TEMPER EMBRITTLEMENT

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INTRODUCTION

- Temper embrittlement refers to the decrease in notch toughness of alloy steels when heated in, or cooled slowly through, a temperature range of 400°C to 600°C. Temper embrittlement can also occur as a result of isothermal exposure to this temperature range. The occurrence of temper embrittlement can be determined by measurement of the change in the ductile to brittle transition temperature with a notched bar impact test, before and after heat treatment. In most cases, the hardness and tensile properties of the material will not show any change as a result of embrittlement, but the transition temperature can be raised by as much as 100°C for embrittling heat treatments.
- Temper embrittlement is caused by the presence of specific impurities in the steel, which segregate to prior austenite grain boundaries during heat treatment. The main embrittling elements (in order of importance) are antimony, phosphorous, tin and arsenic. The fracture surface of a material embrittled by these elements has an intergranular appearance.

- Plain carbon steels with less than 0.5% Mn are not susceptible to temper embrittlement. However, additions of Ni, Cr and Mn will cause greater susceptibility to temper embrittlement. Small additions of W and Mo can inhibit temper embrittlement, but this inhibition is reduced with greater additions.
- The original toughness of a steel which has suffered temper embrittlement can be restored by heating to above 600°C, and then cooling rapidly to below 300°C. However, the best method of avoidance is to reduce the embrittling impurities through control of raw materials and steel production.
- Temper embrittlement has been also related to reheat cracking and low-ductility creep fractures, and a number of types and mechanisms have been proposed, considering carbide precipitation as well as grain boundary embrittling elements.

- The loss of ductility caused in certain steels when they are held in or slowly cooled through the temperature range 300º to 600ºC. This effect is commonly seen in nickel-chromium steels and is due to the precipitation of carbides in the areas between the crystals in their structure (grain boundaries). It can be overcome by adding 0.2% to 0.3%molybdenum.This effect is called temper brittleness since it occurs in the normal tempering range of steels.