2012 CIRMS

Alloy compensation Methodology of Thickness gauge in steel Industry

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Objective

1. The quality improvement of thickness control in cold rolling mill of steel making company
2. To analyze the effect of alloy composition element in thickness measurement
3. To find out the correction equation to improve accuracy for material composition using MCNP
4. The result of on-line application of correction equation derived.

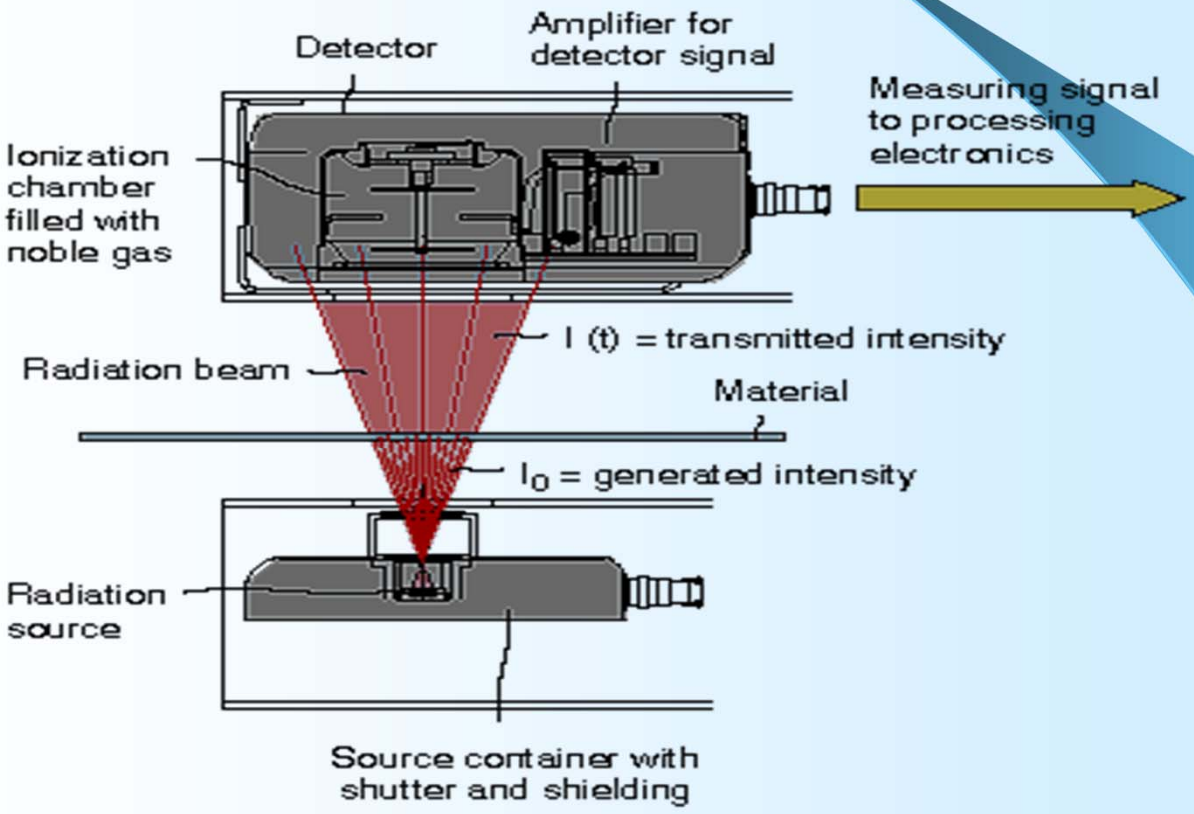
Operation Principle

(Gamma ray transmission method)

$$\mathbf{I(x) = Io \exp(-\mu \rho t)}$$

- Io : the incident intensity
- μ : the mass attenuation coefficient
- ρ : the density of the material
- t : the thickness

Schematic Diagram of Measuring Device



Design of a Transmission measuring head

Given Condition (from POSCO)

- Material: Iron with alloy element
  - Additional element: C, Si, P, Ni, etc
  ∴ Composition of material varies by usage of final product.
- Thickness: 0.2 ~ 4 (mm)
- Source: Am-241 3Ci (Point)
- Distance (H: Source~Detector): 50cm
- Detector: Ionization Chamber (Gas: Argon)
- Accuracy to be required : ± 0.5% (2 sigma level)

Methodology in MCNP

1st Step (Using MCNP)
To investigate the influence of each element in measurement
(Condition: each element wt% by thickness)

- C(0~0.65%), Si(0~0.4%), P(0~1%), Ni(0~2%)

2nd Step
To calculate correction value in each element per thickness

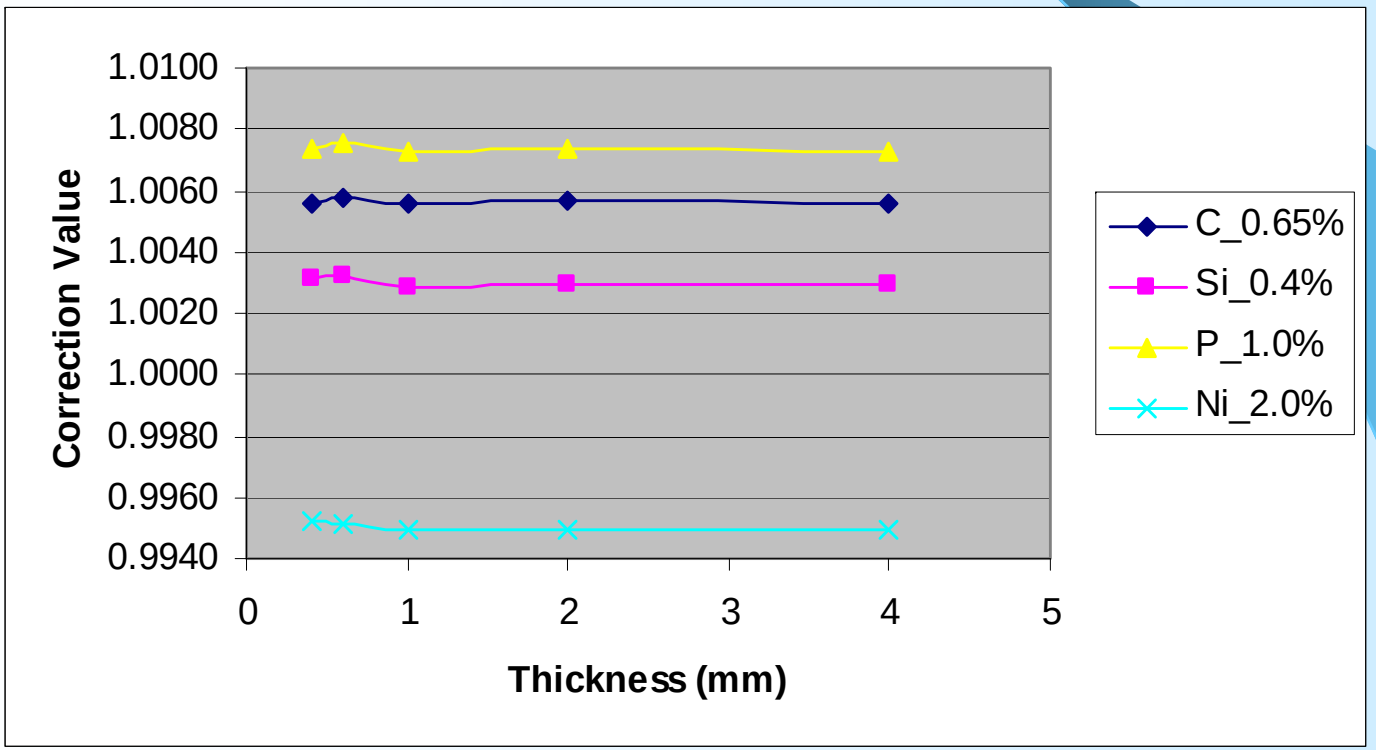
- $C.V = T_n / C_n$
  - $-T_n$: Ratio of exposure rate (F6 Tally) of "Measured T"
  - $-C_n$: Interpolated from "Pure Fe"

3rd Step
To find out correction equation in thickness measurement

Result of MCNP Simulation

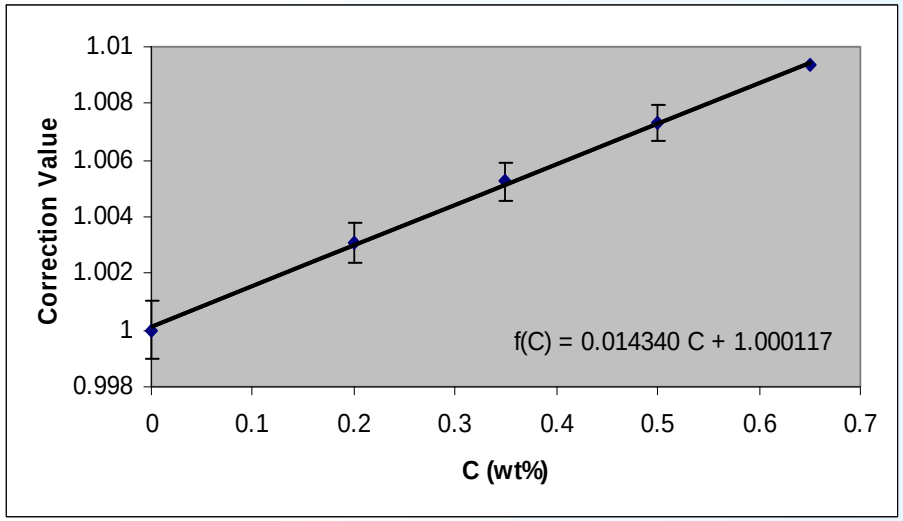
1. Influence of alloy element

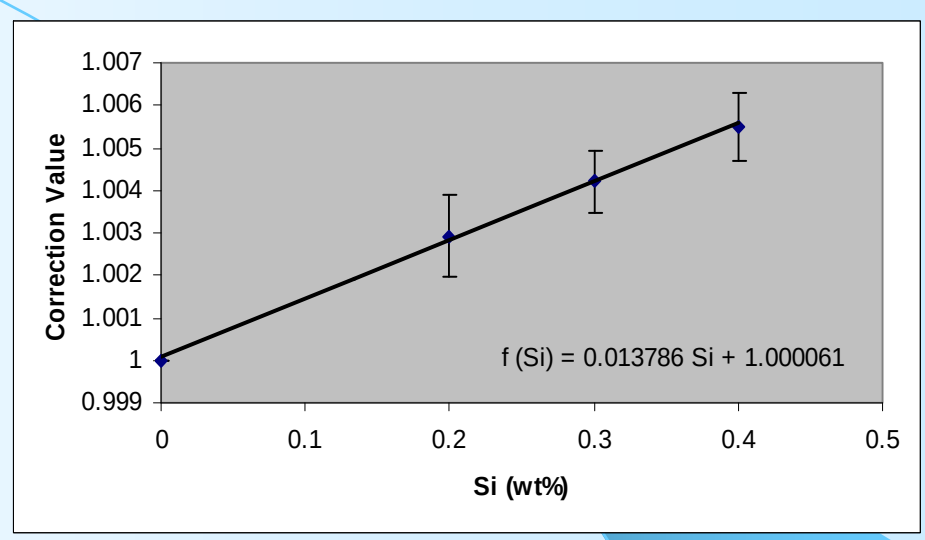
(Condition: Max. mixed of each element to iron)

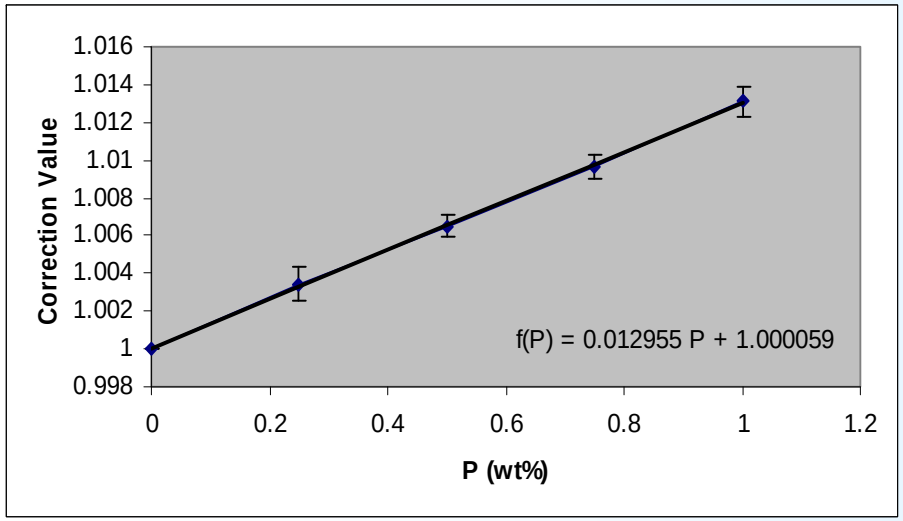


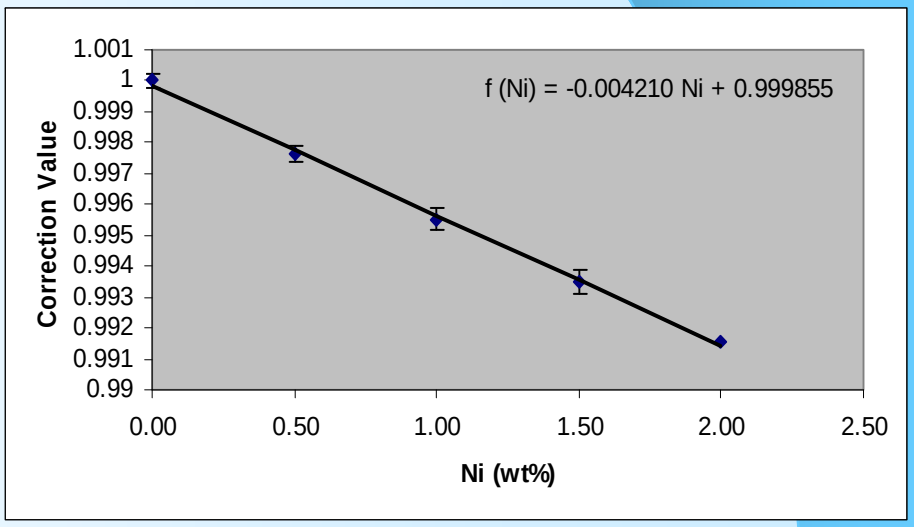
→ **The Correction Value is independent of Iron thickness.**

2. To derive correction function of each element









3. Proposal of Final Correction function

- From the each function of element, the final correction equation can be derived as below.

$$Q(eq) = \prod_{i=1}^{N} (A_i w_i + B_i)$$

Element	A_i	B_i	W_i
C	0.014340	1.000117	0.1 ~ 0.65
Si	0.013786	1.000061	0.1 ~ 0.4
P	0.012955	1.000059	0.1 ~ 1.0
S	0.004562	0.999965	0 ~ 0.06
Cr	0.001889	0.999911	0 ~ 2.5
Mn	0.001242	1.000024	0 ~ 1.5
Ni	-0.004210	0.999855	0 ~ 2.0

4. The difference between Q(eq) and Q(MCNP)

Sample	1mm	2mm	4mm
No.1	0.038%	0.026%	0.020%
No.2	0.013%	0.038%	0.018%

(Note)

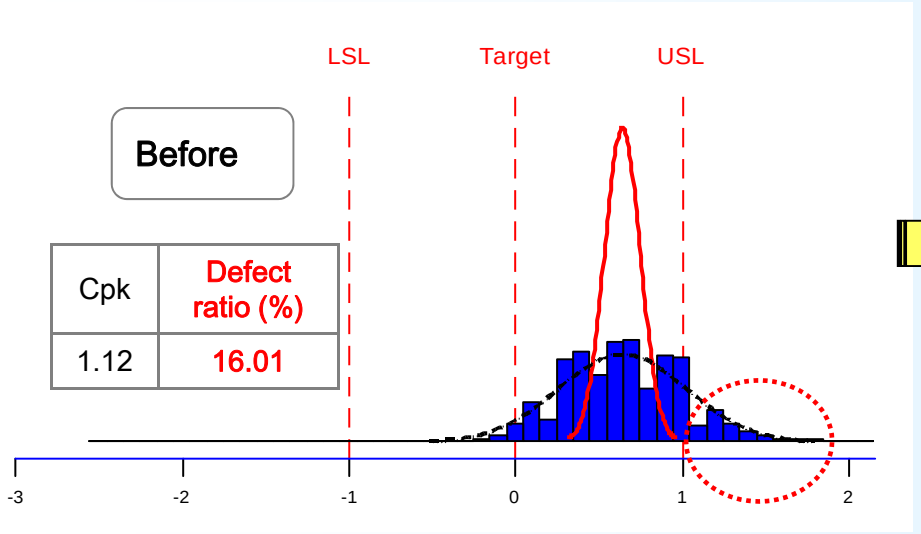
Sample	Alloy Composition	Q(eq)
No.1	C(0.6%), Si(0.3%), P(0.5%), Ni(0.5%)	1.009744
No.2	C(0.3%), Si(0.3%), P(0.75%), Ni(0.5%)	1.009001

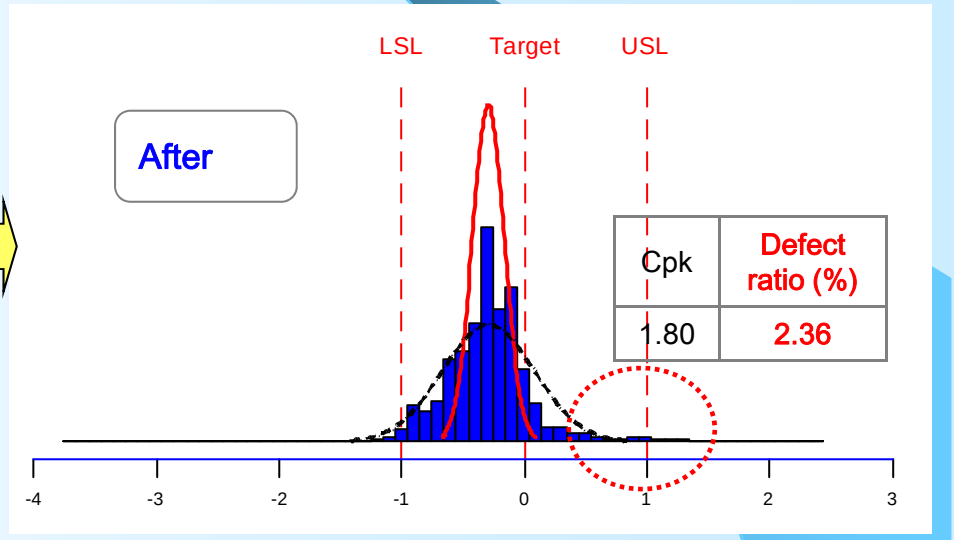
- Q(MCNP): result of MCNP simulation for each thickness
- Difference (%) = $\frac{Q(MCNP)-Q(EQ)}{Q(EQ)}\times(100\%)$

Result of Field Application

Q(eq) application → Thickness quality control improvement

(Cold Rolling Mill of POSCO, since 2010.December)





- Defect Ratio improvement : 16.01% → 2.36% (target thickness: 0.8mm)
- Reduction of thickness measurement deviation of AHSS: 34㎛→7㎛
- Building a consistency compensation system for thickness gauge

Conclusion

1. The alloy correction of material composition can improve gauge performance accuracy.

2. The final correction equation can be reliable compared to MCNP simulation.

3. The result is successfully used in field application of cold rolling mill thickness gauge in POSCO.