NANO STRUCTURED MATERIALS

Considerable research work is being carried out in producing nano structured metals having grain sizes on the nano scale and producing new metals incorporating metal Nano particles. Nano structured metals are stronger, harder and tougher. Nano structured copper for example has six times the strength for a given weight relative to the regular metal. Nano structured metals can be used for applications where corrosion and wear resistance are required. Nano structured versions of bulk metals such as Cu, Ni and Ti are available.

High creep strength austenitic stainless steel (Fe-20Ni-14Cr-2.5Al) with Nano dispersions of niobium carbides has been developed by ORNL, USA. The material offers superior creep and oxidation resistance at high temperatures and can be used in energy conversion systems. Creep rupture time exceeds 2000 hrs at 750 °C and 100 MPa in air. Oxidation resistance has been demonstrated in air with 10 % water vapour at 650 °C and 800 °C.

Advanced materials are now being deployed in new and existing power plants to improve operating performance and reliability. Increase of steam parameters from around 180 bar and 540 °C - 560 °C to ultra supercritical condition of 300 bar and 600 °C have led to efficiency increases from around 40 % in 1980 to 43 - 47 % in 2006 and reduction in emission of CO_2, NO_x and SO_x. Further advancement in operating parameters can be achieved by strengthening the already developed creep resistant steels by altering microstructure with in-situ formation of nano nitrides and carbo nitrides.

Nano strengthened creep resistant steels: At National Institute of Materials Sciences, Japan, scientists reported the development of a 9 Cr martensitic steel dispersed with nano metre scale carbo nitride particles using conventional processing techniques [1-4]. At 923 K, the dispersion strengthened material exhibited a time to rupture that is increased by two orders of magnitude relative to the current strongest creep resistant steels.

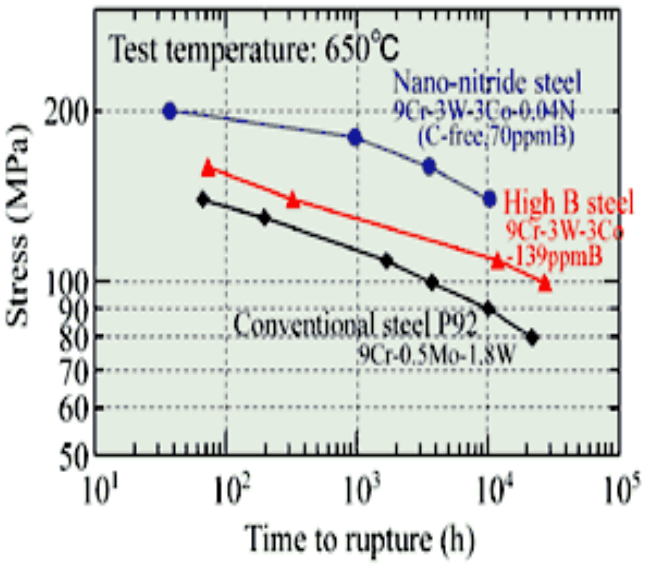

Figure 1 Comparison of creep properties of conventional and nano strengthened steels

Nano strengthened creep resistant steels display an improvement of 100 times in creep life compared to conventional steels. The 10,000 h creep strength of nano strengthened P 92 steel at 650 °C is 150 MPa as compared to 90 MPa for conventional P 92 steel [Figure 1]. This improvement in creep resistance is attributed to a mechanism of boundary pinning by the thermally stable carbonitride precipitates. Extensive Transmission Electron Microscopic (TEM) studies have helped to identify the nature, shape, size and distribution of the nano size particles, which are responsible for the improvement in the creep properties.

The steel also demonstrates enough fracture toughness. The developed nano strengthened steel will be utilised for super and ultra super critical power plants.

Research is going on to produce super hard metals that can be used in defence applications such as vehicle and personnel armour, sports equipment such as ski or snow board edges, jet engine components such as blades and rotors, etc.

Sandvik Asia has developed ultra high strength stainless steel using nano technology. The material has ultra high strength combined with good formability, good corrosion resistance and surface finish. Work related to understanding the formation and thermal stability of nano-sized structural features including second phases, particles and grains, in metals under typical industrial conditions continues to be an area of interest.