Research Scholar, Casting Research Centre
Department of Metallurgical and Materials Engineering
National Institute of Technology, Karnataka, Surathkal, India
Ph- +91-9482017365
Email: s.agarwala16@gmail.com

SWATI AGARWALA

CAREER OBJECTIVE

To learn, work and grow in a challenging and dynamic research environment with an opportunity to utilize my knowledge and skills to perform up to the expectations of the team and use it successfully for the education and betterment of the society.

EDUCATIONAL QUALIFICATIONS

2016 – Present: Doctor of philosophy (Ph.D.) (ongoing)

- **University:** National Institute of Technology, Karnataka, India
- **Department :** Metallurgical and Materials Engineering
- **Specialization:** Thermal Energy Storage Materials
- **CGPA:** 10 (coursework)
- **Supervisor:** Dr. K. Narayan Prabhu (Professor)
- **Research topic:** "Development and characterization of the low temperature phase change materials for thermal energy storage applications."
- **Thesis submission:** June, 2021

2012- 2014 : Master of Technology (M. Tech)

- **University:** National Institute of Technology, Karnataka, India
- **Department :** Metallurgical and materials engineering
- **Specialization:** Process metallurgy
- **CGPA:** 9.56 (topper and gold medalist)
- **Supervisors:** Dr. Mike Tan (Professor, Australia) and Dr. A.O. Surendranathan (Professor, India)
- **Research topic:** "An alternate way of cleaning the heat tint of stainless steel weldments in desalination plants" at **Institute for Frontier Materials, Deakin University, Geelong, Australia**

2006-2010 : Bachelor of Technology (B. Tech)

- **University:** Biju Pattnaik University of Technology, Rourkela, India
- **College:** Orissa Engineering college, Bhubaneswar, India
- **Department :** Mechanical Engineering
- **CGPA :** 8.23

WORK EXPERIENCES

July 2014 – July 2016 : Assistant Professor- Trident Academy of Technology, Bhubaneswar, Odisha, India

- Handled subjects of **heat transfer, thermodynamics and strength of materials** for engineering students.
- Undertook lab responsibilities of **workshop** and **design**

July 2010 – June 2011 : GET – UltraTech Cement Ltd, Raipur, Chhattisgarh, India

- Handled the **manufacturing and maintenance** department of **pyro section**
- An active member of the **annual preventive maintenance shutdown**
- Handled the **routine checkup** of the pyro-section parts.
- Was awarded for introducing **kaizen in the pyro-section** of plant.

RESEARCH EXPERIENCES

- 4 Years (July 2016 to present) of research experience as a **research scholar** in the Department of Metallurgical and Materials Engineering, National Institute of Technology, Karnataka, India.
- **M.Tech** research project (2013-2014)

  Place: Institute for Frontier Materials, Deakin University, Geelong, Australia

  Topic: "**An alternate way of cleaning the heat tint of stainless steel weldments in desalination plants**" It was an industrial project done at the corrosion lab of the institute.

  Explanation: The corrosion behavior of the weldments of different grades of stainless steels were studied after cleaning the heat tint using ammonium fluoride and nitric acid.

RESEARCH INTERESTS

- Thermal Energy Storage materials
- Concentrated Solar Thermal Power Systems
- Material Development & Characterization
- Heat transfer
- Thermal Analysis of Phase Change Materials
- Casting & Solidification of Alloys
- Nano Fluids, Heat Treatment of Steel and non-Ferrous alloys making

SOFTWARE SKILLS

- TmmFe Inverse heat conduction problem (IHCP) solver
- Lab View signal express (National Instruments)
- Solid Cast
- Solidworks
- Matlab
- Photoshop
- Origin
- Kaleidograph
- Catia

EQUIPMENT OPERATION SKILLS

- Transmission Electron Microscope
- Scanning Electron Microscope
- Differential Scanning Calorimeter
- X-ray diffractometer
- Temperature Data Acquisition
- KD2Pro Property measurement device
- Coating thickness measurement device
- Drop shape Analyzer with contact angle measurements
- Rheo-viscometer
- Talysurf Profilometer
- Probe type and bath ultra sonicator
- Tensile Testing machine
- Bond Testing Machine
- Micro Hardness Testing machine
- Optical Microscope and stereomicroscope

JOURNAL PUBLICATIONS:

Ph.D:

- Swati Agarwala, and Narayan Prabhu, K. (2018). "Assessment of Solidification Parameters of Salts and Metals for Thermal Energy Storage Applications using IHCP-Energy Balance Combined Technique." Trans Indian Inst Met https://doi.org/10.1007/s12666-018-1407-8.
- Swati Agarwala, and Narayan Prabhu, K. (2019). "Characterization of Metals and Salts based Thermal Energy Storage Materials using Energy Balance method." Heat Transfer- Asian research DOI: 10.1002/htj.21461
- Swati Agarwala, and Narayan Prabhu, K. (2020). "An experimental approach based on inverse heat conduction analysis for thermal characterization of phase change materials."ThermochimicaActa https://doi.org/10.1016/j.tca.2020.178540
- S. Agarwala and K. Narayan Prabhu, "A Quantitative Approach for Thermal Characterization of Phase Change Materials," Materials Performance and Characterization 10, no. 1 (2021): 166–172. https://doi.org/10.1520/MPC20200031

M. Tech :

- "The restoration of the passivity of stainless steel weldments in pickling solutions observed using Electrochemical and surface analytical methods" corrosion science (2015) DOI.org/10.5006/1830.

CONFERENCE PROCEEDINGS

- Swati Agarwala, and Narayan Prabhu, K. (2018). "Characterization of Thermal Energy Storage Materials using Energy Balance Cooling Curve Analysis Technique". ICAMPS'18, Trivandrum

CONFERENCES AND WORSKSHOPS ATTENDED

- Participated in the **Seventh International Conference on Solidification Science and Processing (ICSSP 2018)** organized by CSIR-NIIST, Trivandrum, India
- Participated in the **Third International Conference on Advanced materials and manufacturing processes for strategic sectors (ICAMPS-2018)** organized by IIM, Trivandrum, India
- Participated in a short term course on **Energy Efficient and Green Energy Technologies** conducted under TEQIP at IIT, Guwahati, India
- Participated in a one day **National workshop on Recent Advances and challenges in solar thermal systems** at

NITK, Surathkal, India

- Participated in a two day **National workshop on Materials Processing and Degradation** at NITK, Surathkal, India
- Participated in a five day **National workshop on Advanced Materials and Characterization techniques** at NITK, Surathkal, India
- Participated in a two day **National seminar on Frontiers in Materials** at NITK, Surathkal, India

TRAININGS/PROJECTS UNDERTAKEN

- Participated in three days training program on **Aspects of pedagogy for prospective Engineering Teachers** at NITK, Surathkal, India
- Undertaken the project at **Institute of frontier materials, Deakin University(Australia)** as my M.tech project in corrosion.
- Underwent training in **Solid works** by **Dassault systems** under the faculty development program.
- Underwent training in **material management** in SAP at the UltraTech plant.
- Had an **Industrial training** at **Visakhapatnam steel plant**.
- Presented a seminar on **vacuum induction melting** of steel at BTTD 2013 organized by NML Jamshedpur
- Presented a presentation on **addition of hot metal in EAF**.
- Had a visit to the Pelletisation plant **OMML,** Jamshedpur along with steel plant at **Adhunik alloys and steel,** Jamshedpur.
- Industrial training at **Rourkela steel plant**, Rourkela.
- Done a course in **CATIA** at CTTC, Bhubaneswar.
- Had a foundry visit to **lamina foundries** at NITTE.
- Prepared a project report on **4 stroke cylinder engine using Catia.**
- Prepared a workshop project on **manufacturing of hand injection mold of key ring.**
- Presented a seminar on **wear debris analysis**
- An academic project on **portable pipe cutting machine**

LEADERSHIP/TEAMWORK EXPERIENCES

- Organizing Committee member 'FIM-2019-National seminar on frontiers in materials', Department of Metallurgical & Materials Engineering, National Institute of Technology Karnataka.
- Organizing Committee member 'Prof. T Ramachandran Lecture Series' from 2016-present, Department of Metallurgical & Materials Engineering, National Institute of Technology Karnataka.
- An Active member of the NBA and NAAC accreditation

committee at TAT, Bhubaneswar.

- Undertook proctorship for B. tech students.
- Member of the PRONITES Committee of INCIDENT2013, Cultural festival of NITK 2013.
- Class representative and the placement coordinator of the M.Tech-Process Metallurgy batch 2012-2014.
- Been the chief engineer in the pyro section during the annual shutdown maintenance.
- Was the organizer of the monthly safety meet for mechanical section at UltraTech Cement Plant.
- I was the active member of the task force commission for OHS (Overall health survey) results at UltraTech Cement Plant.
- Organized the Paper Presentation event (PAPYRUS) and the BPLAN event in ZAZEN2010 in Orissa Engineering College.
- Was the member of the editorial team of our college magazine (TECHNOFLAME)
- Was one of the organizer of literary and book club in B. Tech

PERSONAL QUALITIES

- Strong analytical and people management skills.
- Excellent verbal and personal communication skills.
- Detailed Accuracy and Attention to details.
- Passion for constant learning and improvement.
- Hard work, good team management skills and ability to make sound decisions.
- Excellent organization and prioritization skills.

PERSONAL DETAILS

- **Languages Proficiency**: English, Hindi, Oriya and Bengali
- **Permanent Address:** FF-3, Civil township, Rourkela, Odisha, India, Pin Code- 769004
- **Correspondence Address:** Research Scholar, Department of Metallurgical & Materials Engineering, National Institute of Technology Karnataka, Surathkal, Srinivasnagar P.O. -575025, Dakshina Kannada, Karnataka, India
- **Email :** s.agarwala16@gmail.com
- **Contact Number:** +91-9482017365

REFERENCES

- Prof. K. Narayan Prabhu
  Professor (HAG) and Head of the Department
  Department of Metallurgical and Materials Engineering
  NITK, Surathkal
  Ph: +91-824-2473756, +91 9343560935
  Email: knprabhu.nitk@gmail.com
- Prof. Anandhan Srinivasan

Professor
Department of Metallurgical and Materials Engineering
NITK, Surathkal
Ph: +91 9663054756
Email: anandhan@nitk.edu.in

DECLARATION

I do here by affirm that the information furnished above is true to the best of my knowledge.

Swati Agarwala

16-04-2021

Materials Performance and Characterization

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Swati Agarwala[1] and K. Narayan Prabhu[2]

A Quantitative Approach for Thermal Characterization of Phase Change Materials

Reference

S. Agarwala and K. Narayan Prabhu, "A Quantitative Approach for Thermal Characterization of Phase Change Materials," *Materials Performance and Characterization* 10, no. 1 (2021): 166–172. https://doi.org/10.1520/MPC20200031

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[1] Department of Metallurgical and Materials Engineering, National Institute of Technology, Karnataka, PO Srinivasnagar, NH 66, Surathkal, Dakshina Kannada, Mangalore 575025, India

[2] Department of Metallurgical and Materials Engineering, National Institute of Technology, Karnataka, PO Srinivasnagar, NH 66, Surathkal, Dakshina Kannada, Mangalore 575025, India (Corresponding author), e-mail: knprabhu.nitk@gmail.com, https://orcid.org/0000-0002-8359-2587

ABSTRACT

A quantitative method for the calculation of phase change parameters of salt-based phase change materials (PCMs) has been proposed. This technique involves the estimation of mold-salt interfacial heat flux by solving Fourier's law of heat conduction within the salt and using it for the calculation of phase change enthalpy of salt PCMs. Radial heat transfer was ensured by keeping the length to diameter (L/D) ratio of the mold equal to 5. The proposed method eliminates any drawbacks involved with sample size, reference material, the baseline fitting calculations, and the errors introduced due to the selection of solidification points. Pure salt PCMs such as potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), and solar salt mixture (60 wt. % $NaNO_3$ + 40 wt. % KNO_3) were used for validation of this technique. The thermal behaviors of the salt and the mold during solidification of the salt sample were analyzed, and solidification characteristics such as cooling rate, solidification time, and phase change enthalpy of PCMs were determined.

Keywords

thermal energy storage, Fourier's law of heat conduction, solidification, energy balance

Introduction

With the slowly increasing consumption of the available energy resources, the energy demand worldwide is steadily increasing. This creates an energy shortage problem when the demand and the supply of energy do not match. Solar energy is one source of clean energy that is inexhaustible. The integration of thermal energy storage systems (TES) with thermal heat generation is the most efficient and promising way to solve this energy problem. In TES, the latent heat storage systems (LHTES) utilizing the phase change materials

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An experimental approach based on inverse heat conduction analysis for thermal characterization of phase change materials

Swati Agarwala, K. Narayan Prabhu*

Department of Metallurgical and Materials Engineering, National Institute of Technology, Surathkal, Karnataka, India

ARTICLE INFO

Keywords:
Thermal energy storage
Inverse heat conduction problem
Solidification
Energy balance

ABSTRACT

A new method based on solution to inverse heat conduction problem for the assessment of solidification parameters of PCM salts has been proposed. The method estimates the mold -salt interfacial heat flux and it is used to calculate the latent heat of salt PCMs using calorimetry based energy balance equations. This method is more accurate compared to Computer Aided Cooling Curve Analysis (CACCA) techniques as it eliminates the drawbacks involved with base line fitting calculations and errors introduced due to the improper selection of solidification points. Pure salt PCMs such as KNO_3 and solar salt were used for the validation of this technique. Both air and furnace cooling were adopted to demonstrate the effect of cooling rate on solidification characteristics. The wettability of salt samples on mild steel surface was analyzed to account for the difference in the thermal behavior of salts.

1. Introduction

The development and growth of the renewable source of energy is increasing and is expected to increase further in the near future. Solar energy is an important source of this renewable energy. The only drawback associated with it is its intermittent nature. In order to create a continuous and reliable stream of power throughout without interruption, there is a need to store this excess thermal energy. Energy storage integrated with solar thermal power generation will help in the reduction of pollution and hence global warming. This thermal energy storage systems (TES) are of two types, sensible heat thermal energy storage systems (SHTES) and latent heat thermal energy storage systems (LHTES). The LHTES using phase change materials (PCMs) is considered to more promising than SHTES due to its higher energy storage density particularly at constant temperature or narrow temperature range [1].

For successful development and implementation of the PCMs, an accurate database of the various solidification parameters and thermophysical properties of these materials is very important which can be obtained by the thermal characterization of these PCMs. Thermal analysis is a reliable technique which is used for characterization of the energy storage materials. In this technique, the temperature dependent properties are measured. Differential scanning calorimetry (DSC) is the technique widely used by researchers to measure solidification parameters and the thermophysical properties. However, the limitation on the sample size has restricted its usage. In the case of inhomogeneous samples, the DSC results are reflective of the sample used, not of the entire material used. Another limitation associated with DSC is the loss of latent heat due to overestimation of the super cooling. The results obtained are affected by the rates of heating and cooling used which also affects the measured values. Due to these limitations, researchers are looking for alternate characterization techniques. T-history method is an alternate calorimetry based thermal characterization method. This technique incorporates larger sample size unlike DSC. Here reference materials are needed for the analysis of PCMs. Many researchers have used this technique for low temperature applications especially organic PCMs. However, the reference material and dimensional constraint; limits its usage for high temperature applications. Because of such limitations, a new method called as computer aided cooling curve analysis (CACCA), based on the analysis of the thermal behavior and the cooling rate curve is widely used. This CACCA method can be used to evaluate the solidification characteristics and the latent heat of the PCMs during solidification [2].

Newtonian and the Fourier methods are the two characterization techniques which uses CACCA technique as their basis and have gained importance among researchers in recent times. In both these methods, the PCMs are characterized only during the cooling cycle. The Newtonian technique is a one thermocouple system whereas the Fourier is a two thermocouple system. The Fourier technique takes the thermal gradient obtained within the salt sample into consideration. Both these

* Corresponding author.
E-mail addresses: s.agarwala16@gmail.com (S. Agarwala), prabhukn_2002@yahoo.co.in (K.N. Prabhu).

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0040-6031/

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DOI: 10.1002/htj.21461

WILEY

ORIGINAL ARTICLE

Characterization of metals and salts-based thermal energy storage materials using energy balance method

Swati Agarwala | **Narayan K. Prabhu**

Department of Metallurgical and Materials Engineering, National Institute of Technology Karnataka, Surathkal, Karnataka, India

Correspondence
Narayan K. Prabhu, Department of Metallurgical and Materials Engineering, National Institute of Technology Karnataka, Surathkal, Karnataka 575025, India.
Email: prabhukn_2002@yahoo.co.in

Abstract

Thermal energy storage technologies minimize the imbalance between energy production and demand. In this context, latent heat storage materials are of great importance as they have a higher density of energy storage as compared with the sensible heat storage materials. The present study involves the characterization of energy storage materials using an energy balance cooling curve analysis method. The method estimates the convective heat transfer coefficient in the solidification range to characterize the phase change materials for applications in energy storage. The method is more beneficial than the Computer Aided Cooling Curve analysis methods as it eliminates baseline calculations and the associated fitting errors. Metals (Sn) and salts (KNO_3 and $NaNO_3$) were used in the present work. Phase change characteristics like the rate of cooling, liquidus and solidus temperatures, time for solidification, and enthalpy of phase change were estimated for both metals and salts. It was observed that the energy balance cooling curve analysis method worked very well for metals but not well suited for low conductivity salts. Salts could not be characterized since the thermal gradient existing within the salt sample was not considered in this method.

Trans Indian Inst Met
https://doi.org/10.1007/s12666-018-1407-8

TECHNICAL PAPER

Assessment of Solidification Parameters of Salts and Metals for Thermal Energy Storage Applications Using IHCP-Energy Balance Combined Technique

Swati Agarwala[1] · K. Narayan Prabhu[1]

Received: 14 July 2018 / Accepted: 26 August 2018

Abstract Solar energy storage technologies have proved to be promising in terms of providing uninterrupted power supply. The phase change materials (PCMs) with their higher heat storage capacity are more efficient than sensible heat storage materials. In this study, a new method for thermal analysis of PCM salts was proposed. The method was based on the estimation of heat flux at the mold–salt interface using solution to inverse heat conduction problem and characterizing the salt using a simplified energy balance method. It was advantageous over other computer-aided cooling curve analysis methods as it eliminated the use of curve fitting approach involved in baseline calculations. KNO_3 and $NaNO_3$ salts were used to validate this method. The solidification parameters like cooling rate, liquidus and solidus temperatures, solidification time and latent heat were assessed. The results of the analysis were in agreement with the data reported in the literature.

Keywords Energy storage · Thermal analysis · Solidification · Inverse technique · Energy balance

✉ K. Narayan Prabhu
prabhukn_2002@yahoo.co.in

Swati Agarwala
s.agarwala16@gmail.com

[1] Department of Metallurgical and Materials Engineering, National Institute of Technology Karnataka, Surathkal 575025, India

1 Introduction

The world is facing an environmental and energy crisis due to increased population and industrialization. This can be taken care by utilizing the renewable energy resources available, solar energy being one of them. The only limitation associated with this resource is its instability and intermittent nature which creates a misbalance between the energy supply and demand. In order to overcome this limitation, thermal energy storage technologies (TES) have become more attractive among the researchers. In TES systems, latent heat thermal energy storage systems (LHTES) using phase change materials have gained more recognition as it has higher energy storage density as compared to the sensible heat thermal energy storage systems (SHTES) and that too at a constant temperature with phase transformations. For successful development of LHTES materials, an accurate index for the solidification parameters of the phase change materials (PCM) is needed [1]. The methods that are being used for this characterization are differential scanning calorimetry (DSC) technique; thermal history (T-history) method and computer-aided cooling curve analysis methods (CACCA). The limitations associated with DSC are its small sample size and heating and cooling rates driven results which makes it inappropriate to characterize inhomogeneous materials [2]. T-history method overcomes these limitations, but the problem of selecting the appropriate reference materials for high-temperature application limits its usage only for low-temperature materials [3].CACCA techniques have proved suitable as compared to the above discussed techniques and can be used for materials of all temperature ranges [4]. The only drawback is the method of baseline calculations using fitting techniques which affects the results obtained. In the present work, a technique which combines inverse heat

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The Restoration of the Passivity of Stainless Steel Weldments in Pickling Solutions Observed Using Electrochemical and Surface Analytical Methods

Jianyu Xiong,* Swati Agarwala,* Mike Yongjun Tan,‡,* and Maria Forsyth*

ABSTRACT

In this study, a solution containing ammonium fluoride (NH_4F) and nitric acid (HNO_3) was used as an alternative to the conventional highly toxic pickling solution HF/HNO_3 for pickling weldments of selected stainless steels including Type 316 stainless steel (UNS S31600), duplex stainless steel 2205 (UNS S32205), and super duplex stainless steel 2507 (UNS S32750). Electrochemical and surface analytical methods were used to understand the effects of pickling on the stainless steel weldments. Cyclic potentiodynamic polarization (CPP) test results indicated that the restoration of passivity of stainless steel weldments could be achieved by pickling the weldments in both HF/HNO_3 solution and NH_4F/HNO_3 solutions. Scanning electron microscopy observation of the UNS S32750 weldment surface revealed that both the HF/HNO_3 solution and the NH_4F/HNO_3 solution could remove the heat tint on the weldment. X-ray photoelectron spectroscopy analysis indicated that treatment in these two pickling solutions produced passive films with similar characteristics. Thus, this work suggests that the NH_4F/HNO_3 solution is a promising alternative to HF/HNO_3 solution for the pickling of stainless steel weldments, and that the CPP test approach can be used in conjunction with surface analytical methods for further development of safer and environmentally friendly pickling solutions.

KEY WORDS: electrochemical testing, heat affected zone, localized corrosion, passivity, pickling, stainless steels, weldments

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‡ Corresponding author. E-mail: mike.tan@deakin.edu.au.
* Institute for Frontier Materials, Deakin University, Locked Bag 20000, Geelong, VIC 3220, Australia.

INTRODUCTION

Stainless steels are corrosion resistant because of their passivity, which is related to the formation of a compact and strongly adherent oxide film on the surface.[1] The passivity of stainless steels can be lost and consequently, their corrosion resistance can be adversely affected in a process such as welding.[2-6] During welding processes, thermal oxides (also referred to as heat tints) are usually formed. The formation of heat tint is generally considered under diffusion control. Auger electron spectroscopy and glow discharge optical emission spectrometry sputter depth profiles have shown that heat tint formed at comparably low temperatures (300°C to 400°C) consists primarily of Fe as a result of insufficient diffusion of Cr. At higher temperatures, Cr-rich oxide forms because of an increased Cr diffusion rate. Cr diffuses outward from the base metal into the surface oxide film and a thin Cr-depleted layer forms under the heat tint.[7-8] Heat tint can also be formed by redeposition from the weld pool. It has been shown that Cr (and also some other elements) is evaporated from the weld metal and forms weld oxide by subsequent redeposition.[9] The heat tint is thick and porous as compared with the native passive film, which makes stainless steels vulnerable to localized forms of corrosion.[10-11] The Cr-depleted layer under the heat tint also impairs the corrosion resistance of stainless steel weldment because passivity cannot be developed as a result of the lower Cr content in the Cr-depleted layer.[12-13]

In order to restore the passivity of stainless steel weldments, it is essential to remove the heat tints and

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