# بسم الله الرحمن الرحيم

# شبكة المعلومات الجامعية

# التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

# جامعة عين شمس

## التوثيق الالكتروني والميكروفيلم

## قسم

**نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأفلام قد اعدت دون آية تغيرات**

## يجب أن

**تحفظ هذه الأفلام بعيداً عن الغبار**

**في درجة حرارة من 15 – 20 مئوية ورطوبة نسبية من 20-40 %**

**To be kept away from dust in dry cool place of 15 – 25c and relative humidity 20-40 %**

# بعض الـوثـــائق

# الأصـلية تـالفـــة

# بالرسالة صفحات

# لم ترد بالأصـــــل

# ALUMINIZING OF STEEL SHEETS

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***M.Sc. Faculty of Engineering***

***Shebin El-Kom, Menoufia University***

***Ph.D. THESIS***

***Submitted For***

***Ph.D. Degree in***

***PRODUCTION ENGINEERING***

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***FACULTY OF ENGINEERING***

***SHEBIN EL- KOM, MENOUFIA UNIVERSITY***

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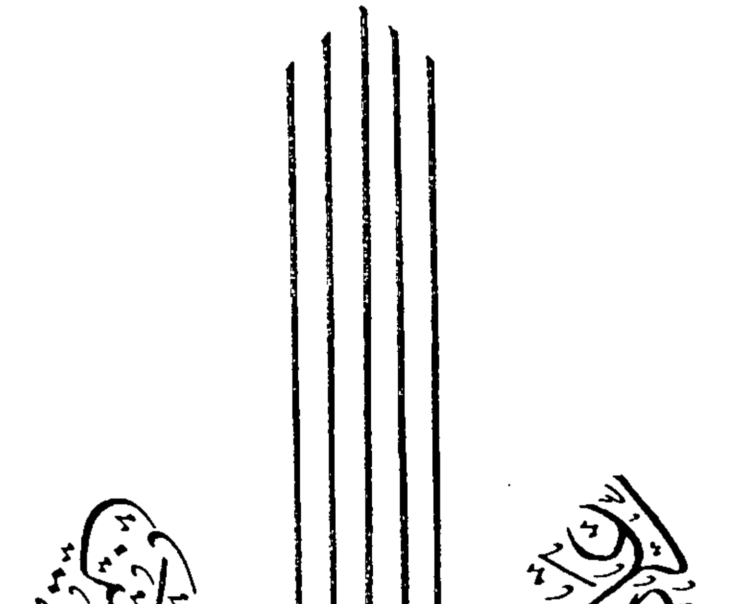
بسم الله الرحمن الرحيم
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# SUMMARY


Hot-dip aluminizing is a simple process in which an aluminium coating is formed by dipping the substrate metal in a bath of molten aluminium. The process, on a continuous basis, is most economical for the production of coated sheet, wire, and strip, as well as for fabricated products made from steel or cast iron.

In this work, aluminizing of low carbon steel sheets (0.19 C) was **achieved** by dipping into different melt baths: Al, Al- 4%Si, -8%Si and -12%Si held at two superheat temperatures (50 and 100° C) for different periods of times (from 1 to 5 min).

The aluminized layer is normaly composed of an outer layer (aluminium layer) followed by a layer of Fe - Al intermetallic compounds with continuously decreasing aluminium content until the parent steel is reached. It was observed that the intermetallic layer thickness decreases with the addition of silicon to the aluminium bath. Also, it increases with the increase of bath temperature especially in aluminium bath. This increase is much less in case of aluminium - silicon baths. The dipping time has an effect similar to that of bath temperature. The aluminium top-coat layer, in general, decreases continuously with increasing bath temperature.

The thickness of the intermetallic layer formed during hot - dip aluminizing was found to follow the parabolic kinetic relationschip, indicating that the reaction is controlled by volume diffusion.

The dissolution of intermetallic layer was studied in case of aluminium and aluminium containing 8%Si baths. The dissolution rate was higher in the case of Al - 8%Si bath. The weight loss from the steel sheet into aluminium and Al - 8%Si baths revealed that it is larger in the case of aluminium bath compared with Al - 8%Si bath.

The intermetallic layer was analyzed by EDS analyzer. In the case of using molten aluminium bath, it consists of two zones - a thin zone of fine-crystalline $FeAl_3$ ($\theta$-phase) adjoining the aluminium layer and a thick zone of acicular crystals $Fe_2Al_5$ ($\eta$-phase). The major phase was $Fe_2Al_5$. On the other hand, the phases formed on iron

aluminized in molten aluminium containing 8 wt.%Si were $Al_7Fe_2Si$, $Al_{20}Fe_7Si$, $Al_{19}Fe_8Si$, and $Al_3Fe_2Si$.

Mechanical tests were made in order to acess the quality of the bond between the steel substrate and the coating layers, as well as to evaluate the mechanical behaviour of the coated samples. For this purpose, UTS, elongation to fracture, To and Fro bending number, and microhardness indentation were measured. It was found that the values of UTS, elongation to fracture for aluminized steel were lowered due to coating process compared with the as received values. In general, good bond was acheived in all cases between the steel and the coating layers. The addition of silicon has the double effect of decreasing the thickness of the intermetallic layer and of lowering the hardness and raising the ductility. Both improves the deformability of the aluminized product.

The corrosion behaviour in NaCl medium with different concentrations (3 to 9% NaCl) at different exposure time up to 420 hr was investigated. The results indicate that aluminizing gives superior corrosion resistance compared with galvanizing.

# INTRODUCTION

The benefits occured by complementing the base strength of steel with the corrosion resistance of aluminium have long been recognised and a patent concerned with coating the steel with aluminium was granted in 1893.

However, difficulties were encountered in the last century due to the high chemical reactivity of aluminium. In the twentieth century these problems were largely overcome and a number of processes have been suggested which enable such a coating operation to be carried out. These include cementation, spraying, cladding, painting, electrophoresis and hot - dip coating. Each of these processes has its respective market but the most eco nomical for the production of coated sheet and strip, on a continuous basis, is that of hot - dipping.

The first large continuous line based on this technique was commissioned in 1939 by the Armco Steel Corporation at Middletown, Ohio. This used a method patented by Sendzimir [1] for the production of galvanized strip, with the provision of an aluminium bath instead of zinc one. Despite the success achieved in the USA and other countries, the only commercial line in Egypt for coating steel sheets, wires and tubes is by galvanizing at Egyptian Copper Company in Alex. This is due to the limited effort in this field [2-5].

There are two distinct grades of hot - dip aluminized steel. The first type produced from a bath of commercial purity aluminium and the second type is produced from an aluminium bath alloyed with up to 12% silicon. The silicon reduces the thickness of iron aluminium intermetallic layer thus improving formability. In this work, the two types were done.

The aluminized layer is normaly composed of an outer layer (aluminium layer) followed by a layer of Fe - Al compounds with continuously decreasing aluminium content until the parent steel is reached.

In 1953, Gebhardt and Obrowski [6] made the first systematic study concerning the growth of the intermetallic reaction between iron and aluminium, the major product phase was $Fe_2Al_5$ which had a serrated profile at the iron - intermetallic interface. Situated between the prongs of the intermetallic, was another phase of extremely small proportions, which could not be identified by X - ray analysis. A number of authors [7-12] have found that more than one intermetallic compound ($Fe_2Al_5$, $FeAl_3$,