Design of Down Scaled Simulator to Apply the Flying Touch Method in Hot Rolling Process

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Abstract

In the hot rolling process, scratches are occurred on the surface of a slab because of its strong friction. One of the methods to solve this scratches problem of slab is proposed which is the Flying Touch hot rolling process. This paper introduces that the simulator for applying Flying Touch Method is manufactured to evaluate a performance of the Flying Touch Method. Furthermore, it is evaluated by the simulator how much Flying Touch hot rolling process can reduce the scratch.

Keywords :Flying touch , hot rolling, simulator

1. Introduction

Steel plates, or slabs, used in industries are produced through the following process: Iron making process, the smelting of iron ores into pig iron, Steel manufacture process, the elimination of impurities, and Casting process, the shaping of molten metal into a plate. The result of this process is slab (Slabs), which can be modified into coils through a process called Rolling process. These coils are then sold after going through processes such as Cold rolling.

One of the many defeats created by hot rolling is called scratch. Scratch is created when the iron plate is in motion. It shows in a long line on the surface of the product and drastically reduces the quality of the product. The flying touch method is one solution to the scratch.

However, this new process is only theoretical and may cause huge financial loss in its application. Therefore it is preferably applied in minimized simulators instead of in actual systems. This paper explains the flying touch method and introduces a simulator of 40:1 ratio, to which this theory can be applied.

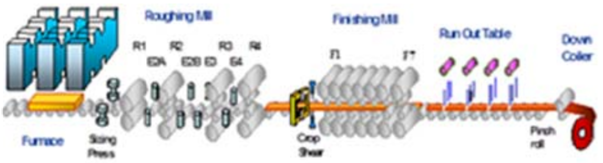
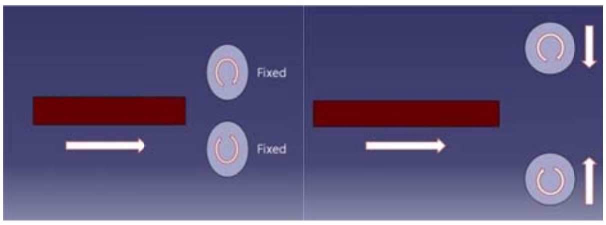


Fig. 1. Hot rolling process

2. Flying Touch Method



(a) (b)

Fig. 2. Previous method and Flying Touch Method

The previous method of rolling process rolled the slab through two stationary rollers as depicted in Fig. 2. (a). As each roller processes only 2-4% of the slab at a time, multiple installed rollers roll slabs. In this process, each installed roller interacts with the slab, and the impact of the last roller creates a scratch at the end of the coil. However, in the flying touch method, as seen in Fig. 2. (b), friction and impact between the roller and the slab is minimized by synchronizing the movement of the slab with the rotation of the roller and using the Soft touch type, in which the rollers are not fixed, but mobile. The speeds of the slab before being rolled and after being rolled are different because as the slab becomes thinner its amount increases. At this moment, a slip occurs between the slab and the roller, and to decrease this slip, the speed value calculated by forward slip must be applied to the roller. forward slip, the average of the slab's speed before and after being rolled, must be applied in order to synchronize the speed of the roller and the speed of the slab.

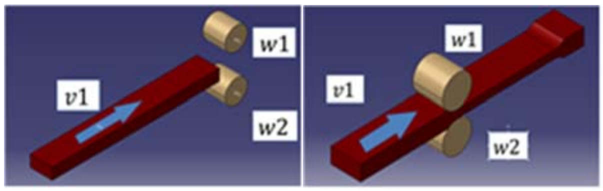
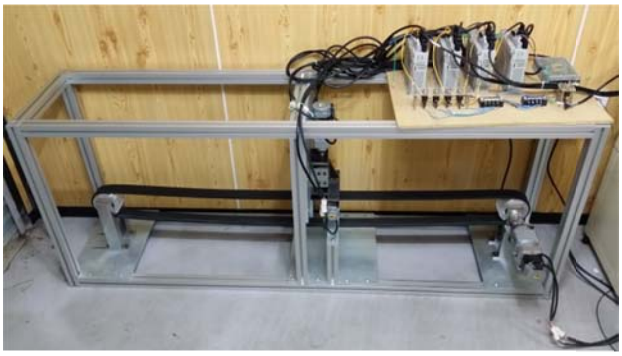


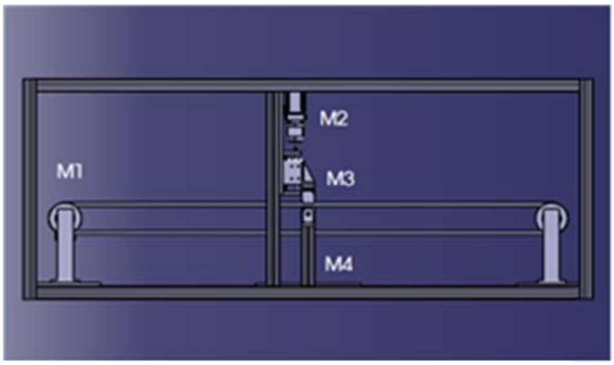
Fig. 3. Flying Touch Method

Fig. 3 depicted the idea of flying touch simply. v1 is the speed of the slab, w1 is the angular speed of the upper roller, and w2 is the angular speed of the lower roller. Because w1 and w2 are connected by joints, they have equal speeds. Thus the scratch and impact can be minimized if the speed of the slab and the speed of the rollers are synchronized.

3. Design of simulator

The simulator in Fig. 4 was constructed in order to apply the flying touch method and it's ratio to an actual rolling mill is 40:1. Fig. 5 is a floor plan of the simulator's modeling picture. Because producing actual iron plates was too difficult for a 40:1 simulator due to the huge torque of the motor, a rubber belt was used.





M1 is a feed motor, and M2, M3 and M4 are position control motor. M3 and M4 are the drive motors of the upper and lower motor. The upper and lower rollers can be controlled by a ball screw. Because the simulator cannot process the 2-4% of the rubber belt as an actual rolling mill would a slab, it is constructed to compress 10% of it, or approximately 1mm.

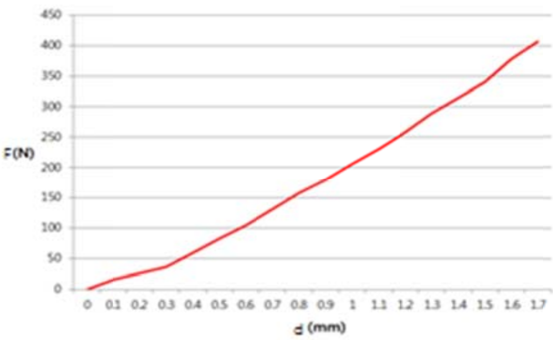


Fig. 6. Rubber belt's deformation-force graph

For getting the rubber belt's elasticity, pressing test has done by deformation processing compressor. The result is represented in Fig. 6. Because the rubber belt's area compressed by the deformation machine is $300mm^2$, the elastic modulus is $0.7\,\mathrm{N}/mm^2$ by calculating the slope of deformation-force graph. This elastic modulus is used to select the motors.
The motors' spec is shown in table.1.

Table 1. Motors' specification

	Stall torque	Velocity
M1	6.5N/m	3000rpm
M2	6.5N/m	3000rpm
M3	3.25N/m	3000rpm
M4	3.25N/m	3000rpm

Fig. 7 shows the results of the flying touch control based on the 1/40 downscaled simulator.
The results showed that a speed between simulator roll and assumed steel slab can be synchronized by the designed simulator.

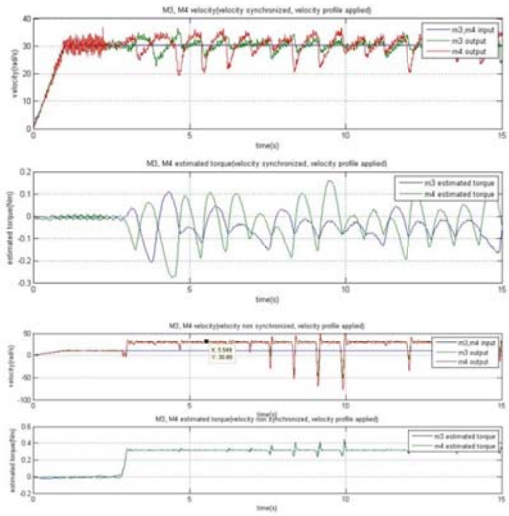


Fig. 7. Simulation graph

4. Conclusion

This research designed the 1/40 downscaled pseudo simulator to apply the flying touch method. The flying touch experiment results showed that the simulator can synchronize a speed between simulator roll and assumed steel slab.

Acknowledgments

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5. References

1. Choi Y. J and Lee M. C. "PID Sliding Mode Control for Steering of Lateral Moving strip in got strip Rolling," International Journal of Control, Automaion, and Systems, pp. 399-407, 2009 7(3):
2. Sansal K. Yildiz, J. Fraser Forbes, Biao Huang, Yale Zhang, Vit Vaculik, Mike Dudzic, "Dynamic modeling and simulation of a hot strip finishing mill, Applied Mathmatical Modeling 33, pp. 3208-3225, 2009
3. Choi Y.J , Yoo K.S, and Lee M. C, "Development of the strip Off-center Meter Using Line Scan Camera in FM Line ", Journal of Control, Automation, and Systems, Engineering Col.11, No.6, 2005
4. Rohde, W. and Rosenthal, D, "High-tech rolling in hot strip mills – theory and practice ", Metallurgical Plant and Technology, Vol.1,p p.48-55, 1990