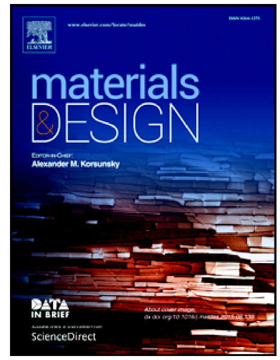
Accepted Manuscript



Beam-pipe coupling in particle accelerators by shape memory alloy rings

F. Niccoli, C. Garion, C. Maletta, E. Sgambitterra, F. Furgiuele, P. Chiggiato

PII: S0264-1275(16)31503-9
DOI: doi: 10.1016/j.matdes.2016.11.101
Reference: JMADE 2537

To appear in: *Materials & Design*

Received date: 31 August 2016
Revised date: 1 November 2016
Accepted date: 28 November 2016

Please cite this article as: F. Niccoli, C. Garion, C. Maletta, E. Sgambitterra, F. Furgiuele, P. Chiggiato , Beam-pipe coupling in particle accelerators by shape memory alloy rings. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Jmade(2016), doi: 10.1016/j.matdes.2016.11.101

Beam-pipe coupling in particle accelerators by shape memory alloy rings

F. Niccoli[a,b], C. Garion[a], C. Maletta[a,b], E.Sgambitterra[b], F.Furgiuele[b] and P. Chiggiato[a]

[a] CERN – European Organization for Nuclear Research, 1211 Geneva 23 Switzerland
[b] DIMEG, University of Calabria, 87036 Rende (CS) Italy

Abstract

Shape Memory Alloy (SMA) rings have been studied for possible applications as beam-pipe connectors in particle accelerators. The rings were analyzed by both experimental tests and finite element simulations. In particular, the tightening performance of NiTiNb rings, in terms of contact pressure and clamping/unclamping mechanisms, was studied for different values of the initial clearance between ring and vacuum pipe. The results have revealed that the contact pressure is not significantly affected by the assembly clearance due to the plateau in the stress-strain response of the material. In addition, thermal dismounting and subsequent re-clamping is obtained by exploiting the two way shape memory recovery capabilities of the SMA rings. Thanks to these features, these connectors can be used in high-energy particle accelerators, especially in radioactive areas, where thermally induced mounting and dismounting operations can be activated remotely.

Keywords: *Shape memory alloys; rings; constrained recovery; strain gages; digital image correlation; finite element analysis*

1. Introduction

Beam-pipe coupling in particle accelerators is nowadays provided by metallic flanges that are tightly connected by several screws or heavy collars. Their installation or dismounting in radioactive area contributes to the radioactivity dose received by the technical personnel. Remote interventions are being considered at CERN in the framework of the High-Luminosity LHC project [1]. Robot interventions are under study for a few selected areas. However, Shape Memory Alloys (SMA) offer a unique possibility to generate tight connections and fast unclamping by remotely changing the temperature of the junction unit. Mechanical simulation and preliminary experimental studies at laboratory scale are the initial steps of the feasibility program.

Thanks to their unique functional properties, namely Pseudoleastic Effect (PE) and Shape Memory Effect (SME), coupled with good mechanical performance, SMA are applied increasingly in many fields of engineering [2-5]. These properties are due to a reversible solid-state phase transition between a parent phase, the body-centered cubic austenitic structure (B2), and a product phase, the monoclinic martensitic structure (B19’). The phase transition is activated either by temperature variation (TIM, Thermally-Induced Martensite) or applied stress (SIM, Stress-Induced Martensite).