Influence of Steel Strip Temperature in Formation Zinc Dross During Process Production Using Continuous Galvanizing Line (CGL) Machine

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Abstract. To control the occurrence of zinc dross during galvanizing process using production Continuous Galvanizing Line (CGL) machine, it is necessary to control steel strip temperature before entry into zinc bath. The Steel strip temperature controls were variable at 320°C and 400°C and zinc bath temperature was fix at temperature 460°C. At temperature steel strips of 320°C, zinc bath was checked using spectrometry, the results of Fe content 0.1293% and Al 0.0759%, because the solubility of Al is lower than Fe, the dross occurs become bottom dross. If the zinc dross change become bottom dross, the bottom dross could decrease quality of product and life time of zinc pot, because bottom dross settled at the floor. Bottom dross properties very hard and absorb heating, then at that position bottom dross make hot spot in the floor, finally zinc pot leakage. At temperature steel strip 400°C, the results content of Al 0.1667% and Fe 0.1217%, due to high temperature steel strip make solubility of Al become higher than Fe, therefore float at the zinc bath become top dross.

1. Introduction
Hot-dip galvanizing is a method of zinc coating by dipping steel into zinc liquid, the purpose this process to improve corrosion resistance. There are two ways to coat the steel with liquid zinc, which steel dipping with high-speed into the liquid zinc, we know is called "continuous" galvanized line (CGL), and the next is dipping large and small steel into liquid zinc called batches process.

Both galvanizing processes always produce dross or impurities, this dross occurs due to the intermetallic reaction between iron with liquid zinc in zinc bath [1,2]. The dross formation rate in liquid zinc depends on steel strip temperature, iron and aluminium solubility in zinc bath [3]. This dross when floating above the surface of the liquid zinc become top dross, this is due to the low iron content in the zinc bath, but the high aluminium content [4], Top dross is intermetallic $\text{Fe}_2\text{Al}_5\text{Zn}_n$ ($n$)[5], and affecting the quality of the product. And if the dross floats in liquid zinc, this is due to its lower aluminium content and high iron content then it becomes the bottom dross $\text{FeZn}_{10}$ ($\delta$)[6,7]. This bottom dross when settled and become hard at zinc bath called hard zinc $\text{FeZn}_{13}$ ($\zeta$), Hard zinc will absorb heat then become hot spots on the walls make steel wall of zinc pot become hole and eventually leaking.
The purpose of this study is to investigate the effect of steel strip temperature before entry to zinc bath to the formation of top dross and bottom dross, and support by microstructures and chemical composition.

2. Materials and Methods
For this study directly using Continuous Galvanizing Line (CGL) production machine with the aim to be in accordance with the real industry. The Continuous Galvanizing Line CGL Production Machine used the NOF (Non-Oxidizing Furnace) system, the steel strip inside the furnace does not react with oxygen. Line speed of the steel strip entry into the zinc bath is 150 MPM and the zinc bath temperature was about 460°C. Scheme zinc bath galvanizing process, could be seen in ‘Figure 1’.

![Zinc bath schematic on galvanizing process.](image)

Steel strips were used Cold Roll Coil (CRC) as standard JIS G 3141 SPCC - 1D or 1B. And zinc ingot use CGG type. The chemical composition of zinc ingot could be seen in table 1. Production process parameters for line speed of the steel strip, the chemical composition of steel strip and chemical composition of zinc ingot were same, but the steel strip temperature parameters before entry into zinc bath using two variation temperatures with 320°C and 400°C.

Method for take bottom dross at the bottom position in pot is using steel stick, after the sharp of position, directly bottom dross take out using small pickup then poured into steel mould to make sample for spectrometry test.

| Table 1. Chemical composition of zinc ingot (mass%). |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Al        | Cd        | Cu        | Fe        | Pb        | Sn        | Zn        |
| 0.389 -   | <0.0001   | <0.0006   | 0.0010 -  | <0.0025   | <0.0001   | Ball      |
| 0.4022    |           |           |           |           | 0.0015    |           |
3. Data and Analysis

In direct production process, steel strip temperature before entry into zinc bath was 320°C, after production for 7 days, and tonnage about 2100 Ton, from visual observations, in zinc bath has seen increased dross occur, and sticky on the strip product, this phenomenon would decrease the quality of the product. When checked floor of the zinc bath using stainless steel rods, it seems there were bottom dross settled at floor already. Then top dross float to the top, bottom dross settled on corner of the zinc pot, then examined chemical composition used spectrometry and microstructure.

Method for take sample for spectrometry test, the dross at the top position of zinc was take out using small pickup then poured into steel mould to make sample for spectrometry.

Table 2. Top dross chemical composition with steel strip temperature 320°C (Mass%).

|   | Al   | Cd   | Cu   | Fe   | Pb   | Si   | Sn   | Zn   |
|---|------|------|------|------|------|------|------|------|
|   | 0.1417 | 0.0001 | 0.0006 | 0.1251 | 0.0005 | 0.0001 | 0.0005 | Ball |

Result examination of top dross chemical composition with steel strip temperature 320°C shown in table 2. From the table shown the Al 0.1417% and Fe 0.1251% reacted. Al and Fe reacted in zinc bath become intermetallic compound \( \text{Fe}_2\text{Al}_5\text{Zn(\eta)} \) where the Al content is more higher than Fe content, the floating dross called top dross. From the microstructural photograph, shown the Zn matrix and beta phase and there were found small amount of dirt spot, that was Fe.

![Figure 2. Top dross microstructure with steel strip temperature 320°C.](image)

Table 3. Bottom dross chemical composition with steel strip temperature 320°C (% Mass).

|   | Al   | Cd   | Cu   | Fe   | Pb   | Si   | Sn   | Zn   |
|---|------|------|------|------|------|------|------|------|
|   | 0.0759 | 0.0001 | 0.0006 | 0.1293 | 0.0005 | 0.0001 | 0.0005 | Ball |
In Table 3, shown bottom dross chemical composition with steel strip temperature 320°C, from examination, bottom dross chemical composition with steel strip temperature 320°C, entry into zinc bath at a temperature of 460°C, heat of steel strip was absorbed by zinc bath, made Al solubility in zinc block more slightly as in Table 3 shown Al 0.0759% and Fe 0.1293%, because the Al content was less then Fe content, when Al and Fe reacted with zinc in zinc bath, become intermetallic zinc FeZn_{10}(\delta), but specific gravity heavier than zinc, intermetallic dropped to down and settled in zinc pot to bottom become FeZn_{13}(\zeta).

*Figure 3* shown the bottom dross microstructure with steel strip temperature of 320°C, shown the Zn matrix and beta phase, shown many dirt spot, that were Fe impurities due to too much solubility Fe.

Steel strip temperature 320°C before entry into zinc bath, many top dross and bottom dross happened, which greatly affects to quality. To increase quality of product, temperature steel strip was increased to 400°C, after 2 days production, tonnage of products about 600 tons, from visual inspection, the dross is started slightly decreased, then checked also by stainless steel rods, Top dross only occurred, bottom dross did not exist. After 7 days or tonnage of product about 2100 Ton, The chemical composition and microstructure were checked, with steel strip temperature 400°C has seen in table 4. Shown Al content of 0.1667%, and Fe content of 0.1217%, Al when reacted with Fe in zinc bath, due to steel stripe temperature 400°C then the solubility of Al is more and then Fe solubility. Therefore, dross occur more less, consequently the top dross then floats more little.

![Figure 3](image)

**Figure 3.** The bottom dross microstructure with steel strip temperature of 320°C.

| Table 4. Top dross chemical composition with 400°C strip steel temperature. |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Al  | Cd  | Cu  | Fe  | Pb  | Si  | Sn  | Zn  |
| 0.1667 | 0.0001 | 0.0006 | 0.1217 | 0.005 | 0.001 | 0.005 | Ball |

*Figure 4*. Shown top dross microstructure with 400°C strip steel temperature. The results of examination microstructure of top dross with steel strip temperature 400°C, shown Zn matrix and beta phase, and shown more cleaner because solubility Fe decreased. Steel strips of temperature 400°C entry into zinc bath with zinc bath temperature of 460°C heat absorption only slightly, solubility of Al...
in zinc ingot increased, when Al reacted with Fe and Zn in zinc bath, the Al bonded Fe become Fe$_2$Al$_5$Zn(η) which becomes dross and floats upward becomes top dross.

![Figure 4. Top dross microstructure with 400°C strip steel temperature.](image)

4. Conclusion
In this study, Influence of strip temperature in the formation of zinc dross by using two-temperature variations for steel strips were 320°C and 400°C, directly using production Continuous Galvanizing Line (CGL) machine, with zinc bath temperature of 460°C.

The conclusion as follows:
1. Both steel strip temperature 320°C and 400°C the Fe content in zinc bath were 0.12% - 0.13%.
2. Strip steel temperatures of 320°C, there are many top dross and bottom dross, because the solubility of Al was less in zinc bath while the solubility of Fe was higher.
3. Steel strip temperature of 400°C, the solubility of Al becomes higher, then only top dross occurred.

5. References
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