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[54] **CARBON-TRAP ALLOYS FOR LIQUID SODIUM**

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[58] **Field of Search** ..... 75/123 M, 123 N, 123 J; 176/37, 38

[56] **References Cited**

OTHER PUBLICATIONS

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[57] **ABSTRACT**

Special binary alloys (Fe-Ti, Fe-V, Fe-Mn) possess the optimum kinetic and thermodynamic properties which make them efficient carbon traps for full-flow liquid sodium cooled system, and thus can be effectively utilized to protect heat exchangers from damage due to carburization during sodium circulation. These alloys do not require heating above normal operating temperatures, for efficient carbon trapping.

4 Claims, No Drawings

CARBON-TRAP ALLOYS FOR LIQUID SODIUM

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of, or under, Contract No. AT(04-3)-189, Project Agreement No. 60, with the United States Atomic Energy Commission.

Liquid sodium coolants used in nuclear reactors, such as the Liquid Metal Fast Breeder Reactor (LMFBR) will transport carbon from the austenitic stainless steel core and the ferritic steel steam generator to the austenitic stainless steel intermediate heat exchanger (IHX), for example. This carbon transport can embrittle the IHX material and degrade its thermal conductivity.

One prior known method for routine or emergency control of carbon is with a bypass carbon trap, wherein the sodium coolant is at least partially circulated through a carbon trapping mechanism. The problem with carbon trapping is that any efficient device must be as active or more active a carbide former as stainless steel, and must remove the carbon from the coolant far more rapidly than the stainless steel of the IHX or other component.

Previous attempts to make carbon traps have not been efficient because an inadequate material was used as the carbon trap. For example, Type 304 austenitic stainless steel has been used as a carbon trap material in sodium cooled systems. However, this material will not operate efficiently as a carbon trap unless it is heated to temperatures substantially higher than the bulk sodium. The same problems are associated with pure titanium (Ti), zirconium (Zr), or niobium (Nb) metals which have also been previously used as carbon traps.

Previous carbon trap metals and alloys have failed for kinetic reasons, i.e., the carbon must diffuse slowly through an austenitic or a carbide crystal structure. This slow diffusion limits the rate of carbon pickup from the stream of liquid sodium coolant. Thus, with increased use of liquid metal sodium as a coolant, a need exists for a simple yet effective method of controlling carbon transport from one component to another via the coolant.

SUMMARY OF THE INVENTION

The invention described herein consists of a series of alloys in which carbon diffusion is significantly faster than in austenitic stainless steels, and which contain active carbide formers. These novel alloy binary alloys consist of iron (Fe) and selected amounts of either titanium (Ti), vanadium (V), or manganese (Mn). These alloys are solid solutions in which the carbide forming elements (Ti, V, Mn) are uniformly distributed on an atomic scale.

Therefore, it is an object of this invention to provide carbon trap alloys for liquid metal coolant.

A further object of the invention is to provide alloys in which carbon diffusion is faster than in austenitic stainless steels, and which contain active carbide formers for trapping carbon being transported in liquid sodium.

Another object of the invention is to provide special alloys which serve to trap carbon contained in liquid sodium coolant and are solid solutions in which the carbide forming elements are uniformly distributed on an atomic scale.

Other objects of the invention will become apparent to those skilled in the art from the following description.

DESCRIPTION OF THE INVENTION

The invention comprises special alloys in which carbon diffusion is about 10 times faster than in austenitic stainless steels, and which contain active carbide formers. Such alloys are particularly useful in liquid metal cooled reactors to protect components, such as heat exchangers, from damage due to carburization during sodium circulation. These novel alloys possess the optimum kinetic and thermodynamic properties which can make them efficient carbon traps for full-flow sodium service in a nuclear reactor, because they do not require heating above normal operating temperatures for efficient carbon trapping.

As pointed out above, liquid sodium coolant in nuclear reactors, such as the LMFBR, will transport carbon from the austenitic stainless steel core and the ferritic steel steam generator to austenitic stainless steel components, such as the intermediate heat exchanger (IHX), causing embrittlement thereof and degrading of its thermal conductivity. The present invention provides carbon trapping alloys which are more active as a carbide former than stainless steel, and thus remove the carbon from the sodium coolant far more rapidly than the stainless steel, thereby effectively protecting reactor components, such as the IHX, from damage due to carburization during sodium service.

The special binary alloys constituting the invention comprise the following for compositions;

1. Iron (Fe) plus 0.5 to 30 wt.% titanium (Ti)
2. Iron (Fe) plus 0.5 to 25 wt.% vanadium (V)
3. Iron (Fe) plus 0.5 to 5 wt.% manganese (Mn)

Each of the above alloys are solid solutions in which the carbide forming elements (Ti, V, and Mn) are uniformly distributed on an atomic scale. The crystal structure of each of these alloys (b.cc) is such, that their rate of carbon pickup will be about 10 times faster than the rate of carbon pickup by an austenitic (f.c.c.) stainless steel such as Type 304. Further, since the activity of carbon is defined by the carbide forming elements, these alloys are as active carbide formers as stainless steels. Finally, since these are binary alloys the trapping of carbon will produce a two-phase moving boundary layer in which carbide particles will be uniformly distributed in a b.cc matrix. Therefore, a carbon trap, utilizing these alloys will not "plug up" by forming a continuous carbide layer.

Experiments conducted to varify the inventive concept show, for example, that the Fe-9 Ti alloy is approximately ten (10) times more effective in trapping carbon than stainless steel, and that Fe-Cr alloys are ineffective. These test results are set forth in greater detailing in U.S.A.E.C. Report GEAP-13919-3 generated under the above-identified contract with the Atomic Energy Commission.

It has thus been shown that with the binary alloys of this invention, efficient carbon traps for primary or secondary liquid sodium systems can be provided, thereby overcoming the problems of the prior known carbon traps, and thus substantially advancing the state of the art relating to carbon trapping.

While particular binary alloys have been described, modifications might be accomplished by those skilled in the art, and it is intended to cover in the appended claims all such modifications as come within the spirit and scope of the invention.

What I claim is:

1. In a sodium cooled nuclear reactor containing austenitic stainless steel components subject to damage due to carburization during sodium circulation, a material for trapping carbon and thereby preventing damage to components due to carburization comprising a binary alloy in which carbon diffusion is faster than in austenitic steels and which contains an active carbide former, said binary alloy consisting essentially of Fe and a second element selected from the group consisting of 0.5 to 30 wt.% Ti, 0.5 to 25 wt.% V, and 0.5 to 5 wt.% Mn.

2. The material for trapping carbon defined in claim **1,** wherein said alloy is consisting essentially of Fe + 0.5 to 30 wt.% Ti.

3. The material for trapping carbon defined in claim **1,** wherein said alloy is consisting essentially of Fe + 0.5 to 25 wt.% V.

4. The material for trapping carbon defined in claim **1,** wherein said alloy is consisting essentially of Fe + 0.5 to 5 wt.% Mn.

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