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A REVIEW OF HEAT EXCHANGER MATERIALS FOR HIGH-TEMPERATURE APPLICATIONS

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INTRODUCTION

The heightened interest in High-Temperature Heat Exchangers (HTHXs) stems from their expanding applications across sectors like Food Processing, Metallurgy, Ceramic Industries, etc. However, corrosion, material degradation, and limited lifespans pose significant challenges. Material selection is critical to address these issues. This review examines the recent advancements in materials for HTHXs, including superalloys, ultra-high-temperature ceramics, and carbon-based materials. It aims to provide a comprehensive overview of their application across various industries, ensuring optimal performance for evolving industrial needs.

MATERIAL SELECTION & HIGH-TEMPERATURE APPLICATIONS

Metal Alloys

Pharmaceutical Industry, Petroleum Refinery, Aerospace and Power Generation

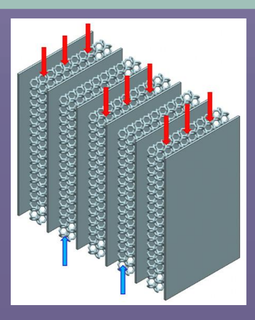
Hastelloy or C-22 (Nickel) alloy.
Kinam Engineering Industries

Haynes 188 (Cobalt-based).
Kara Consulting

Stainless steel A286 (Iron-based).
TITAN Metal Fabricators

Ceramics

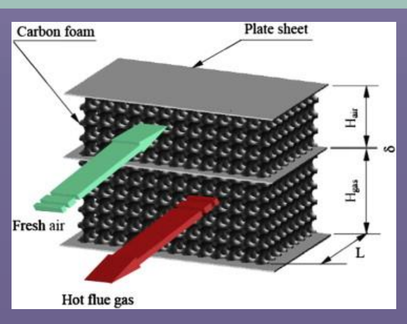
Solar Power Plant



Compact gas-to-gas high-temperature heat exchanger with engineered ceramic cellular architectures between the consecutive border plates.
MDPI

Carbon-based

Solar Thermal Power Plant and Semiconductor Manufacturing

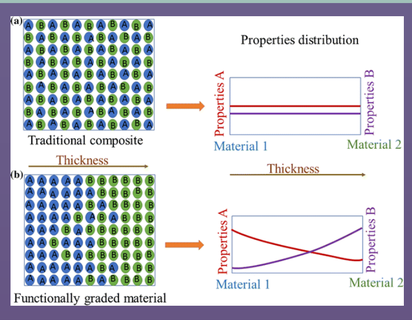


Carbon Matrix Composites.
ScienceDirect

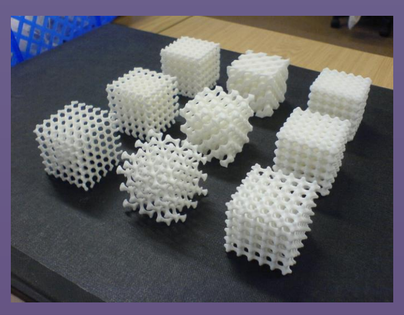
DIABON® (Graphite-based).
SGL Carbon SE

Coatings and Surface Treatments

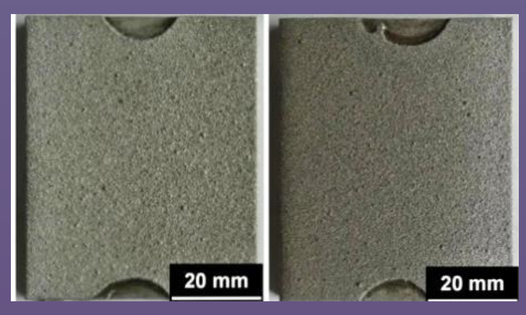
Power Generation and Petrochemical Industry



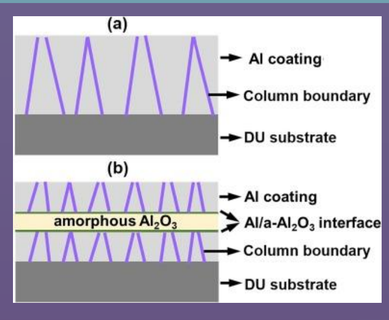
Comparison of Traditional and Functionally composite materials
ScienceDirect



Functional Grade Materials
ScienceDirect

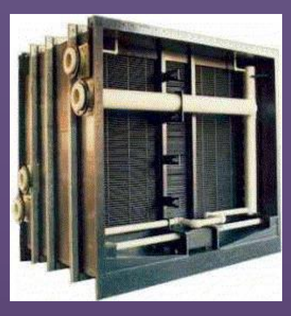


Comparison of the typical surfaces for direct coating for an amorphous iron
ScienceDirect

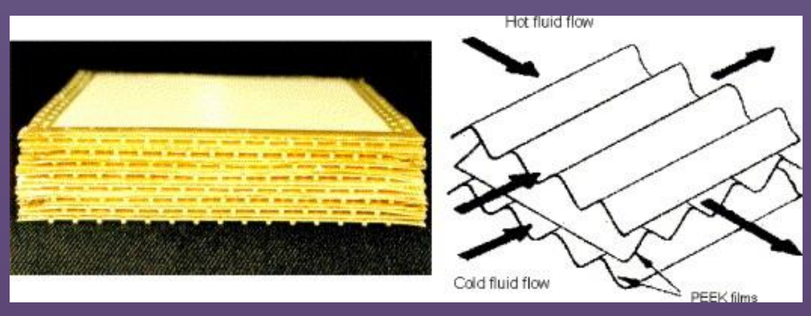


Polymer-based

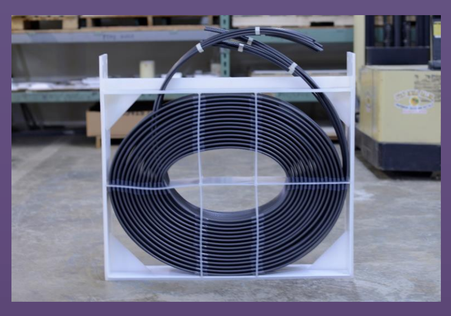
Chemical, Exhaust Gas, and High-Temperature Metal Processing



Polymer Film Compact HX.
ScienceDirect



Corrugated PEEK films stacked at 90 degrees angle to each other in the PFCHE matrix.
ScienceDirect



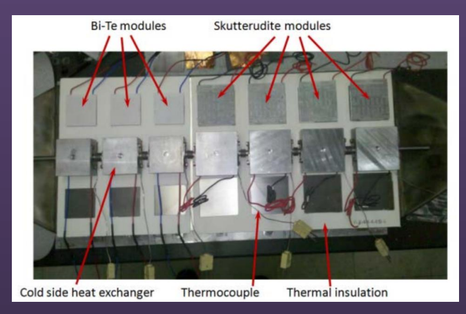
Fluorotherm® immersion heating coils.
Fluorotherm Polymers, Inc.

Advanced Materials

Geothermal Power Plant, Fossil Power Plant, and Waste Heat Recovery

Metal Foam Wrapped Tubular Heat Exchanger.
ScienceDirect

Grain Alignment Along the Tube Circumference (Oxide Dispersion Strength Alloy).
U.S Department of Energy



Skutterudite Thermoelectric Generator (Nanostructured Material).
U.S Department of Energy

FUTURE INSIGHTS

- The advancement of nickel, iron, and cobalt-based superalloys will continue to focus on developing alloy compositions and cost-effective manufacturing processes, while research in UHTCs will find ways to understand its properties in extreme conditions and enhance its toughness for high-temperature applications.
- Carbon-carbon composites and nanotubes can enhance thermal conductivity with future research on scaling up cost-effective production processes, as well as advancement in polymers will focus on enhancing their mechanical properties, improving their performance, and further applications.

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Ohadi, M., Zhang, X., Keramati, H., Arie, M., Singer, F., Tiwari, R., & Shooshtari, A. (2018). Recent developments in high temperature heat exchangers: A review. Frontiers in Heat and Mass Transfer (FHMT), 11. https://doi.org/10.5098/hmt.11.18