P01

Heat-Resistance Alloy for the Next Generation Fossil Fuel Power Plants and Current Situation for Green House Gas Reduction

Hiroshi Akamine,[1] Masatoshi Mitsuhara,[2] and Minoru Nishida[2]

[1]*Department of Applied Science for Electronics and Materials, Interdisciplinary Graduate School of Engineering, Kyushu University*

[2]*Department of Engineering Science for Electronics and Materials, Faculty of Engineering Science, Kyushu University*

Kasuga-koen, Kasuga, Fukuoka 816-8580, Japan,

Abstract

Due to the increasing attentions to the global warming and related natural disasters, governments have been required to take more positive action to reduce greenhouse gas (GHG) emissions. Although the international framework has been established, effectiveness of it is still debatable and there is room to be improved. On the other hand, new heat-resistance alloy for the advanced high-efficiency fossil fuel power plants have been developed to realize lower cost and smaller GHG emission. In the present work, the current framework for GHG reduction is discussed and the brief results of microstructure observation of the new alloy will be described.

1. Introduction

Economic growth and environmental protections are in many cases controversial challenges, since pursuing the lower cost production potentially could drive people to use of cheap, but not environment-friendly ways of production. One of the prominent situations can be found in power generation. Recent increasing attentions to the global warming and related abnormal natural disasters have required governments in many countries to take more active policy action to suppress the worldwide climate change. Although the international framework for reducing greenhouse gas (GHG) emissions, Kyoto Protocol, have been established, it has been debatable whether it truly reduced the sufficient amount of GHG emissions, since U.S. and China, which respectively have the first and second largest contribution to the world GHG emission, are not participated in this framework, and only for the developed countries reduction targets have been imposed. In this work, brief information on the current situation of GHG reduction will be addressed both in perspectives of international and each country's framework.

Based on the above reason, shift from fossil fuels to renewable energies have been the important subject for many countries. However, introduction cost of the renewable energy is still high, and the short of electricity is urgent matter for many developing countries. Thus, in order to realize both to supply enough electricity with reasonable cost and to suppress the GHG emission, advanced fossil fuel power plants, having the higher efficiency compared to the current plants, have been developed, one of which is called Advanced Ultra Super-Critical (A-USC) power plants. Since in A-USC plants increasing processing steam temperature into the order of 700 C is required, developments of reasonable materials with sufficiently high heat-resistance is needed. In the present work, one of the potential candidates for such materials will be investigated in terms of the physical properties and their microstructure.

2. Frameworks and Strategy for GHG Reduction

2.1. Current GHG emission

Figure 1 shows the change in CO_2 emission in selected countries. It is easy to find that developing Asian countries, China and India present clear increasing trends and developed countries stays almost unchanged. It should be noted that according to the

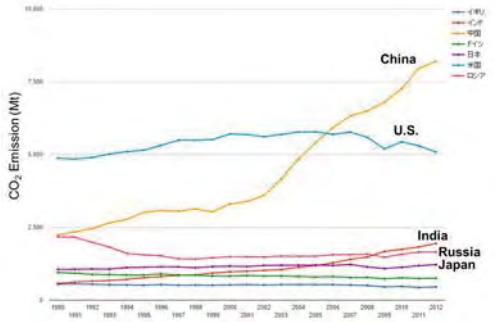

Fig. 1 CO_2 emission in selected countries during 1990-2014 (created based on IEA Statistics 2014)

International Energy Agency (IEA) statistics, China, U.S., India and Russia are the first to fourth largest emitting countries in the world in 2014 and they have not committed to Kyoto Protocol. Thus the participations of these countries are critically important for the post-Kyoto Protocol.

2.2. International Framework for GHG Reduction

IEA have proposed the Bridge scenario in its World Energy Outlook 2014 [1], in which world GHG emission turns into declining around 2017 as shown in Fig. 6. In this scenario, each country is required to make a commitment to five types of improvements, including energy efficiency, reducing inefficient coal, renewables investment, upstream methane reductions, and fossil-fuel subsidy reform.

The details of the Bridge scenario are presented in the World Energy Outlook Special Report [2], in which three scenarios about the world trends on GHG emissions, INDC Scenario, Bridge Scenario, and 450 Scenario are described. The INDC Scenario represents an assessment of the implications of the Intended Nationally Determined Contributions (INDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Since more countries are expected to submit their INDCs, this scenario in its current form reflects the lower limits of the global climate efforts and thus will be improved. On the other hand, in the Bridge Scenario, IEA proposes a near-term strategy, building on available technology and five proven policy measures: (i) increasing energy efficiency in the industry, buildings and transport sectors; (ii) progressively reducing the use of the least-efficient coal-fired power plants and banning their construction; (iii) increasing investment in renewable energies to $400 billion in 2030; (iv) gradually phasing out subsidies to fossil-fuel consumption; (v) reducing methane emissions from oil and gas production. These clearly show that countries are required to take more active plans for improving energy efficiency and shifting to renewable energy.

3. Heat Resistance Alloy for A-USC Power Plants

Figure 2 shows a typical microstructure of as-annealed Ni-based heat-resistance alloy, HR6W [3], which have richer Fe content than other Ni-based candidate alloys to achieve the lower cost. As a result of microstructure observation by scanning electron microscope (SEM) and hardness measurement, it revealed that HR6W includes two kinds of precipitates, $M_{23}C_6$ and Laves, and they are the main strengthening factors. In the presentation, detail characteristics will be shown.

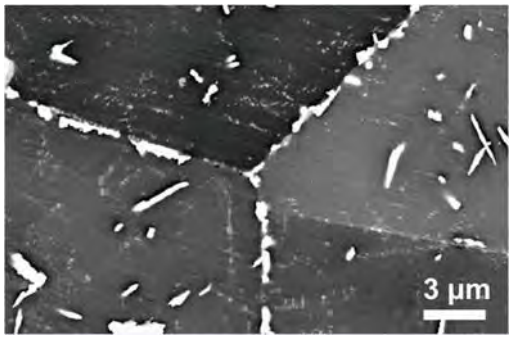

Fig. 2 SEM image of HR6W annealed at 750 C for 3000 h.

Reference

[1] World Energy Outlook 2014, IEA, 2014.
[2] World Energy Outlook Special Report, IEA, 2015.
[3] H. Semba, et al, Nippon Steel and Sumitomo Metal Technical Report, 397 (2013) 71.

Email: 3ES14001R@s.kyushu-u.ac.jp