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Effect of Silicon Content in Steel During Galvanizing

Vijay Singh
Professor & HoD, Dept. of Mechanical Engineering, Aditya College of Technology and Science, Satna, India

***Abstract*: Reactive steel is the term we use for steel that contains an unusually high level of silicon. Very high or low silicon content in steel will increases the zinc coating thickness during the galvanizing process. Silicon is usually added to steel as a deoxidant during its production and is an important part of that process. However, in some infrequent instances, when steel with high proportions of silicon is hot dip galvanized, the zinc-iron alloy layers that are normally one of the benefits of galvanizing continue to grow creating a very thick and sometimes unsightly darker finish. This darker finish conforms to the British Standards for hot dip galvanizing (BS EN ISO 1461 [2009]) but is not visually appealing to some customers looking for a shinier finish. In some extreme cases the coating formed is so thick that it can be susceptible to handling damage. To a lesser degree the level of phosphorus in steel has a similar influence on the coating formation.**

***Keywords*: Deoxiaent, Galvanized, BSEN ISO 1461, and coating.**

1. Introduction

A. Heading

The zinc coating structure consists of several intermetallic layers forming by interdiffusion of zinc and iron. The formation of the coating is directly related to the main production parameters: temperature and chemical composition of the melt, the holding time in the melt, the chemical composition of galvanized steel, especially of silicon content in steel [1]. Silicon is a cheap and very effective reinforcing alloying element in steel. Many sheets of construction steel contain small quantities of silicon because it is used in them as a deoxidizing component in production. The sudden forcing of the reaction between the steel with silicon content about 0,06-0,10% and molten zinc was described by Sandelin in the last century [2], [3]. This reaction leads to the abnormal growth of zinc coating thickness and is called in the literature "Sandelin effect". Furthermore, low-alloy steels containing silicon as a cheap alloying element in an amount up to 1% are widely used in reliable constructions. It is known that the presence of silicon in the steel in amounts more than 0.5% can impact negatively on the quality of the zinc coating and leads to its discontinuity, increasing the thickness and impairing the adhesion to the base metal. [4]-[7]. Despite the great number of studies, the mechanism of the silicon effect on the interdiffusion processes between Fe and Zn in the coating formation is still not completely clear. Thus, the main aim of this work was research the influence of silicon in the steel on the phase transformations taking place during the zinc coating formation.

B. Sub-headings

The silicon content of steel is determined through a mill test report. Silicon is not just one value through the heat of steel but is rather some type of distribution throughout the heat. Just what the distribution actually contains is not known, but let's try to put some numbers together for an estimate. Say the steel has a mill test report with a silicon value of 0.04%. Where is this value within the distribution of silicon values throughout the steel? Is it the maximum, the minimum, the average, the mean or some other function of the distribution? Well, the answer is NO! The silicon value is only one point on the distribution curve of all of the silicon values in the heat. Since you cannot say for certain what this mill test report actually represents you make the deadly assumption the silicon value is somewhere around the middle of the distribution. This is good statistics until your part comes out with a dull gray and thick coating and your customer is not very happy!

So, what happened to our galvanized coating and why does the part have a thick coating? The answer lies in the Sandelin curve (Figure 1).

Pay particular attention to the slope of the curve around 0.05% silicon content. The slope is very steep, so meaning a small change in the silicon content will result in a large change in the coating thickness. Therefore, if you have a part where the mill test report gives a value of 0.04% silicon and this silicon value is in the center of the steel heat silicon distribution or on the high side of the distribution, the galvanized coating will come out bright and shiny and right on specification coating thickness. On the other hand, if the 0.04% on the mill test report is on the very low side of the distribution, then some parts from this steel heat will have higher silicon values and will yield galvanized coatings that may be much thicker and even dull gray in appearance. The small difference between a silicon value of 0.04% and 0.06% can make a big difference in the galvanized coating thickness and appearance. The two micrographs below (Figures 2 and 3) show the difference in the coating structure with just a little change in the silicon content. The first micrograph has a structure of three intermetallic layers and a free zinc layer as the outer layer. The second micrograph has very small gamma and delta layers and a very large zeta

layer with no free zinc layer so it will have a dull gray appearance. The recommended limits (below 0.04% or between 0.15% and 0.22%) for silicon content are given in ASTM A385. However, there will be times when silicon levels are within these limits yet the coating comes out with a dull gray appearance and a thick galvanized coating. One of the ways to lower the chance of this happening is to use a kettle chemistry that contains nickel.

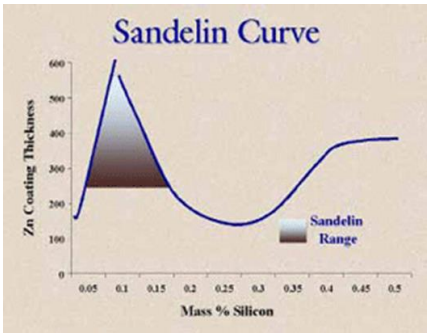

Fig. 1. Sandelin curve

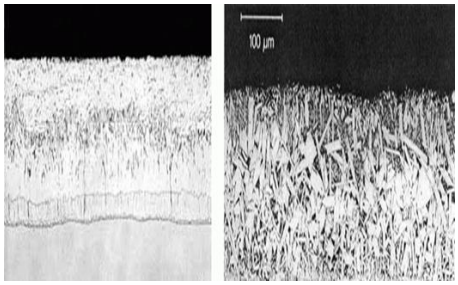

Fig. 2. Difference in the coating structure

Table 1
The influence of silicon content when galvanizing cold- and hot rolled

	Cold rolled steel	Hot rolled steel
Si<0.03	Acceptable surface in most cases. Shiny coating	Acceptable surface in most cases. Shiny coating
0.03<Si<0.14	Not suitable	Not Suitable
0.15<Si<0.21	Thicker coating than standard	Thicker coating than standard
0.22<Si<0.28	Thicker coating gray appearance	Thicker coating gray appearance
0.28<Si<0.35	Thick brittle coating Gary appearance	Thick brittle coating Gary appearance

2. Conclusion

The coating thickness on galvanized steel depends mainly on: Steel silicon content, Steel phosphorous content, dipping time in zinc melt, Steel dimension and surface roughness, Heat treatments of steel during working. Selection of steel Si content should be depending on the requirement of galvanizer and user of galvanized steel. It is recommended that medium reactive steel is proffered as the coating have not brittle and coating thickness also achieved by less effort of galvanizer. The Alternate method is being suggested for low reactive steel to achieve the standard coating like over pickling and sand blasting of steel is used for low reactive steel galvanizing.

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