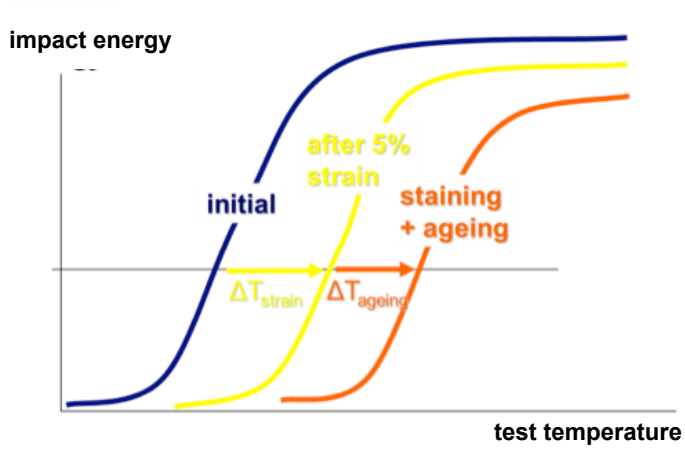
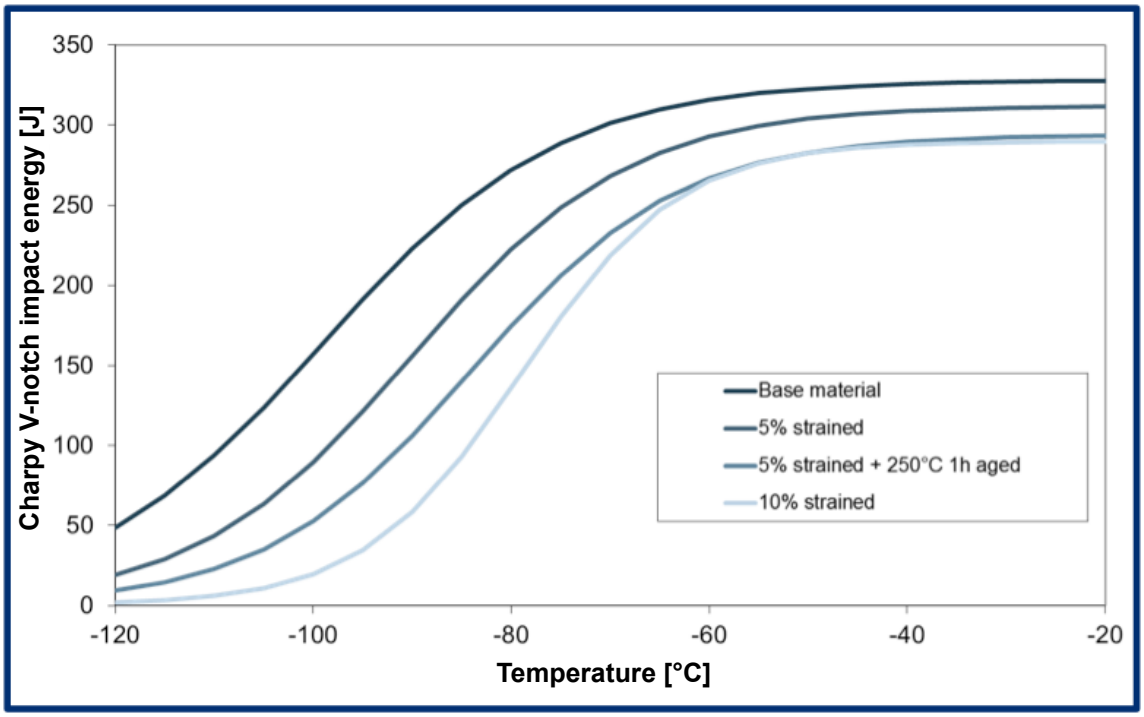
DI-MC

Cold forming

DI-MC steels can be cold formed without difficulty, providing the forming temperature is below 580 °C. As in the case of conventionally produced steels, the strength characteristics R_{eH}, $Rp_{0,2}$ and R_m generally increase proportionally as plastic deformation rises during cold forming, while the toughness values fall. The reduction in the toughness of the steel as a result of cold forming and ageing is reflected in a shift in the Charpy V-notch impact energy/temperature curves toward higher temperatures.



Cold deformation of 1 % thus causes a shift in the curve of around 3 to 4 °C on average; additional ageing can shift the curve by a further degree Celsius per percent cold deformation. DI-MC steels already possess extremely high reserves of toughness in their delivery condition, and thus continue to exhibit extremely good toughness properties, assuring significantly greater component safety, even after such treatment processes. Below figure illustrates this correlation, showing typical shifts in the Charpy V-notch impact energy/temperature curve for a DI-MC 355 T for various degrees of cold forming with and without subsequent ageing treatment.



Example of the influence of cold deformation and ageing on the Charpy V-notch impact energy/temperature curve of DI-MC 355 T (average curves, scatter not shown)

The change in mechanical properties caused by cold forming or ageing can be partially reversed by means of stress relief annealing.

Stress relief annealing

DI-MC steels can be stress relief annealed without difficulty. This heat treatment scarcely impairs the microstructure state, and thus the materials properties, achieved by means of TM rolling. Stress relief annealing is generally conducted at temperatures of 530 to 580 °C, with subsequent cooling in still air. It is recommended that a holding time of 4 hours not be exceeded in total, even in case of multiple annealing cycles.

Hot forming

The advantageous properties of thermomechanically rolled steels can be achieved during the production phase only by means of a special combination of forming and heat treatment at final rolling temperatures of between 700 and 900 °C. Classical hot forming, typically performed at temperatures of between 750 and 900 °C, is therefore not possible using TM steels, and would result in the destruction of the special microstructural state previously achieved by TM rolling. Semi-hot forming at temperatures of 530 to 580 °C (maximum stress relief annealing temperature) may be expedient for the shaping of thicker walled components, however. This can be accomplished without difficulty using DI-MC steels: the yield strength of the material at 500 °C is only around 50% of its yield strength at room temperature, and the necessary forming forces are therefore already significantly reduced. In semi-hot forming, however, the strength characteristics also rise, as a result of the cold deformation component. A significant shift in the Charpy V-notch impact energy/temperature curve needs not be expected, on the other hand.

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