process safety program is critical for maintaining a healthy workforce for protecting the environment and for sustaining the business The Center for Chemical Process Safety CCPS has identified Process Knowledge Management as one of its twenty Elements in its Risk Based Process Safety RBPS approach With an effective Process Safety Knowledge Management PSKM system an organization will be able to capture organize maintain and access its technical engineering and administrative information Thus an effective PSKM system will help an organization successfully manage its risks This book provides a set of comprehensive guidelines for implementing a Process Safety Knowledge Management PSKM system which will help an organization improve its process safety performance The book begins with a discussion on the characteristics of a PSKM system Then it describes the underlying factors for successful implementation and ends with guidance on overcoming common implementation difficulties Produced by a leading global process safety organization this book is essential for any organization looking to ensure that systems are in place to sustain their process safety knowledge during the life of the process Guidelines for Process Safety Knowledge Management readers will also find Case studies throughout the book with PSKM related lessons Detailed discussions of how a PSKM system helps cultivate leadership improves organizational culture and involves employees A business case for PSKM demonstrating the benefits to the business Guidelines for Process Safety Knowledge Management is ideal for process safety professionals engineering managers facility managers maintenance managers production managers and others responsible for creating or managing their process safety knowledge management systems [Introduction to Process Safety for Undergraduates and Engineers](#) CCPS (Center for Chemical Process Safety),2016-06-27 Familiarizes the student or an engineer new to process safety with the concept of process safety management Serves as a comprehensive

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Heat Exchanger Failure Investigation Report: Bestsellers in 2023 The year 2023 has witnessed a remarkable surge in literary brilliance, with numerous engrossing novels captivating the hearts of readers worldwide. Lets delve into the realm of bestselling books, exploring the fascinating narratives that have charmed audiences this year. Heat Exchanger Failure Investigation Report : Colleen Hoover's "It Ends with Us" This poignant tale of love, loss, and resilience has gripped readers with its raw and emotional exploration of domestic abuse. Hoover skillfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Uncover the Best : Taylor Jenkins Reid's "The Seven Husbands of Evelyn Hugo" This captivating historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reid's captivating storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Heat Exchanger Failure Investigation Report : Delia Owens "Where the Crawdads Sing" This captivating coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens crafts a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These popular novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of engaging stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a exceptional and thrilling novel that will keep you wondering until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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Table of Contents Heat Exchanger Failure Investigation Report

1. Understanding the eBook Heat Exchanger Failure Investigation Report
 - The Rise of Digital Reading Heat Exchanger Failure Investigation Report
 - Advantages of eBooks Over Traditional Books
2. Identifying Heat Exchanger Failure Investigation Report
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Heat Exchanger Failure Investigation Report
 - User-Friendly Interface
4. Exploring eBook Recommendations from Heat Exchanger Failure Investigation Report
 - Personalized Recommendations
 - Heat Exchanger Failure Investigation Report User Reviews and Ratings
 - Heat Exchanger Failure Investigation Report and Bestseller Lists
5. Accessing Heat Exchanger Failure Investigation Report Free and Paid eBooks
 - Heat Exchanger Failure Investigation Report Public Domain eBooks
 - Heat Exchanger Failure Investigation Report eBook Subscription Services
 - Heat Exchanger Failure Investigation Report Budget-Friendly Options
6. Navigating Heat Exchanger Failure Investigation Report eBook Formats
 - ePub, PDF, MOBI, and More
 - Heat Exchanger Failure Investigation Report Compatibility with Devices
 - Heat Exchanger Failure Investigation Report Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Heat Exchanger Failure Investigation Report
 - Highlighting and Note-Taking Heat Exchanger Failure Investigation Report
 - Interactive Elements Heat Exchanger Failure Investigation Report
8. Staying Engaged with Heat Exchanger Failure Investigation Report

- Joining Online Reading Communities
- Participating in Virtual Book Clubs
- Following Authors and Publishers Heat Exchanger Failure Investigation Report
- 9. Balancing eBooks and Physical Books Heat Exchanger Failure Investigation Report
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Heat Exchanger Failure Investigation Report
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Heat Exchanger Failure Investigation Report
 - Setting Reading Goals Heat Exchanger Failure Investigation Report
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Heat Exchanger Failure Investigation Report
 - Fact-Checking eBook Content of Heat Exchanger Failure Investigation Report
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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