Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 123 (2017) 188–195

Energy Procedia

www.elsevier.com/locate/procedia

1st International Conference on Sustainable Energy and Resource Use in Food Chains, ICSEF 2017, 19-20 April 2017, Berkshire, UK

A new technology for cost effective low grade waste heat recovery

Michael Langan*, Kevin O'Toole

Exergyn Ltd, DCU Alpha, Old Finglas Road, Glasnevin, Dublin, D11 T0VC Ireland

Abstract

Exergyn has developed the Exergyn Drive™, an innovative, new engine cycle which runs on hot water. This technology will enable low-grade waste heat ("LGWH") to be recovered cost effectively for the first time, with attractive returns on investment and rapid payback. LGWH is heat below 100°C and there is no cost effective solution commercially available and, as 63% of waste heat is at a temperature below 100°C, there is a significant untapped resource. Cost effectiveness is the key barriers that have left this market untapped. Exergyn's technology will change this as it is very simple, which allows costs to be reduced, and will enable LGWH to be recovered in a wide range of applications to deliver low cost, zero emission electricity on demand. The Exergyn Drive™ applies a solid state drive to utilise hot water of suitable temperatures (c. 90°C) from sources such as reciprocating engines, industrial processes or geothermal resources. Installation is also simple, potentially a flow and return from the heat source and an electrical hook up utilising heat directly from engine jackets without the need for heat exchangers, which enhances efficiency and reduces costs. The low through life costs give, making low grade waste heat recovery attractive for the first time.

Peer-review under responsibility of the scientific committee of the 1st International Conference on Sustainable Energy and Resource Use in Food Chains.

Keywords: Waste heat recovery; heat to power; low grade waste heat; Shape memory alloy; energy efficiency; geothermal

* Corresponding author. Tel.: +44 1509 216128.
E-mail address: mike.langan@exergyn.com

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 1st International Conference on Sustainable Energy and Resource Use in Food Chains.
10.1016/j.egypro.2017.07.261

Nomenclature

σ_{max}	Maximum applied stress to wire (MPa)
σ_{min}	Minimum applied stress to wire (MPa)
$\varepsilon_{recovered}$	Wire recovered strain (%)
ρ_{SMA}	Wire density (kg/m3)
A_f	Austenite finish temperature (˚C)
A_s	Austenite start temperature (˚C)
M_f	Martensite finish temperature (˚C)
M_s	Martensite start temperature (˚C)
I_t	Capital expenditure
M_t	Maintenance expenditure
F_t	Fuel expenditure
r	Discount rate
E_t	Electricity Generated
n	Life of product
t	Year

1. Introduction

Low-grade waste-heat (LGWH) is a major source of energy that remains untapped, a recent evaluation revealed that 72% of the global primary energy consumption is lost after conversion, of which 63% is waste heat streams at a temperature below 100 °C. Our analysis indicates that the LGWH resource could be equivalent to double the energy output from Saudi Arabia.

Although there are numerous technologies available for waste heat recovery, none are cost effective in the recovery of LGWH [2]. The 2nd law of thermodynamics means that waste heat is a by-product rejected from the creation of work, and Carnot's principle shows that the work available decreases as the difference in temperature is reduced [3]. As a consequence of Carnot's principle, most waste heat recovery technologies focus on high grade waste heat where more energy can be recovered [4]. Although 63% of all waste heat is LGWH, it is difficult to recover this energy so the problem can be ignored [5]. LGWH is widespread across markets and geographies. Electricity generation is the major source of LGWH, followed by transport and industry [1]. In the industrial sector, refineries, chemicals and metals are the key sources of waste heat. In the US, 94% of this waste heat resource remains untapped [6]. Exergyn has developed a new technology to convert LGWH into power. Exergyn has developed an innovative solution which can resolve the LGWH problem.

2. Technology

The *Exergyn Drive*™ deploys an innovative technology to convert heat into linear motion. The fundamental phenomenon utilized in the technology which underpins the energy conversion is the contraction of a shape memory alloy (SMA) wire when heated. This occurs as a result of the Shape Memory Effect [7]. Nitinol is an example of a SMA comprising of nickel and titanium. Nitinol undergoes a solid state phase change when heated, changing from martensite to austenite, where the austenite state is 2-4% shorter on length. In doing so, a single wire can lift tens of kilograms. When cooled the material returns to its martensite state and size. Thermally cycling an SMA wire will cause a high force linear movement (Fig 1).

SMA has been utilized in actuator applications in robotics, aerospace, biomedical and automotive applications [8]. Many of these applications utilize the super-elastic properties of the material.

Work done by the SMA during its thermal cycle is a function of the difference between the high applied stress and recovered strain (contraction) during heating and the low applied stress and strain (expansion) achieved during cooling (Eq.1).