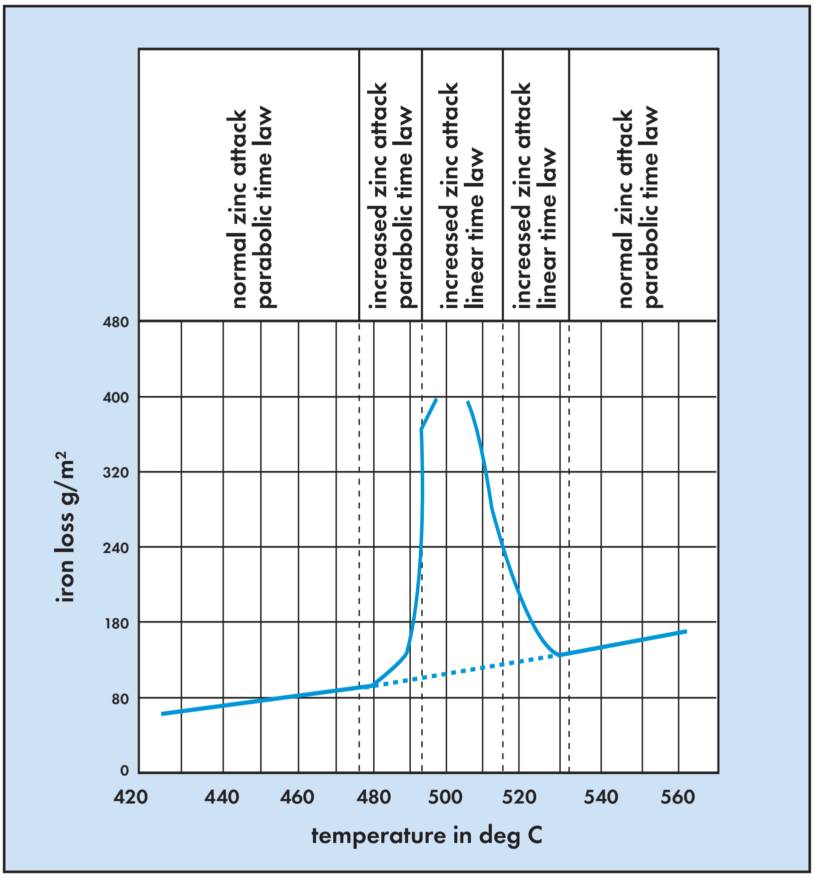

Figure 32. The influence of temperature on diffusion of iron in molten zinc.

is achieved at a given zinc temperature in 5 minutes, doubling immersion time to 10 minutes is unlikely to increase the coating thickness by more than about l0µm. In contrast, with steels prone to high reactivity galvanizing (reactive levels of Si and/or P), the ultimate coating thickness can well increase by 50 to 100% over similar dipping periods.

When feasible, reducing immersion time remains the most practical method available to galvanizers for avoiding excessive coating growth. The main difficulty arises with structures where the configuration necessitates manipulation while under the molten zinc, particularly in the case of tubular components where zinc is required to penetrate and coat internal surfaces and then be allowed to drain out of the product on withdrawal. It is recommended that optimum sized fill and drainage holes be used when fabricating a tubular structure. Failure to comply with this requirement frequently renders extended immersion periods to be unavoidable.

7.4 ALLOYING ADDITIONS TO THE MOLTEN ZINC

Aluminium

The presence of aluminium in the molten zinc retards the initial formation of Fe/Zn alloys, even at low concentrations (≤0.007%). When extended immersion cycles are unavoidable, the influence of aluminium on coating growth is not effective, although it may improve surface appearance.

Aluminium additives have impacted positively in the galvanizing of continuous strip. Thin sheet with aluminium alloyed coatings have been commercially available under various trade names for a number of years. They contain different levels of aluminium and other additives. Similar coatings applied by the general galvanizing process, require special fluxing agents and have to date had limited success.

Nickel

Additions of 0.06% nickel can retard excessive alloy formation but nickel is only a partial solution. While it controls coating structure and thickness for steels containing less than 0.2% Si, it fails to control alloy growth for steels with a higher silicon content *(figure 34)*. The nickel-zinc concept can also result in thicknesses below the specified minimum in the case of coatings applied to less reactive steels.

It would seem that nickel does not retard the zinc iron reaction but rather that alloy is released into the molten zinc as it forms. This results in an increase in dross formation in the galvanizing bath.

Vanadium and Titanium

Recent research has shown that additions of vanadium and titanium to the molten zinc in the galvanizing bath can overcome the problem of reactive steel galvanizing. The coatings produced consist of uniform layered microstructures similar to those found in coatings on non-reactive steels.

Negative aspects of this development are an increase of approximately 25% in metal cost (which could be offset to a degree by lower overall zinc consumption) and a substantial increase in oxide formation on the surface of the molten zinc in the galvanizing bath.

7.5 THE WITHDRAWAL RATE OF THE ARTICLE FROM THE MOLTEN ZINC

The principle of good galvanizing is rapid immersion and slow withdrawal. For instance, if an article is withdrawn at 3,0m/minute as opposed to 1,0m/minute the resultant coating thickness will be greater by about 30%, as molten zinc is dragged out of the bath.

7.6 SURFACE CONDITION

Varying surface roughness of the steel leads to variations in thickness of the coating. The rougher the surface of the steel, the thicker the coating. Depending on the type of steel and the surface profile, preparation treatment such as abrasive blasting can result in a 15 to 25% thicker coating. Steel that has been severely attacked by rust, or pickled without inhibitors, also results in increased coating thickness.

7.7 THICKNESS OF THE STEEL

The thickness of the steel influences the coating thickness - the thinner the steel, the thinner the coating. This applies especially to silicon-killed steels. One reason for this is that articles fabricated from thinner steels, generally require shorter immersion times. It is for this reason that when reactive thinner steels are welded to non-reactive thicker steels, inordinately thicker coatings may result on the thinner steel. This thicker coating may be aesthetically less acceptable and prone to brittleness and therefore potential damage, particularly on edges. Working, rolling and heat treatment of the steel can vary, leading to different reactions in the zinc bath.