2.8 Avoiding Distortion

1. Causes

The release of inherent internal stress when steel components are heated in the zinc bath (normal galvanizing temperature is approx. 450°C) is often responsible for distortion which may occur during the process. At this temperature the limit of elasticity of the steel is reduced to about half the value at room temperature.

When very high internal stresses are generated in a steel structure it may happen that the highest level of stress is relieved by plastic deformation. If the internal stresses of a structure are mainly above the elasticity of the steel (which has been reduced during hot dip galvanizing) then the steel may no longer accommodate these internal stresses. Stresses are released as plastic deformation and distortion results (Fig. 1).

Internal stresses to some degree are present in most steel structures and as a rule are not a problem when hot dip galvanizing. Internal stresses which may be present in the structure, for example, in the form of cylindrical distortion or weld stresses, can be in equilibrium with each other and would not result in distortion.

The amount of possible distortion depends amongst other things on;

– the size of the internal stresses involved
– their distribution and direction inside the structure
– the type and thickness of the material used.

2. Remedy

Positive steps can be taken to minimize the distortion of steel structures during galvanizing but consideration must be given to which internal stresses can be minimized even during welding.

It can be said that internal stresses due to welding play the greatest part in creating distortion. Care must be taken from the beginning to keep the stresses in a steel structure as low as possible so that the steel is able to withstand the internal stresses (despite its reduction in durability during the galvanizing process) without distorting. Drawing up a plan of the results of welding may help (see also data sheet 2.9). The main requirements for reducing the danger of distortion are utilising symmetrical cross sections, symmetrical arrangement of the welding seams and restricting the size of welding seams to a minimum.

Fig. 1: Schematic view of the yield limit of the steel changed by the increase in temperature showing stresses which can result in distortion.

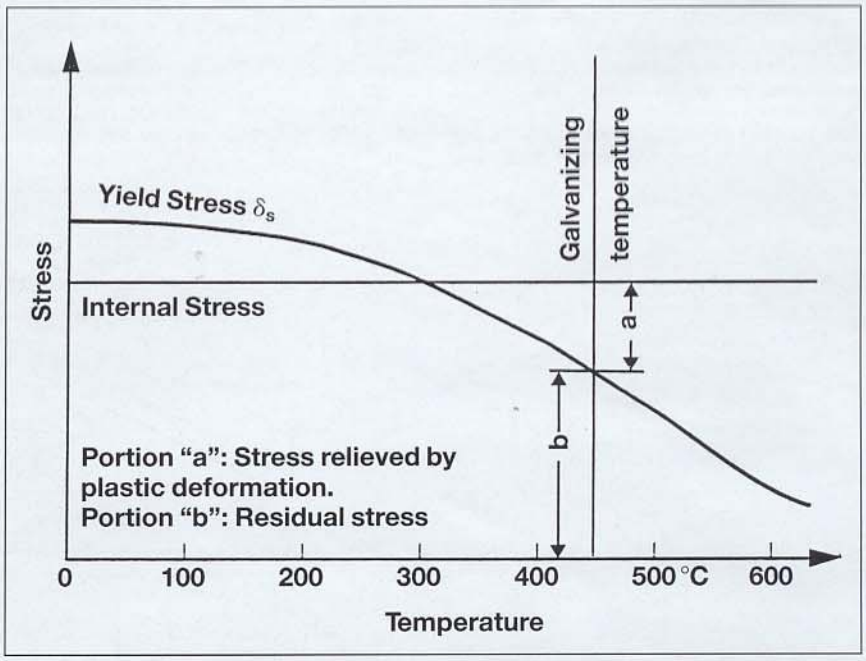
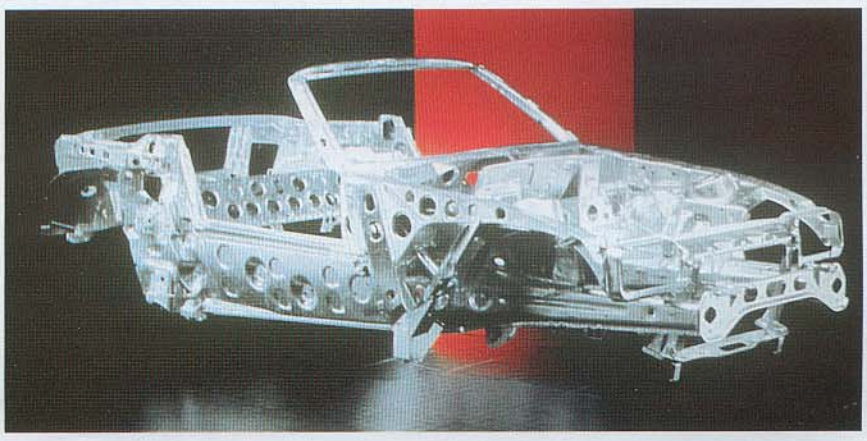


Fig. 2: Galvanized chassis of a BMW.



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3. Large steel structures

Large steel structures cannot be hot dip galvanized in one operation because their size is larger than any of the galvanizing baths currently available. In these cases steel components of an extreme size can be hot dip galvanized by multiple dipping them in stages, but this means that other considerations must be taken into account.

Multiple-dipping of thin spiral sections for supports and girders generally causes no problems as these do not have indentations commonly found with plate supports provided with strap stays. Also, the differences caused by the differential heating of upper and lower edge of a section are relatively insignificant. However, with very large structures the danger of distortion and the possible formation of cracks due to uneven heating of the components is increased. As well as maintaining a careful balance between the steel fabrication and the requirements of the hot dip galvanizing process the following points must be observed:

With multiple dipping of large structures the main problem is one of distortion due to expansion rather than one of stress due to welding operations. This is because stresses occurring locally exceeding the yield point of the steel are reduced.

Severe distortion and the possibility of subsequent cracking can be avoided if the various linear expansions of individual components caused by multiple dipping are accommodated in the design. The linear expansion which then occurs is restricted to the elastic area i.e. after hot dip galvanizing the cooled steel component returns to its original shape and size.

Figure 3 shows some examples of this which are explained as follows:

Series 1: The difference 1 of the change in length of upper and lower strap is actually less than in column 2 and makes relatively lower demands due to the shorter lengths dipped in the zinc bath.

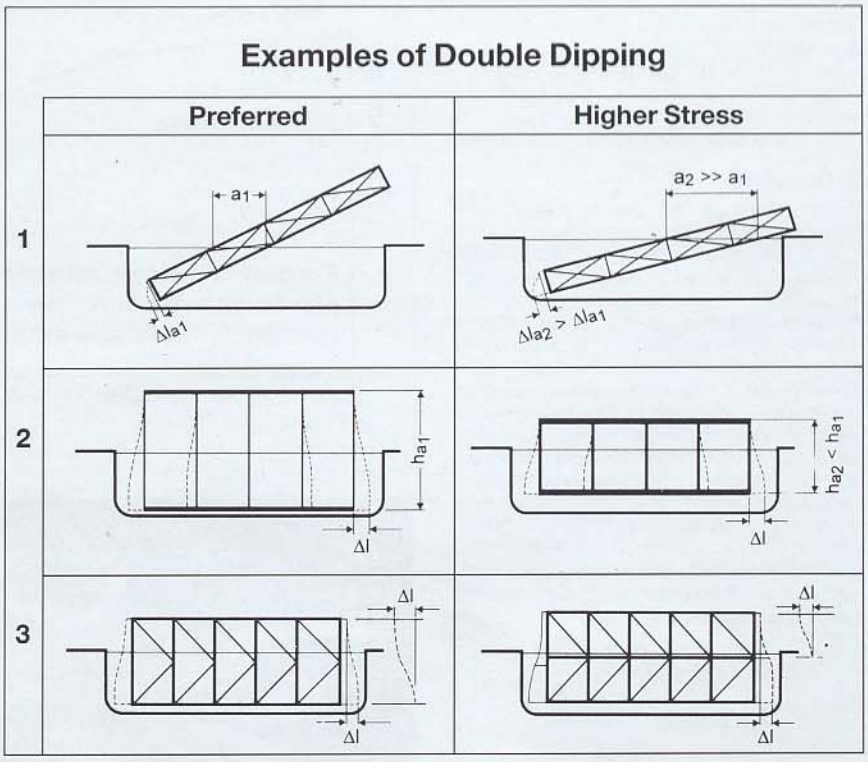
Series 2: The difference 1 of the change in length of upper and lower strap makes lower demands in column 1 than in column 2 due to the greater height of support and less rigid structure.

Series 3: The difference 1 in expansion of upper and lower strap, almost the same in column 1 and 2, makes a higher demand than in column 1 without this additional bar due to the disc effect of the lower part of the structure in column 2 (additional strap welded in the centre of the connection). Equilibrium of the linear change can be achieved across the whole height of the component.

Summary:

Damage to structures in the form of distortion and cracking can be avoided by good design which takes into account the relationship of temperature and expansion during the galvanizing process.

Fig. 3: Examples of multiple dipping of large steel structures.



Published by:
Galvanizers Association
Wren's Court, 56 Victoria Road,
Sutton Coldfield,
West Midlands,
B 72 1 SY, U.K.