ELSEVIER
www.elsevier.com/locate/pnucene
Available online at www.sciencedirect.com
SCIENCE DIRECT
doi:10.1016/j.pnucene.2005.05.003
Progress in Nuclear Energy, Vol. 47, No. 1-4, pp. 44-52, 2005

Printed in Great Britain
0149-1970/$ - see front matter

RENEWED INTEREST IN LEAD COOLED FAST REACTORS

H.U. WIDER, J. CARLSSON and E. LOEWEN*

Joint Research Centre of the European Commission, Postbus 2, 1755 ZG Petten, The Netherlands
* Idaho National Engineering and Environmental Laboratory, INEEL Research Center (IRC), 2351 N. Boulevard, P.O. Box 1625, Idaho Falls, ID 83415 USA

ABSTRACT

In the last few years a number of compact designs of lead-alloy cooled systems have been promoted. Moreover, in Russia a design effort was started earlier on the pure lead-cooled BREST reactor but this effort does not appear to be strongly funded any more. But now the lead cooled and compact STAR-LM reactor is promoted in the US and in the European Union there is some interest in a medium-sized lead-cooled fast reactor (LFR). It has brought some nuclear industries, a large utility, several research centers and universities together to ask the European Commission for a partial funding of design and safety efforts. A 600 MWe LFR design is proposed which would be useful for base load operation but as a fast system it could also be used for load following. Because of the possible plant simplifications and the use of pure lead, the economics of such a system should be good. Moreover, efficient fuel utilization, the burning of higher actinides and a closed fuel cycle make it a sustainable system. Whether, this larger system has the same inherent / passive safety characteristics as smaller LFRs needs to be examined. In this paper the passive emergency decay heat removal by reactor vessel air-cooling of such a larger system is investigated. Moreover an inlet blockage in a subassembly of a low power density LMR is analyzed. Furthermore, the pros and cons of lead vs. lead/bismuth coolants are discussed.

KEYWORDS:

Lead-cooled; Fast reactors; LFR

1. INTRODUCTION

Nuclear power will probably increase strongly in the next half-century, see **Fig 1**. This is driven by the necessity for the mitigation of the climate change, rising energy demand in developing countries and energy security concerns in developed countries.

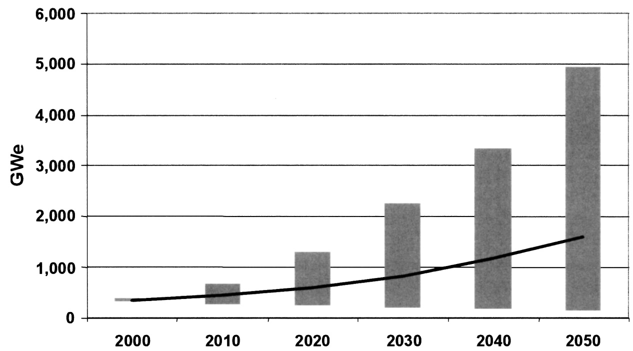

Fig. 1. Range of nuclear power capacities in SRES scenarios. Solid line represent median.

This is reflected in the Special Report on Emission Scenarios (SRES) that was commissioned by the Inter-governmental Panel on Climate Control (IPCC). The 40 scenarios generated do not include policies designed to avoid or mitigate climate change. Nevertheless, three of the SRES scenarios, which have a large nuclear component, lead to a decline of the world carbon emissions by the middle of this century (INPRO, 2003).

A large increase of nuclear power requires reprocessing and fast reactors, which use the fuel efficiently and can burn long–lived higher actinides. This will lead to a major reduction of nuclear waste but also of mining, milling and enriching uranium. This is in the spirit of sustainability and should also help with regard to the public acceptance of nuclear power. Furthermore it would not lead to a strong upward pressure on uranium prices.

The fast reactors that are under consideration in the Generation IV international forum (GIF) are sodium-, gas-, and lead or lead-alloy cooled reactors. Another GIF system is the molten salt reactor, which can breed ^{233}U from thorium in a thermal spectrum. Its major advantage is that it does not generate higher actinides.

The lead or lead-alloy cooled fast reactors have potential advantages regarding economics, inherent and passive safety, and also regarding proliferation resistance. Furthermore, there has been an 80 reactor-year experience with lead/bismuth eutectic (LBE) cooling in the Russian Alpha submarines (Zrodnikov et al., 2003). The most advanced LBE-cooled fast reactor design is the modular SVBR75/100 modular reactor. Its inherent and passive safety behavior has been described in an OECD workshop (Toshinsky, 2002). A prototype of such an LBE-cooled system could be built in this decade in co-operation with Russia. The economics of this modular system is indicated in the following table (Zrodnikov et al., 2003), in which the relatively low cost for all systems probably reflect the lower wages and cost in Russia more than 10 years ago.