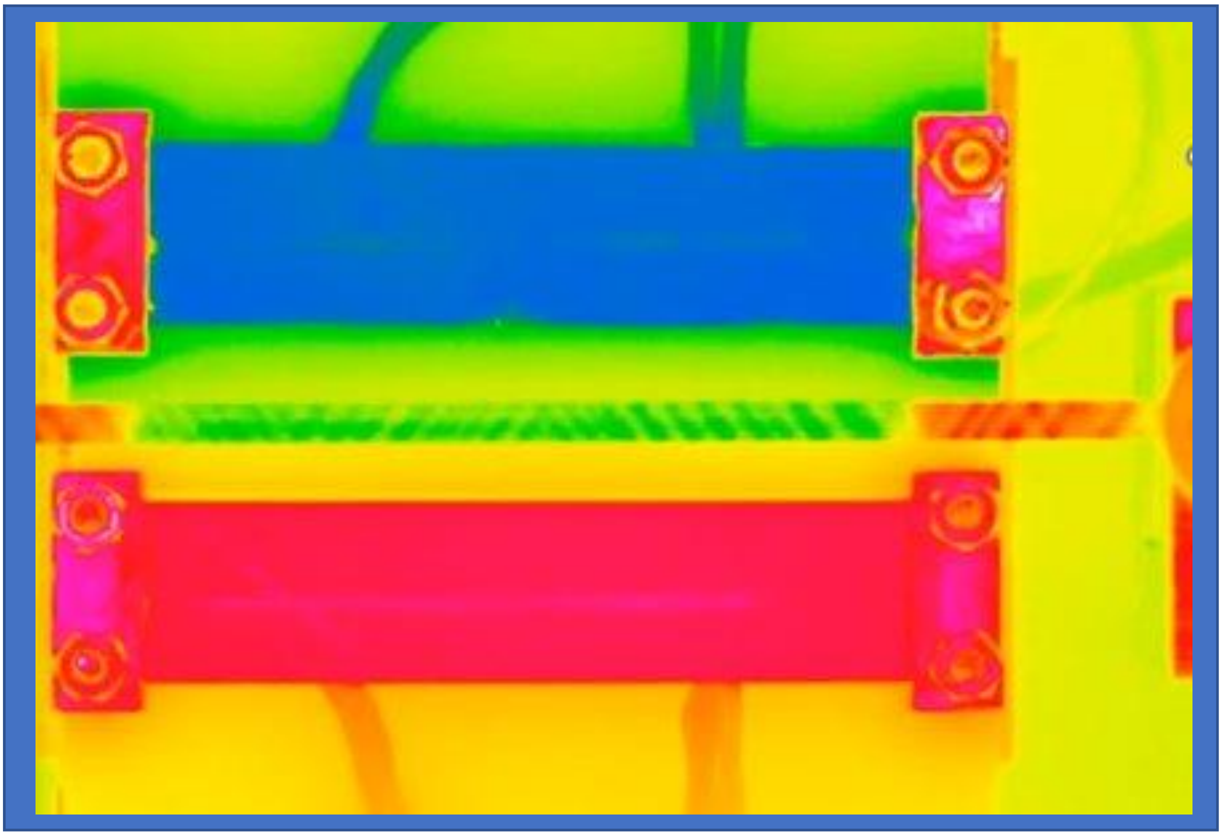
ELASTOCALORICS2023



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LOCATION ZeMA Saarbrücken

CONTENT

KEYNOTES

Compression-based Elastocaloric Cooling: Advances in Materials and Systems

Ichiro Takeuchi, University of Maryland

The open challenge in caloric cooling technologies at large is the scale-up in terms of capacity and performance, while keeping the cost of materials and driving mechanisms to a manageable level. We have been pursuing different materials and device designs for compression-based elastocaloric cooling. It has been shown that in compression geometries elastocaloric NiTi can survive over 1 million cycles, opening the door to long-term applications. Commercial superelastic NiTi tubes are useful for implementing them in a variety of compression configurations. Our four-bundle multi-mode elastocaloric system can be operated in a high-utilitization mode as well as the active regenerator mode. It has produced 260 W in delivered cooling in the high-utility mode and the temperature lift of 22.5 K in the active-regeneration mode. When implemented in a multi-stage regenerator, we have been able to achieve a temperature lift of 27.5 K to date. We are now working toward developing cascade regenerators where different NiTi parts of the device have varying Af temperatures. We are also working with Cu-based elastocaloric materials, whose main advantage is a significantly reduced critical stress compared to NiTi.

This work is carried out in collaboration with David Catalini, Nehemiah Emaikwu, Jan Muehlbauer, Suxin Qian, Jun Cui, Huilong Hou, Sumio Kise, Kenjiro Fujimoto, Yunho Hwang, and Reinhard Radermacher. We are funded by the U.S. Department of Energy.

The Thermodynamic Competition between B19' Martensite and the R-Phase

Tom Duerig, Confluent Medical Technologies

As the cubic B2 structure of NiTi is cooled, two lower entropy martensitic phases compete to replace the parent: the well-known monoclinic B19' phase, and the lesser known rhombohedral R-phase. Both transformations are thermoelastic and are self-accommodated through twinning. The B19' product phase offers a much higher transformational strain, suiting it to a variety or superelastic and shape memory applications for which the R-phase is nothing more than a pesky complication. However, the transformation of B2 to the R-phase may hold the greater promise for elastocaloric applications: its large and complex unit cell provides a surprisingly low entropy and high latent heat, yet because the transformational strain is much lower than that of B19', it exhibits a very low hysteresis, greater dσ/dt and far better fatigue life.

Recent work will be reviewed that sheds new light on how the triple point of the three phases can be moved through aging and the precipitation of Ni_4Ti_3, whose coherency strains strongly suppress B19' a but have little interaction with the R-phase, thus allowing one to isolate the parent to R-phase transformation.

ELASTOCALORIC DEVICES & CONCEPTS I

Development of a Regenerative Elastocaloric Device

Jaka Tušek, University of Ljubljana

In recent years, elastocaloric cooling has emerged as a highly promising alternative to traditional vapor compression technology. This innovative technology is based on the elastocaloric effect found in superelastic shape memory materials. In the last decade various operating principles of elastocaloric devices have been developed and tested. Among these, the active regeneration principle has demonstrated the best performance for medium and large-scale applications.

In this talk, our latest advancements in the design of durable and high-performance elastocaloric regenerators, which are the key components of a future elastocaloric heat-pump/ cooling device, will be presented. The talk will cover a wide range of topics, including an analysis of novel elastocaloric thermodynamic cycles, different training regimes, thermo-hydraulic evaluation of different tube-based regenerators, buckling stability and fatigue-life of elastocaloric tubes under compression. In the second part of the talk, the design and performance of shell-and-tube-like elastocaloric regenerator will be presented and discussed.

Acknowledgements

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The First US DOE Project on Elastocaloric Cooling

Jun Cui, Iowa State University

The shape memory effect is closely related to the first-order martensitic phase transformation, accompanied by latent heat. While this scientific principle was established long ago in the early age of shape memory alloy research, it had not been considered for any practical cooling applications. This is because the dominating vapor compression-based cooling technology, after over 100 years of engineering effort, has reached its perfection. It is highly efficient, cost-effective, and sufficient to meet most industrial and residential needs. In 2010, the United State Department of Energy Advanced Research Projects Agency-Energy (ARPA-E) called out the environmental issues and efficiency plateau of the current vapor compression cooling technology and solicited proposals for new cooling technologies. Derived frσom GE’s stress-biased magnetocaloric cooling, GE, Pacific Northwest National Laboratory, and the University of Maryland teamed together and proposed “Thermoelastic Cooling” to ARPAe. This is the world’s first effort to apply the elastocaloric effect for practical cooling application. Back then, we named it thermoelastic cooling to rival thermoelectric cooling technology. In this talk, we will retrace the process of concept development, proposal, rebuttal, award, the first prototype, the first patent application, and the follow-on funding.

Elastocalorics – Exergyn's Technology for Next Generation Heating and Cooling Systems

Paul Groves, Exergyn Ltd.

The demand for greener and more sustainable heating and cooling is increasing. This is a must if we are to achieve Net Zero by 2050. Elastocaloric systems can play a key role in reducing emissions of greenhouse gases from refrigerants and displacing fossil fuels across the thermal management spectrum. Exergyn has been at the forefront in the development of industrial scale elastocaloric technology. The evolving drivers and increasingly stringent regulation are forcing change. Exergyn's technologies aim to satisfy the demands of the existing and emerging markets through key drivers such as efficiency, deltaT, size, and weight amongst other commercial considerations required for mass adoption. At the heart of these products is Exergyn's SMA Core technology primed for integration into cost effective solutions by OEM partners. As part of this development, we have tested a number of prototypes aiming to prove the viability and scalability of this revolutionary technology.

ELASTOCALORIC MATERIALS I

The Origin of Functional Fatigue in Shape Memory Alloys

Huseyin Sehitoglu, University of Illinois UC

There are a large number of elasto-caloric shape memory alloys (SMAs) with considerable future potential. However, the functionality of SMAs degrades with cycling, which is common to all shape memory alloys, with no exception. The degradation of functionality means that the transformation strains decrease and the transformation domains reduce with cycling. The degradation results in changes in hysteresis and transformation stress as well. If the loops shakedown to an elastic state in the limit, the forward and reverse transformation no longer occurs, and the elastocaloric effect would disappear. The presentation will explain the underlying causes of the cyclic-induced degradation in shape memory alloys from theoretical considerations. In particular, we will focus on the generation of dislocations from crystallographic misfit at interfaces using advanced theory, including first principle calculations, anisotropic elasticity, and the theory of martensitic transformations. This understanding at the lattice level will allow refined phenomenological models to be developed that can be utilized in engineering applications.

Customized Shape Memory Alloys for Elastocaloric Applications

Burkhard Maaß, Ingpuls GmbH

The elastocaloric effect can be observed well in standard, binary NiTinol for medical applications. An off-the shelf material that is widely available. But: Does it really fit the requirements for Elastocaloric Applications, besides showing pseudoelastic behaviour at room temperature? Previous works show that ternary and quaternary NiTi-XY alloys have a much higher potential to reach higher COPs – and device concepts in the community show that it might not be enough to have one single material state for a cascaded system. In our work for different research groups, we show that there is not “the best” material that can be used for all applications, but that the functional component, i.e. the SMA part, has to be customized and tailored for each concept. Beside the load state, the mechanical and temperature requirements, the composition, processing and microstructure development play an important role in the fabrication of SMA parts for Elastocaloric Applications.

Supercompatibility and its Role on Fatigue in Shape Memory Materials

Eckhard Quandt, CAU University Kiel

Functional shape memory alloys need to operate reversibly and repeatedly. This is especially crucial for many future applications such as e.g. elastocaloric cooling, where millions of transformation cycles will be required. In recent years examples of unprecedented functional and structural fatigue resistance and lowered hysteresis in shape memory alloys have been achieved by combining conditions of supercompatibility between phases with suitable grain size and a favorable array of fine precipitates. In my talk I will review and compare these examples to elucidate the relative roles of these factors, especially in the case of the more demanding stress-induced phase transformations, and will pose key open questions. The control of these factors point to significant opportunities to discover improved shape memory alloys.

THERMODYNAMICS OF CALORICS I

Elastocaloric Materials under Magnetic Field: The Multicaloric Response

Lluis Mañosa, University of Barcelona

Elastocaloric Materials exhibit a thermal response (isothermal entropy and adiabatic temperature changes) when subjected to the application and removal of uniaxial stresses. Some of these materials are magnetic, and they also exhibit giant magnetocaloric properties resulting from the application and removal of magnetic fields. Thanks to the coupling between magnetic and structural degrees of freedom, the magnetocaloric effect is influenced by stress, as well as the elastocaloric response is influenced by magnetic field. Hence, when subjected to a combination of uniaxial stress and magnetic field these materials are prone to exhibit a caloric response known as the multicaloric effect. In general, the isothermal entropy and adiabatic temperature changes associated with such a multicaloric effect cannot be directly computed form the entropy and temperature values corresponding to the individual (magnetocaloric and elastocaloric) effects because there is a significant contribution arising from the coupling between structural and magnetic degrees of freedom (cross-coupling contribution).

In this talk I will present experimental studies on prototype magnetic elastocaloric materials (Fe-Rh and magnetic shape memory alloys). First, I will show how the magnetic field affects their elastocaloric properties, and next I will present a detailed study of their multicaloric response, in which the diferent contributions to the multicaloric entropy change will be elucidated.

Elastocaloric and Related Mechanocaloric Effects

Antoni Planes, University of Barcelona

Most of the research to date on mechanocaloric effects has been carried out by application and/or removal of uniaxial stress or hydrostatic pressure and the corresponding effects are usually denoted as elastocaloric and barocaloric effects, respectively. After a brief historical introduction to recent development on these caloric effects, I will discuss flexocaloric effects, that can be understood as particular variants of the elastocaloric effect induced by either bending or torsion. In contrast to the elastocaloric effect, the stresses causing flexocaloric effects are non-homogeneous, which gives rise to strain gradients that concentrate in the regions of maximum curvature. In materials undergoing ferroelastic/martensitic transitions, this is an interesting situation because the transition can be induced in these regions with much smaller forces than those needed by application of homogeneous stress.

In the talk I will present experiments on flexocaloric effect performed in a single crystalline Cu-Al-Ni shape memory alloy and will discuss the obtained results within the framework of a Ginzburg-Landau model adequate to study the martensitic transition induced by bending. Finally, I will show that a reliable comparison of elastocaloric and flexocaloric performances requires that the mechanical work exchanged in both cases is the same. The comparison confirms that the flexocaloric effect is more efficient at low work since less driving force is required to nucleate the martensitic phase by bending.

ELASTOCALORIC MATERIALS II

Shape Memory Alloy Wire Ropes

John Shaw, University of Michigan

Wire ropes (or structural cables) are hierarchical constructions of straight and helical wire filaments and strands, which are in ubiquitous use due to their desirable mechanical tension properties and increased bending compliance for spooling/packaging. Our experiments on superelastic cables made from NiTi shape memory alloy (SMA) wires show interesting thermomechanical phenomena as measured by infrared imaging and digital image correlation. Different mechanical responses and load-rate sensitivities are observed, depending on the construction and layup. SMA cables leverage the excellent properties of SMA wires in a scalable and tailorable form, and thus hold promise for new adaptive and enhanced structural properties over a broad range of applications.

A Unified Approach to Thermo-Mechano-Caloric Characterization of Elastocaloric Materials

Franziska Louia, Saarland University

Usually, tensile experiments are performed to determine the rate- and process-depending stress/strain behavior of Nickel-Titanium-based shape memory alloys and potentially other elastocaloric materials. These tests are relevant for, e.g., characterization of hysteresis properties and subsequent calculation of mechanical work input. In addition, simultaneous observation with an infrared camera is useful to understand temperature evolution and maximum temperature changes achievable during the loading/unloading process. Characterization of the caloric properties of the materials determines latent heats and, together with the mechanical work, also the material coefficient of performance. It is typically carried out via Differential Scanning Calorimetry (DSC), which is performed in a separate device and requires a second experiment with different types of samples. Furthermore, DSC measurements do not reflect the way mechanically induced phase transformations trigger the release and absorption of latent heats as it is the case for elastocalorics.

In order to provide a more consistent understanding of the relevant elastocaloric material properties, we here present a novel method that a) allows for a systematic determination of load-dependent latent heats and b) introduces a comprehensive testing setup and suitable testing routine to determine the mechanical, thermal and caloric parameters in the same experimental device and with the same sample, thus greatly simplifying the overall procedure.

ELASTOCALORIC DEVICES & CONCEPTS II

Shape Memory Film-based Elastocaloric Cooling

Manfred Kohl, Karlsruhe Institute of Technology

The elastocaloric (eC) effect associated with the stress-induced first order phase transformation in superelastic shape memory alloys (SMAs) is of special interest for cooling applications. NiTi-based alloys, for instance, exhibit a unique combination of large latent heat in the order of 24 J/g, large transformation strain of 8 % and good scalability on miniaturization. EC cooling in film devices is expected to enable fast heat transfer, high cycling frequencies as well as tunable temperature change [1]. Potential applications are particularly at small scales such as microelectronic devices and lab-on-chip systems. This review covers the development of SMA film-based eC cooling covering the various engineering aspects of material properties, design, fabrication, experimental and numerical characterization as well as performance optimization. Several generations of demonstrators will be presented that address the various design issues.

The potential of SMA film-based eC cooling is demonstrated for single-stage cooling devices. A device temperature span up to 14 °C is reached in combination with a high specific cooling capacity of up to 19 W/g. In addition, the devices operate efficiently with a device coefficient of performance of up to 6. However, absolute cooling capacities in the small-scale devices are limited to about 200 mW and the device temperature span is already close to its theoretical limit given by the adiabatic temperature change of the SMA film. To overcome these limitations, two different advanced device architectures are developed and investigated. A parallelized eC cooling device is engineered to increase the absolute cooling capacity. In order to overcome the limitation of the device temperature span, a cascaded eC cooling device is developed. We demonstrate that the device temperature span of a three-stage cascade is increased up to 27.3 °C. These results form the basis to provide a variety of cooling applications for efficient and environmentally friendly SMA film-based eC cooling.

SMA-based Elastocaloric Cooling/Heating Materials, Structures and Devices

Qingping Sun, Hong Kong UST

Recent progresses of my research group in (1) developing compression-based high cyclic stability, high fatigue life and cooling capacity bulk SMAs of NiTiCuCo polycrystal rod and NiFeGa single crystal rod; (2) design and precision manufacturing of thin-walled SMA tubular structures with high specific surface area, high buckling resistance and rapid heat transfer; and (3) developing desktop heat pump prototypes with large temperature span (75 K) and large specific cooling power (12 W/g) are reported in this talk.

THERMODYNAMICS OF CALORICS II

Thermal Control Devices for Caloric Technologies

Andrej Kitanovski, University of Ljubljana

Thermal Control Devices (TCDs) represent an alternative thermal management technique to active regeneration processes, which are widely used as a heat transfer principle in caloric technologies. TCDs control heat in a manner similar to the control of electricity by electronic devices and circuits. Their application in the form of thermal diodes, thermal switches, thermal regulators, and thermal conductors has the potential to significantly improve the power density of caloric devices while maintaining high energy efficiency, thus meeting the most important market condition and facilitating the commercialization of caloric technologies.

Despite some research activities on TCDs integrated in caloric technologies, research in this particular area is still at an early stage. There is a great lack of knowledge and experience regarding the operational performance of the different types of TCDs as well as their performance when integrated into caloric devices. In addition, the materials, being considered for the construction of TCDs, have not yet been adequately characterised in terms of their thermal properties. Based on our review of materials and methods for different types of TCDs and thermal control circuits (TCCs), we have begun development of an open-source virtual platform called TCCBuilder, which contains a library of materials, with properties suitable for TCDs. This platform will help researchers develop new design principles for TCDs and TCCs. With integrated transient modelling of heat transfer in such devices and circuits, the TCCBuilder will also enable prediction of operation and optimization of caloric technologies through the use of TCDs as a novel thermal management technique.

In this work, we provide a critical review of the research activities and applications of TCDs in all types of caloric devices, as well as an overview of various mechanisms that have not yet been applied in calorics. Based on this, we provide guidelines for future research. We present the structure of our open-source TCCBuilder tool and encourage researchers to use it, enrich its material and TCDs library, and contribute to its future improvements.

Ferroelectric Materials for Heating & Cooling

Xavier Moya, University of Cambridge

Half of the world's CO2 emissions can be attributed to heating and cooling. This is primarily due to heating with natural gas and cooling with compression of greenhouse gases, which are neither environmentally friendly nor energy efficient. There is great interest in developing energy-efficient solid-state heat pumps that can replace these environmentally damaging technologies. Caloric materials are at the core of novel solid-state heat-pump technologies. During this talk I will describe our work on electrocaloric effects driven by electric field, and barocaloric effects driven by hydrostatic pressure on ferroelectric materials for heating and cooling applications.

Thermodynamics and the Concept of Energies for Modeling Elastocaloric Materials

Stefan Seelecke, Saarland University

Thermodynamics and the various forms of energies are vital for understanding the elastocaloric behavior of shape memory alloys. The talk discusses the central roles of, e.g., Helmholtz and Gibbs Free Energies along with their implication on the materials' coupled thermomechanical behavior, phase transformations, hysteresis, and elastocalorically relevant load-dependent latent heats. Their implementation in a free-energy-based shape memory alloy model is subsequently illustrated and shown to reproduce all relevant material phenomena from a physics basis.

MODELING AND SIMULATION

The First Italian Elastocaloric Device for Air Conditioning

Adriana Greco, University of Naples

The research is part of the project SUSSTAINEBLE (a Solution Using Solid-STate cooling: An INvestment Eco-compatiBLE) funded by the Ministry of University and Research (MUR) of Italy. The aim of this research, carried out by the group of the University of Naples Federico II, is the developing of a demonstrative prototype of the first Italian elastocaloric device for air conditioning. Air is the auxiliary fluid that will be used to avoid an intermediate heat exchanger. The operation of the device based on the AeR cycle uses a rotary mechanism that ensures a continuous flow of hot and cold air. The elastocaloric material has the shape of 600 thin wires (diameter 0.5 mm and length 300 mm) arranged in the annular section between two concentric cylinders (with an internal radius of 120 mm an external radius of 135 mm and a length of 300 mm). The annular section is divided into two parts: one represents the cold regenerator and the other the hot one. The prototype is based on a traction loading mechanism ensured by 10 pistons each connected to 60 wires. The pistons are connected each other to ensure the work recovery. A 2D rotative numerical model has been developed through COMSOL to attain the device's potential cooling and heating capacities and to optimize the geometrical parameters and the operative conditions of the device. The presentation will consist of the following points:

- description of the experimental prototype that is being built in the Heat Transfer Laboratory at the University of Naples;
- results of the numerical model in terms of: outlet air temperature, cooling power and COP for different air velocities inside the air channel and different rotation frequencies of the device. Exploring the behaviour of the device under variable working conditions a performance map has been obtained to identify the optimal configuration of the heat pump both in cooling and heating mode. In these simulations the elastocaloric material is the binary alloy $Ni_{55.92}Ti_{44.08}$.
- Evaluation of the environmental impact through a TEWI (Total Equivalent Warming Impact) analysis, by comparing the TEWI indexes proper of the elastocaloric rotary prototype operating with $Ni_{55.92}Ti_{44.08}$ and the TEWI of a vapor compression heat pump (A++/A+ working with HFC32).

CHECK TEMPERATURE – Heating Control of Electronic Circuits

Claudia Masselli, University of Naples

CHECK TEMPERATURE is the acronym of *Controlling the Heating of Electronic Circuits: a Key-approach Through Elastocaloric Materials in a Prototype Employing them as Refrigerants of an AcTive Ultrasmall Refrigerator*. The CHECK TEMPERATURE project intends to develop the first elastocaloric device for electronic circuits cooling basing on the Active elastocaloric Regenerative as thermodynamical cycle and bending as loading/unloading mode. The aim is to realize a prototype with small dimensions and low weight.
Among the novelties introduced by the project, there is for sure the field of application: interesting but never touched before by elastocaloric refrigeration is the electronic circuits cooling field. Many are the applications where a more advanced cooling system is required to avoid the unconditional rising of the working temperatures of the devices. As a consequence of temperature rising the failure probability of electronic circuits increases exponentially. None of the elastocaloric devices previously reviewed is explicitly devoted toward this field.

The studies that were conducted up to now with regard to the advancements of this project are:

- to compare two different configurations for the active elastocaloric regenerator with respect to the method of load application: tensile and bending. Two prototypes where designed and their behaviors were virtually tested through two 2D numerical models based on finite element method. The accuracy and completeness of the numerical model represent another point of novelty with respect to the state of the art since most of the models on elastocaloric systems developed and presented to scientific community are 1D. The energy performances were carried out keeping equal the weight of the elastocaloric material: the device is designed to mount 240 wires of $Ni_{50.8}Ti_{49.2}$ alloy, for a total mass of 61g. Temperature span, cooling power and coefficients of performances were calculated and compared. From the results emerged comparable temperature spans and cooling powers but the much lower coefficients of performance found in the bending device ensure that bending is a good way to build the device.

- A numerical analysis where the energy performances of the elastocaloric device basing on bending was carried out with the purpose of optimizing at the same time the geometrical design and the operative parameters. The latter is another novelty because in literature are not published studies drawing wide maps of performances on elastocaloric devices on small scale and at the same time optimizing the geometrical design and the operative parameters. The distance stacked by the placement of the wires and the length of the wires are the two investigated parameters with respect to variable frequency of the AeR cycle and velocity of the auxiliary fluid (air). The placement of wires stacked at 0.5 mm along the channel is to be preferred than 1.2 mm since greater are temperature span, cooling power and COP. Moreover, even if slightly better are the energy performances coupled with wires 30 cm long, keeping constant the number of wires, the solution where 20 cm is the length of every wire must be preferred since 30% less elastocaloric material is used with consequent cost saving.

The collected and discussed results confirm the favorability in betting on elastocaloric technology for the application to the field of electronic circuits cooling. The optimized geometrical design conditions have been identified and the device is currently under construction. The next perspective related to the future research work will be the comparison between the experimental results given by the CHECK TEMPERATURE device and the numerical ones. The model will be a useful tool to investigate further points of improvement to be implemented in the experimental device.

Modeling of Elastocaloric Cooling Systems

Suxin Qian, Xi'an Jiaotong University

Elastocaloric cooling attracted worldwide attention due to its environmental-friendly and fully recoverable nature. This talk will focus on the numerical modeling of elastocaloric cooling systems, starting from zero-dimensional modeling, including both the thermodynamic cycle analysis and the analysis of strainrate-dependence of caloric effect. The relationship between the zero-dimensional model and higher-order models will be discussed. One-dimensional modeling and its application in multiple elastocaloric cooling systems will be presented, including compressive elastocaloric cooling system, solid-solid contact tensile elastocaloric refrigerator, and the heat driven elastocaloric cooling system. The necessity of higher-order models will also be discussed and techniques to simplify the solution procedure will be introduced, including reduced-order modeling and decoupled modeling, and the compressive stacked tube elastocaloric regenerator will be used as an example.

ELASTOCALORIC DEVICES & CONCEPTS III

Enabling Low-Cost Elastocaloric Cooling with Composite Active Structures

Julie Slaughter, Ames National Laboratory

Advanced regenerators and laboratory-scale devices using commercially-available NiTi materials as refrigerants have demonstrated feasibility, efficiency, and scalability of regenerative elastocaloric heat pumping. Unique active elastocaloric regenerators that utilize composite structures and reduce forces needed for actuation will be discussed along with how these regenerator configurations enable the use of compact, low-cost actuators and increase the potential of commercializing elastocaloric cooling. Experimental and model results will be discussed with a particular focus on efficiency and durability. Also presented are plans for future work to demonstrate advances in active regenerative elastocaloric cooling systems for a specific application.

This work was performed with joint funding from the Advanced Manufacturing Office and the Building Technologies Office of the Office of Energy Efficiency and Renewable Energy of the United States Department of Energy. Ames Laboratory is operated for the U.S. Department of Energy by Iowa State University of Science and Technology under Contract No. DE-AC02- 07CH11358

Long-term Stability of Elastocaloric Material in a New System Approach

Kilian Bartholomé, Fraunhofer IPM

Elastocaloric materials enable efficient concepts for cooling that eliminate the need for flammable or environmentally harmful refrigerants. Demonstrator systems already prove the functionality of elastocaloric cooling systems. In most of these systems, the load is applied via tensile stress. However a challenge of these systems is the long-term stability of the materials due to the occurrence of micro-cracks under tensile load.

Elastocaloric systems, in which the material is loaded under compression, promise an increase in long-term stability. However, compression leads to limitations of the aspect ratio of the material, and this in turn leads to smaller surface areas available for heat transfer between material and heat transfer fluid.

In the approach presented in this work, experimental results of an elastocaloric system are shown where this heat transfer is realized by evaporation and condensation of the working fluid. The heat transfer coefficient based on condensation and evaporation of a harmless working fluid is significantly higher than, for example, the one based on forced convection or heat conduction.

Thereby very good system performances can be attained for systems with a long-term stability outreaching several million cycles.

Development of Optimized Concepts for Elastocaloric Cooling Applications

Paul Motzki, Saarland University

The talk starts from elastocaloric machine concepts developed in first research projects. It will present ideas on how to improve current demonstrators to enable different applications in the future. These improvements are based on first results from systematic experimental investigations, relating to fluid flow as well as thermo-mechanical SMA component characterization. The talk also presents different machine concepts, such as rotational or translational drive systems, as well as scalability considerations for power optimization or cascading concepts to increase temperature spans. Some other design concepts will introduce first steps towards future, more product-like devices, highlighted by application fields such as air/air cooling in industrial applications, or by first ideas about fluid/fluid cooling for, e.g., future E-mobility applications.

POSTERCONTRIBUTION

Numerical Modeling of Elastocaloric Devices
Žiga Ahčin, University of Ljubljana

Defining Fatigue-Resistant Conditions of Elastocaloric Materials
Jan Cerar, University of Ljubljana

Elastomer Foil-Based Elastocaloric Cooling
Carina Ludwig, Karlsruhe Institute of Technology

Development of Driving System of the Elastocaloric Cooling Technology
Andrej Žerovnik, University of Ljubljana

NEKKA-Project: Neuartiges Elastokalorisches Klimasystem
Christoph Baumgärtner, vitesco Technologies

NEKKA-Project: EC-Material Modeling and EC-Subcomponent Development
Lukas Ehl, David Zimmermann, Saarland University

NEKKA-Project: Simulation of Automotive Elastocaloric Air Condition System using Mean Climate Data
Sven Försterling, TLK-Thermo GmbH

Continuously Operating Elastocaloric Cooling Device based on Shape Memory Alloys: Development and Realization
Susanne-Marie Kirsch, Saarland University

First Validation Setup for Elastocaloric Cooling Systems
Lukas Ehl, Saarland University

Elastocaloric Machines – First Step from Demonstrator towards Application-ready Device
Philipp Molitor, Saarland University

First Elastocaloric Demonstrator based on Antagonistic Principle in Linear Arrangement
Nicolas Scherer, Saarland University

Mechanical and Thermal Characterization of Elastocaloric Shape Memory Alloy Bundles
Jonathan Fehrenbach, Saarland University

Continuously Operating Elastocaloric Cooling Device based on Shape Memory Alloys: Modeling and Characterization
Felix Welsch, Saarland University

Elastocaloric Cooling: System Simulation, Modeling and the Thermodynamics of Moist Air
David Zimmermann, Saarland University

iSMAT: Innovative Manufacturing Processes for the Production of Smart Material Systems
Michael Fries, Saarland University

DEPART!Saar: Creating Product Life Cycles of Resource-Efficient Energy Conversion
Dirk Bähre, Alexander Frank, ZeMA gGmbH

Innovative Heat Storage for Energy Efficient Buildings
Elham Abohamzeh, Saarland University

Analysis of Residential Heat Pump Systems using System Simulation
Josef Meiers, Saarland University

From Research to Products: Advancing Elastocalorics for Efficient Cooling and Heating Machines
Yannik Goergen, mateligent nititec GmbH