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Measuring blast furnace slag flow rate at slag runner by image analysis method

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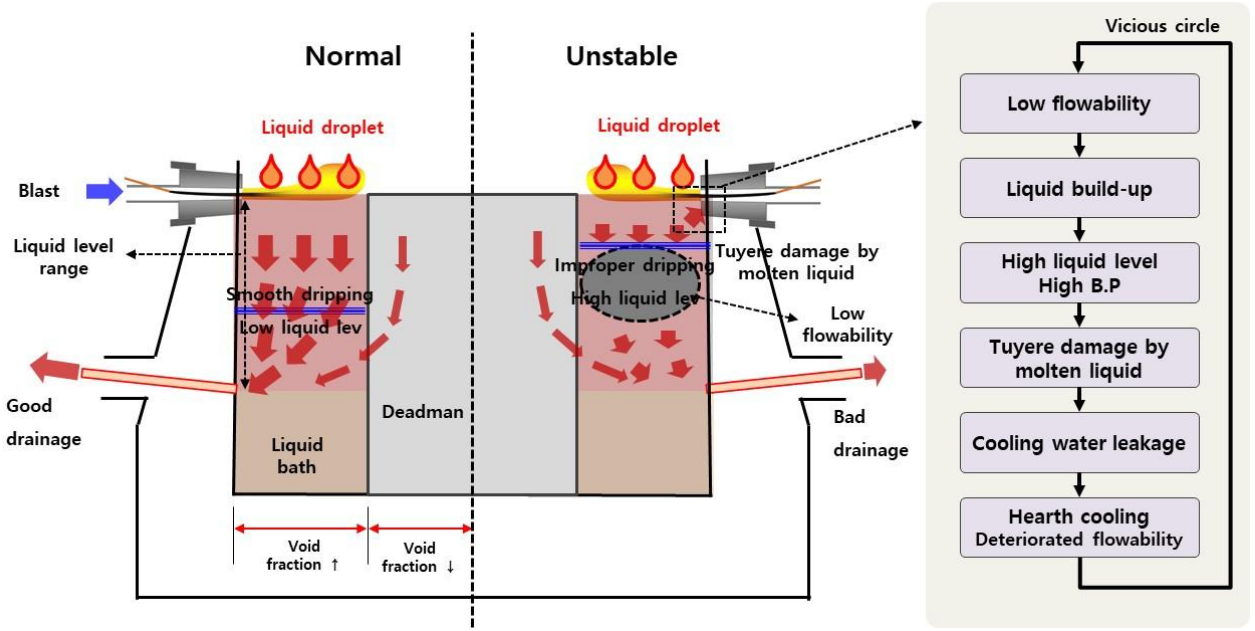
Introduction

■ Background

○ Tapping is critical in blast furnace/melter gasifier process because it can affect inner state of the furnace : Improper drain results blast pressure increase, burden level irregularity, unstable burden descent and thermal level instability

○ Furnace operators try to optimize tapping by controlling tapping sequence, tap hole opening/closure, bit size and tap-hole clay mineralogy

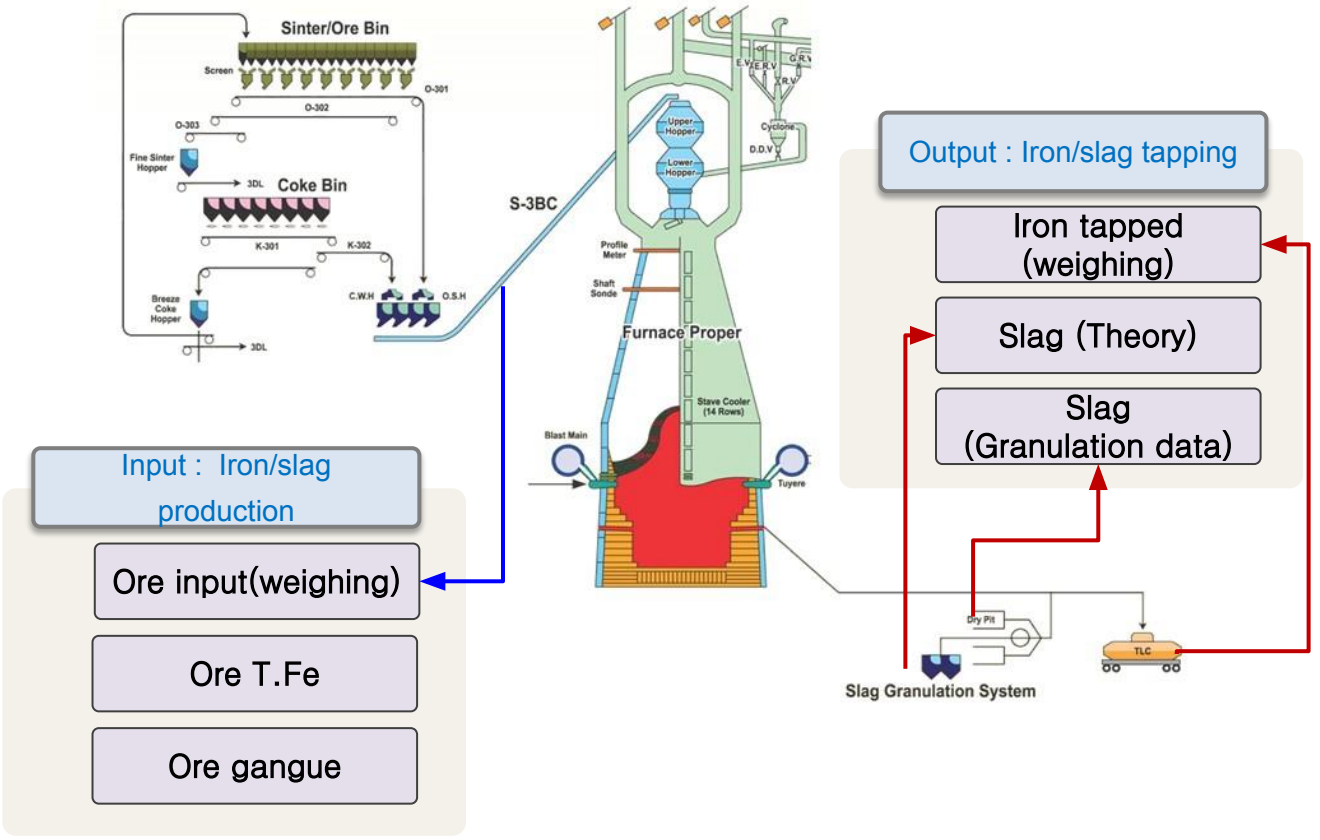
○ But it is still very difficult to optimize tapping strategy because there are no in-line tool to interpret inner state of furnace hearth : liquid level, flowability…..



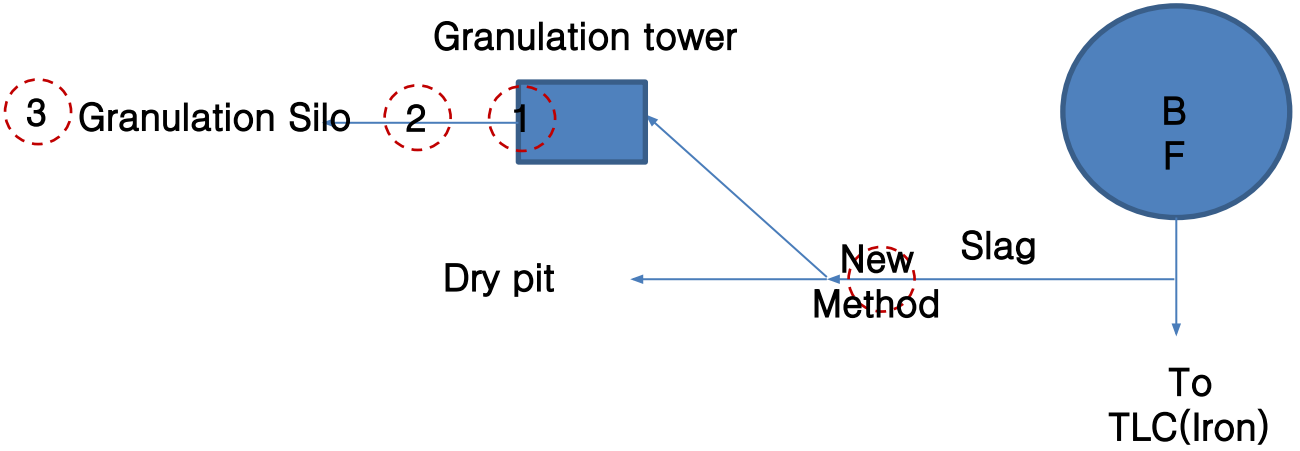
■ Research target

○ Develop image analysis method to measure slag outflow mass at slag trough where slag is liquid state

○ By measuring slag outflow mass at slag trough, both of slag mass goes to granulation tower and dry pit can be monitored.



■ Various method to measure slag discharging mass

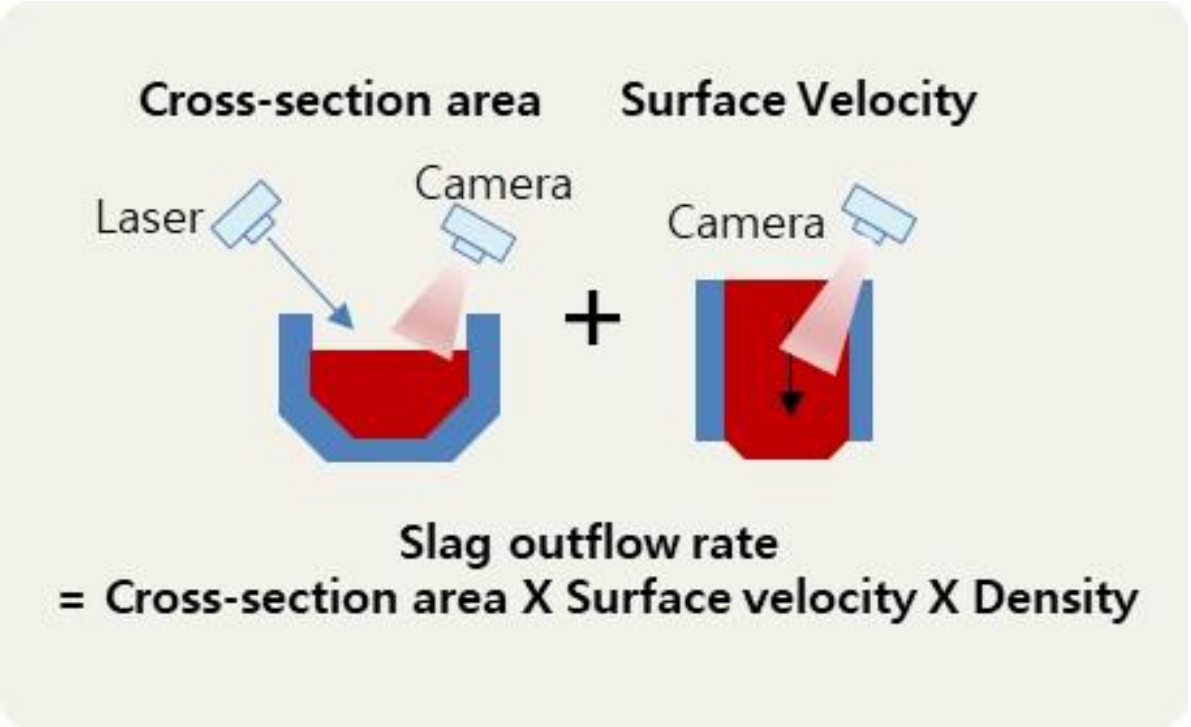


	Method	Advantage	Disadvantage
1	Granulation Screw RPM	– Easy to calculate	– Dry pit X – Screw is not always working – Slag/water ratio not stable – Time delay
2	Granulation Belt weigher	– Easy to calculate	– Dry pit X – Belt is not always working – Slag/water ratio not stable – Time delay
3	Granulated slag Truck weinging	– Accurate	– Not a real time data

■ Concept of slag flow rate measurement by image analysis method

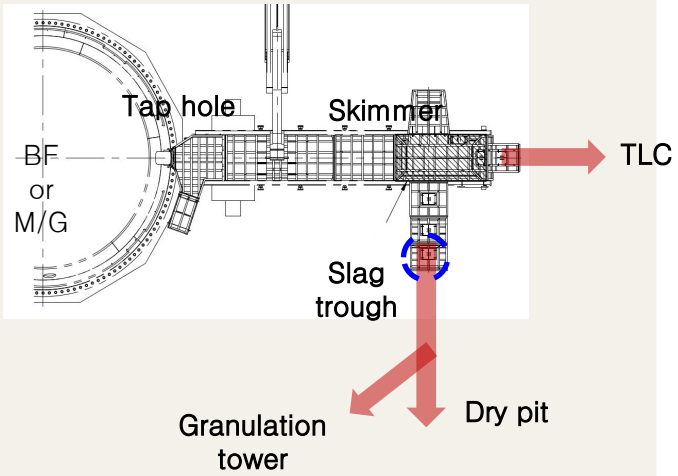
○ Measuring cross-section area of slag at slag runner by camera and laser marker

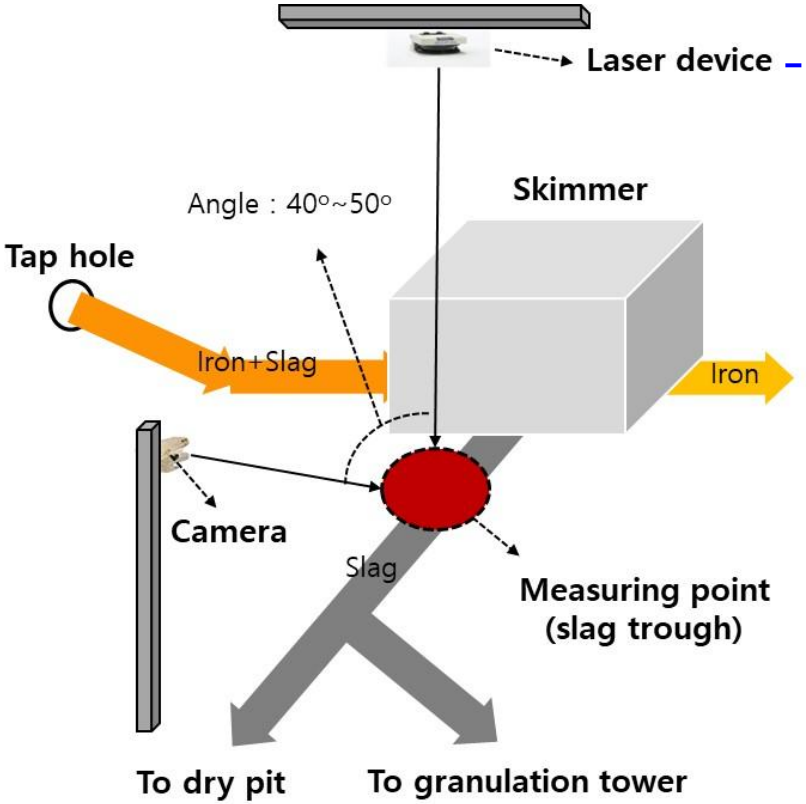
○ Measuring surface velocity of slag at slag runner by camera image



■ Slag flow rate measuring system installation

○ Installing slag flow rate measuring system at No.2 & No. 3 FINEX located in Pohang steel works





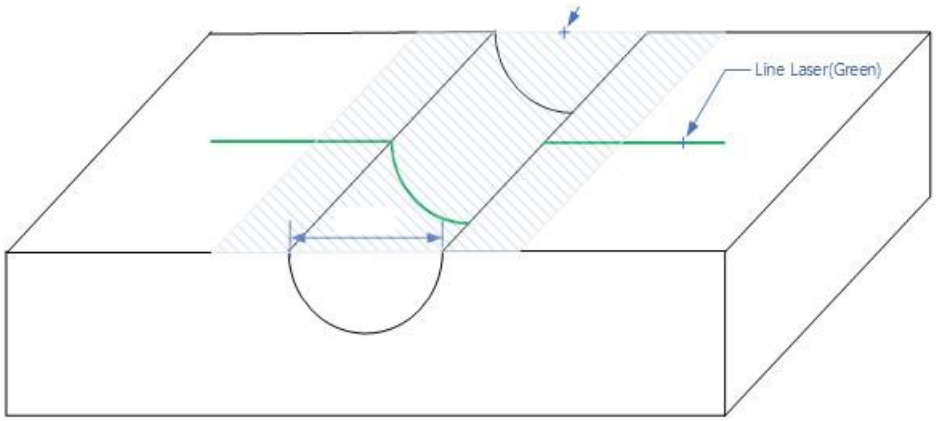
■ Slag flow rate measuring system installation

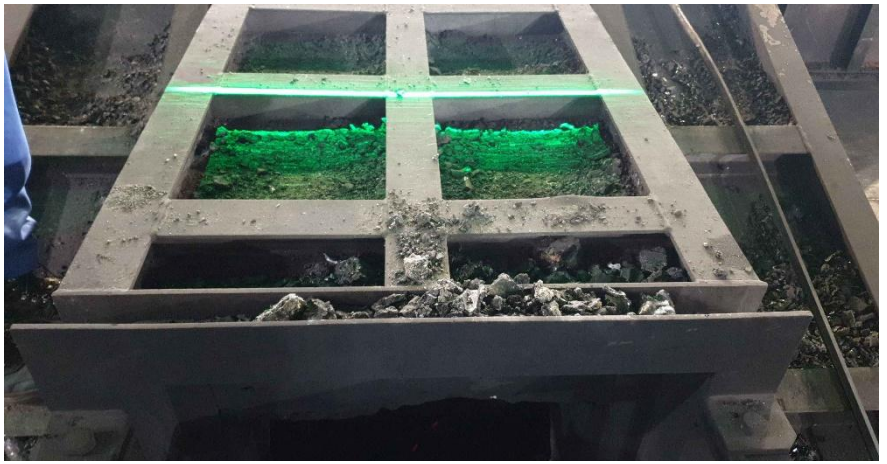
○ Line laser is projected at the top surface of slag runner

○ Laser marking is interfered by slag cover in normal operation

☐ Remodeling of slag cover is required

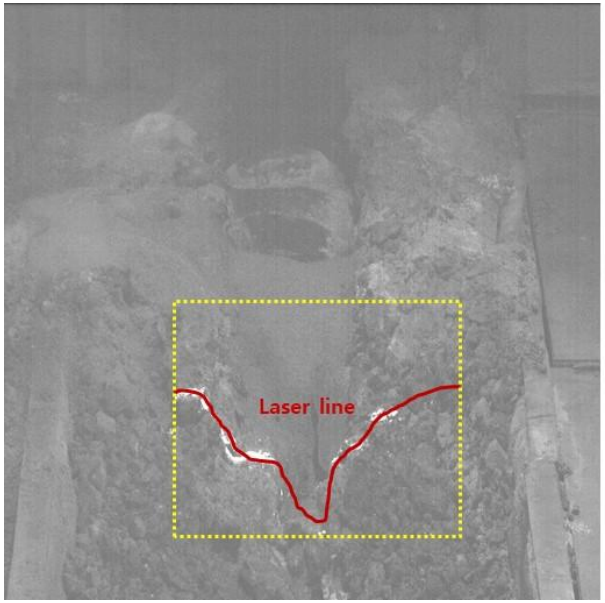
☐ Top of slag cover was partially removed so that laser can pass through slag cover

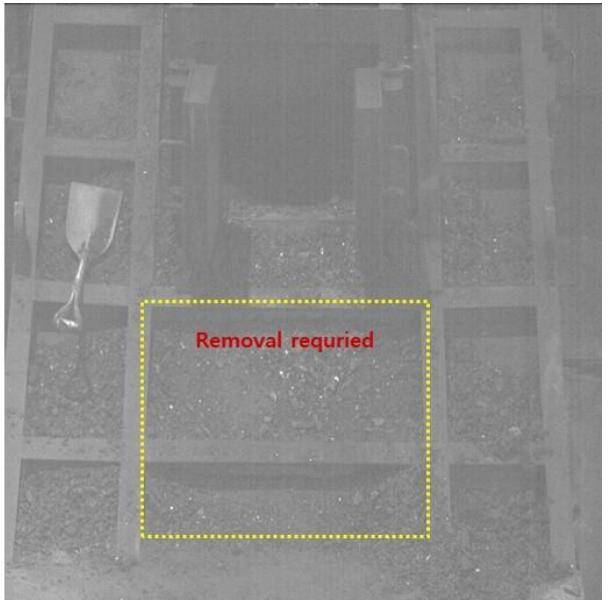


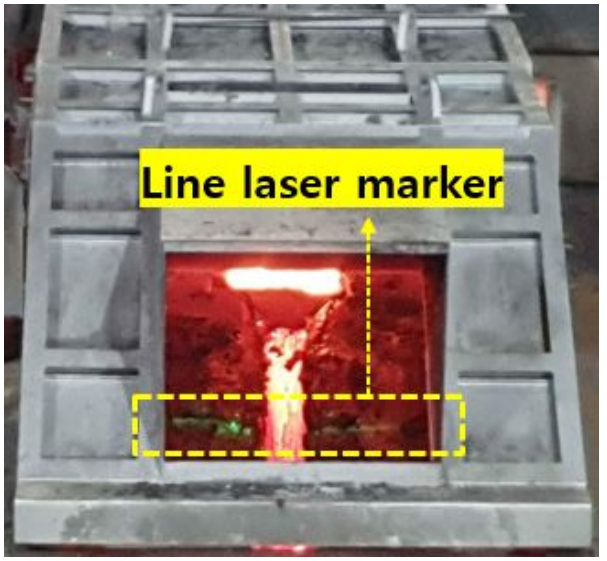


■ Slag flow rate measuring system installation

○ Remodel slag cover so that line laser can be observable

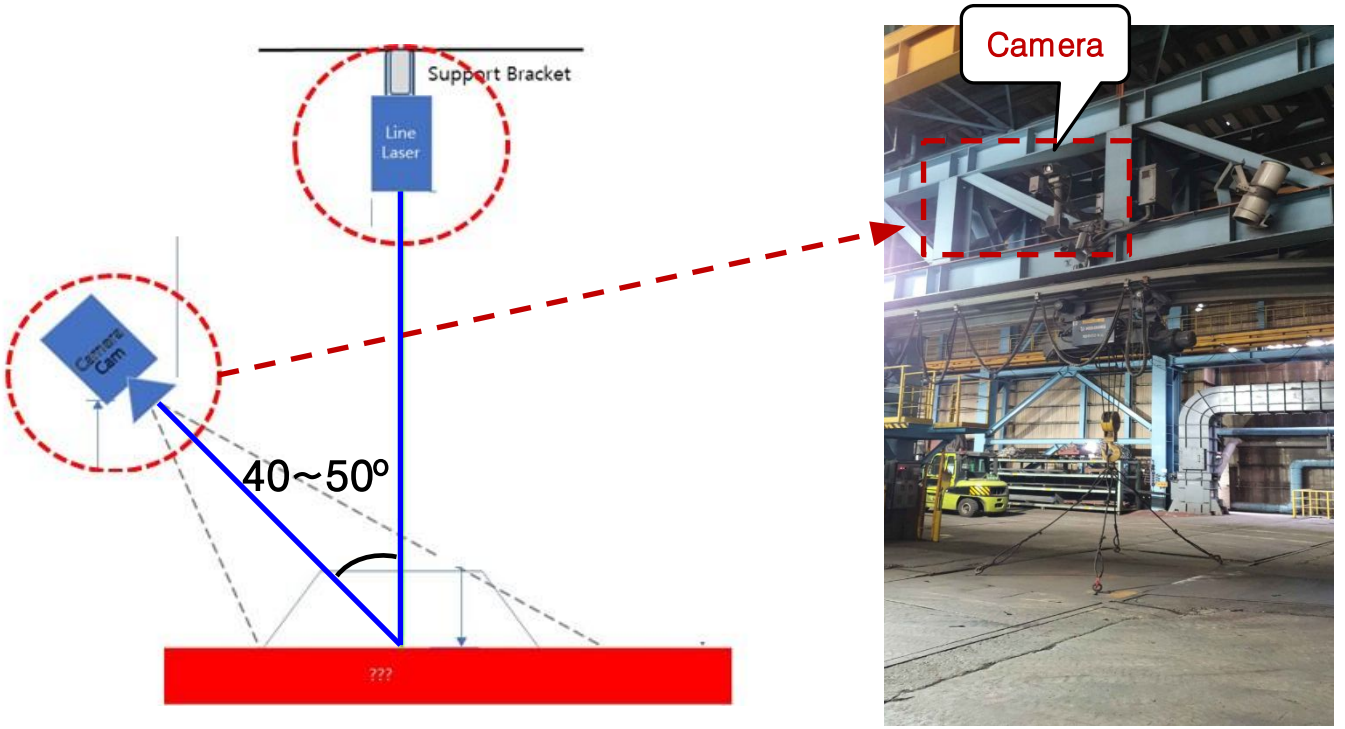






■ Slag flow rate measuring system installation

○ Camera was installed so that enough angle between laser device-measuring point-camera to be secured



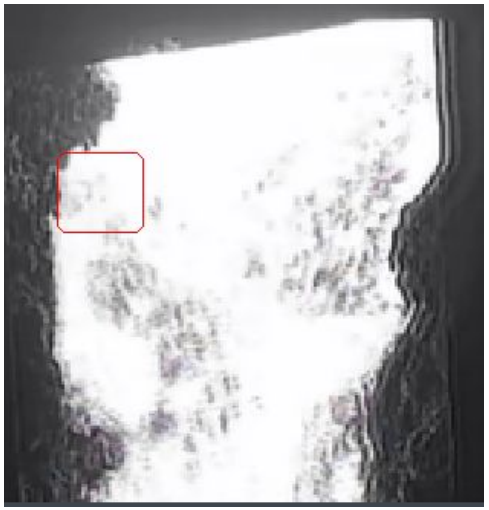
■ Slag flow rate calculation logic

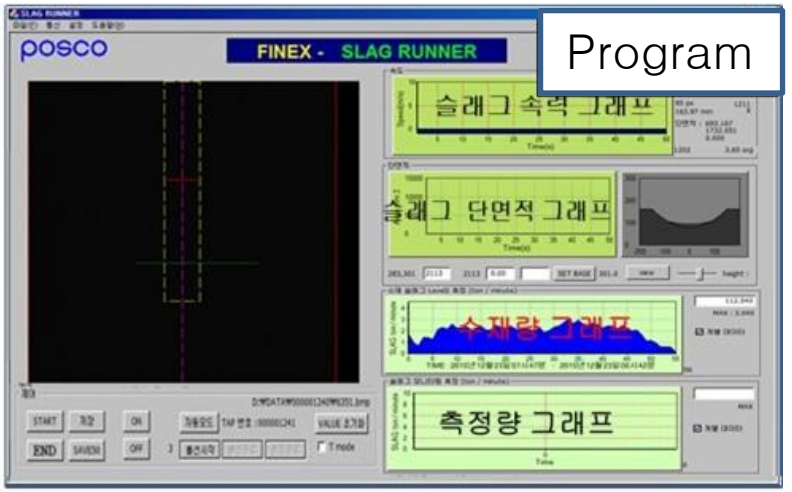
○ Slag cross-section : Detect slag surface height(laser marking line position) + width of slag runner
(In every tap, inner profile of slag trough is measured before slag flow starts)

○ Slag surface velocity was measured continuously by camera image
: Compare two images with 0.5 seconds time gap, track particles or shade pattern at the slag surface every defined time gap (time averaged for certain periods)

○ Calculating volumetric flow rate of slag by multiply cross-section area and surface velocity

○ With defined density of slag, mass flow rate can be obtained from volumetric flow rate of slag





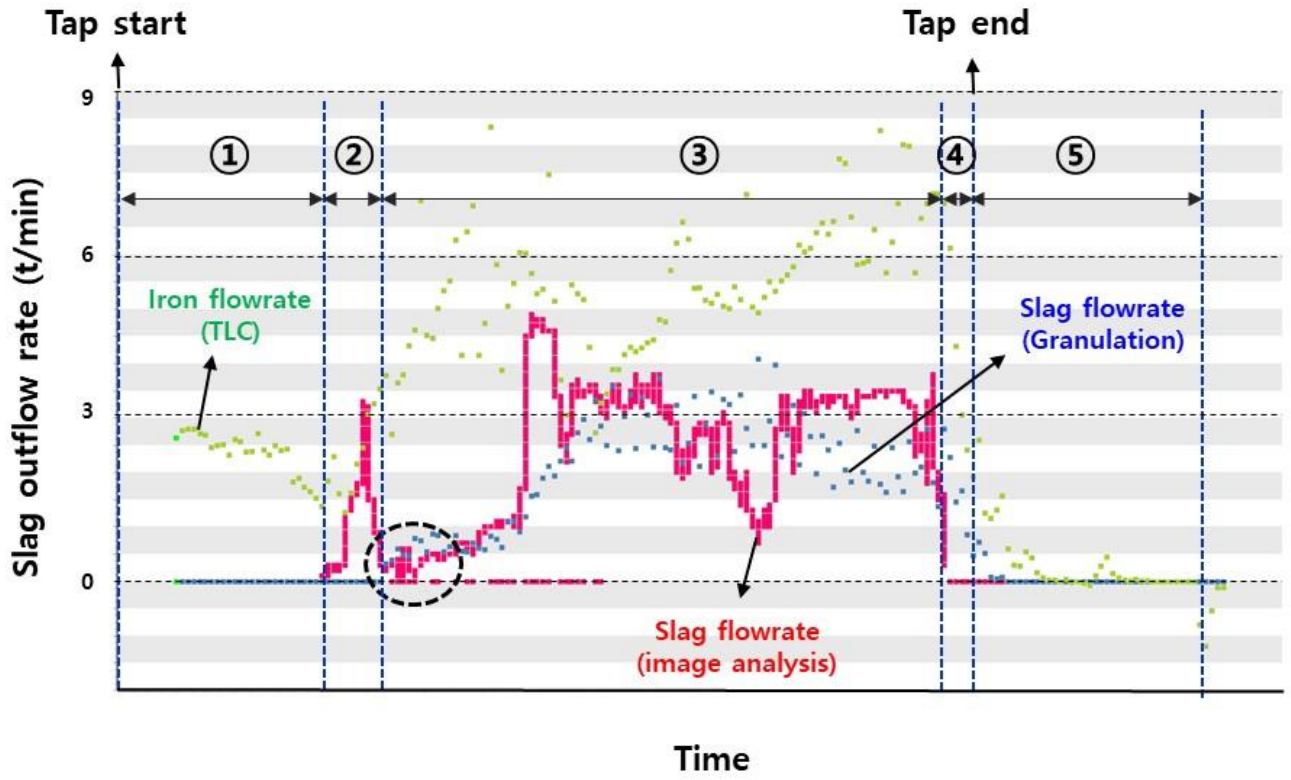
Program

■ Slag flow rate calculation result

○ Slag flow rate calculated by image analysis method shows similar trend with granulation data

: But it has more realistic value than conventional method

○ It shows no time delay as show in stage 2 and 4



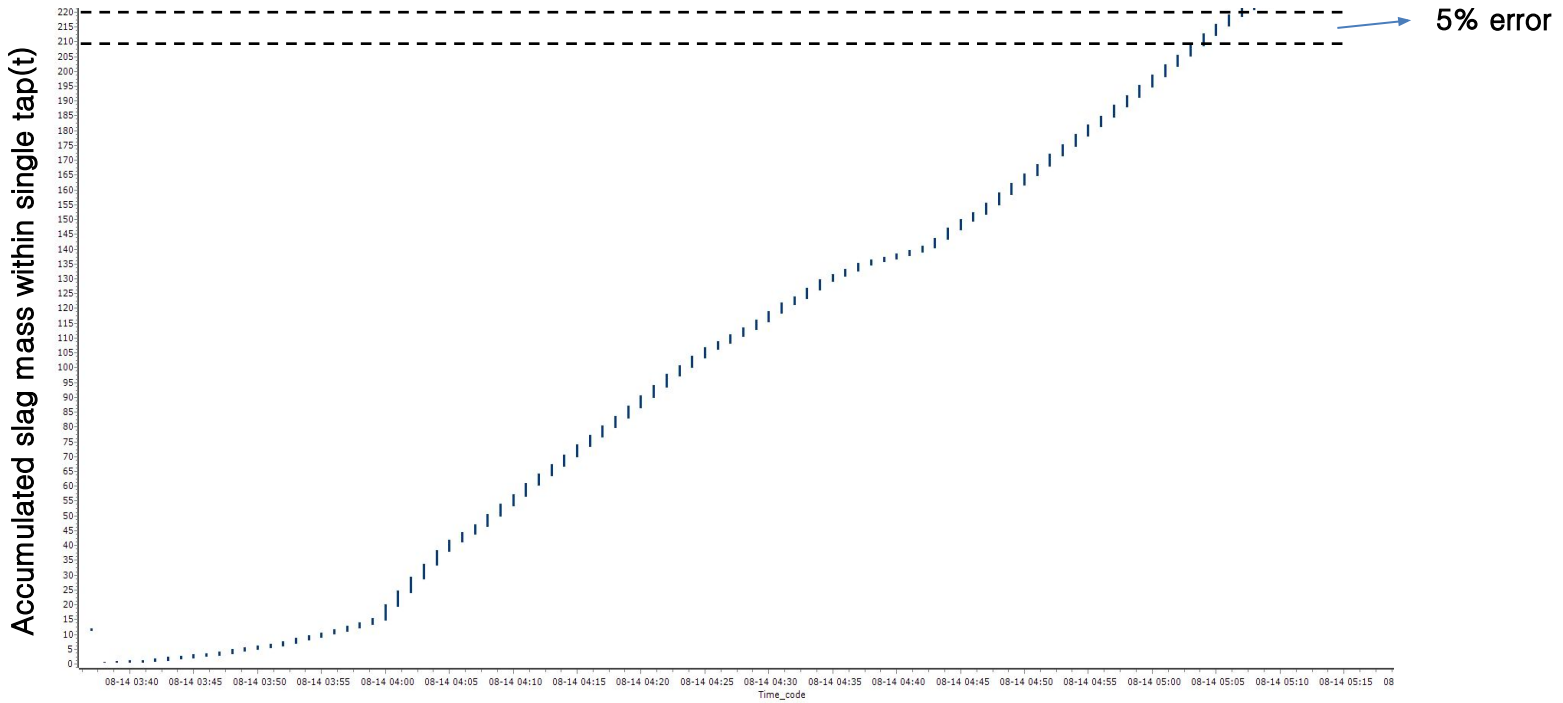
■ Accuracy of slag flow rate by image analysis

○ Comparing accumulated slag mass within a single tap

: Generally, difference was within 5% between image analysis method and other method

○ Reasonable accuracy was achieved in many stable cases

: Image analysis method can be applied even when slag goes to dry pit



■ Individual data derived from raw signal

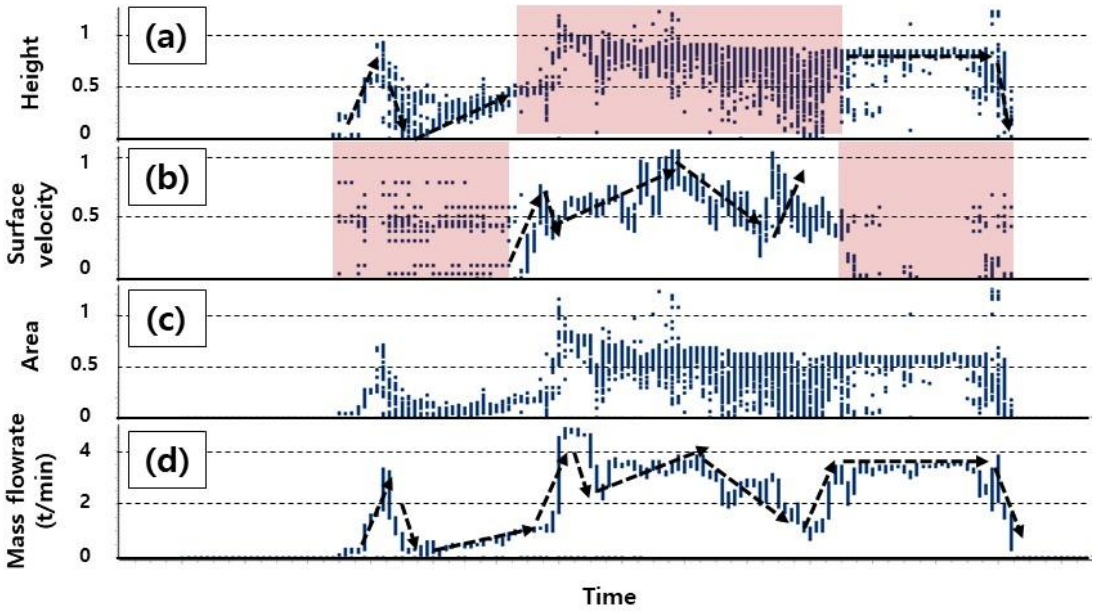
○ Missing value rate of height of slag surface is lower compared with surface velocity of the slag

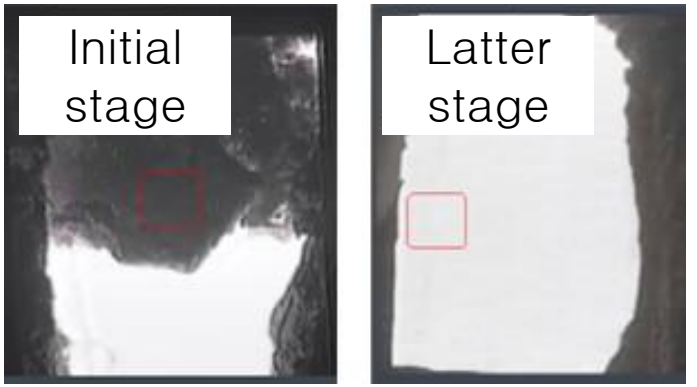
: Easy to calculate cross section area of slag trough

○ slag surface velocity data is clear at the middle of the tap while it is unstable and has lots of missing value at

the initial and last period of the tap

: Require data pre-process such as time average or median method





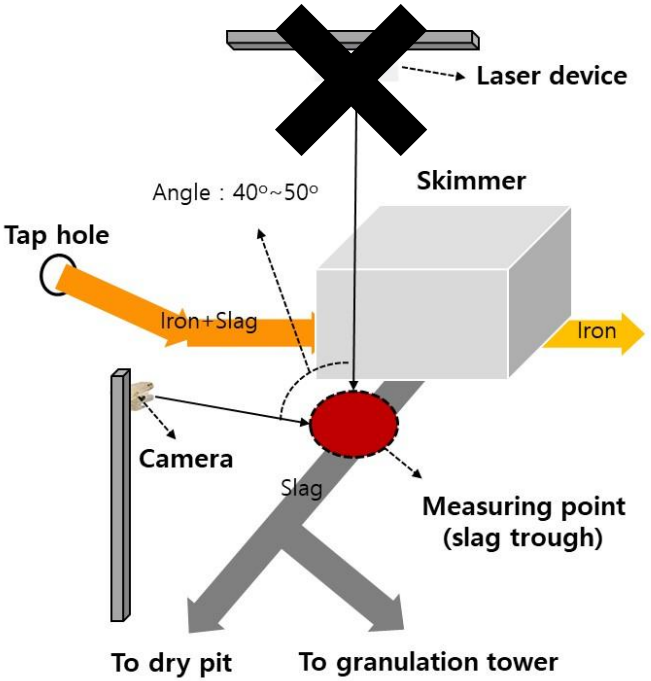
■ System without laser marking device

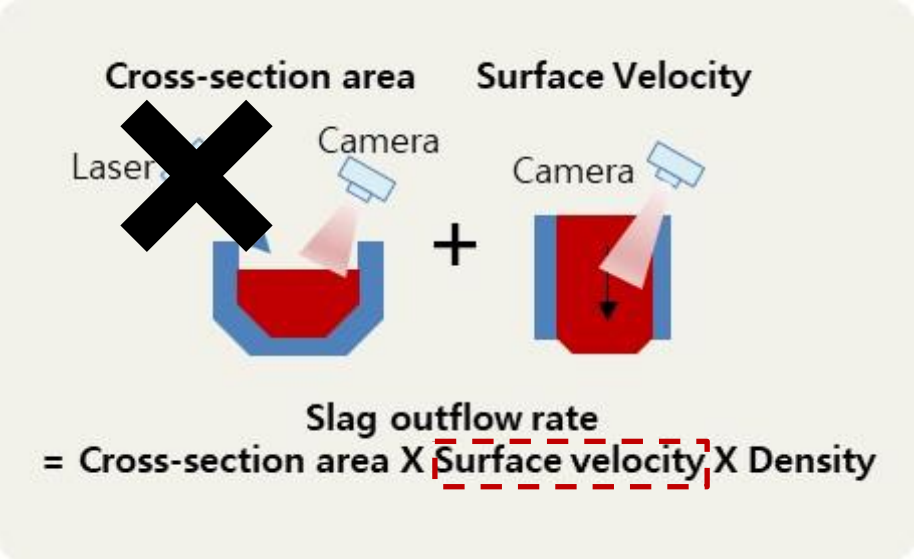
○ Installation and maintenance of laser device is not easy

○ 'Camera(CCTV) only system' can be helpful when laser marking device is not easy to install

: Accuracy vs Easy maintenance

○ Data analysis is required for this 'light' system



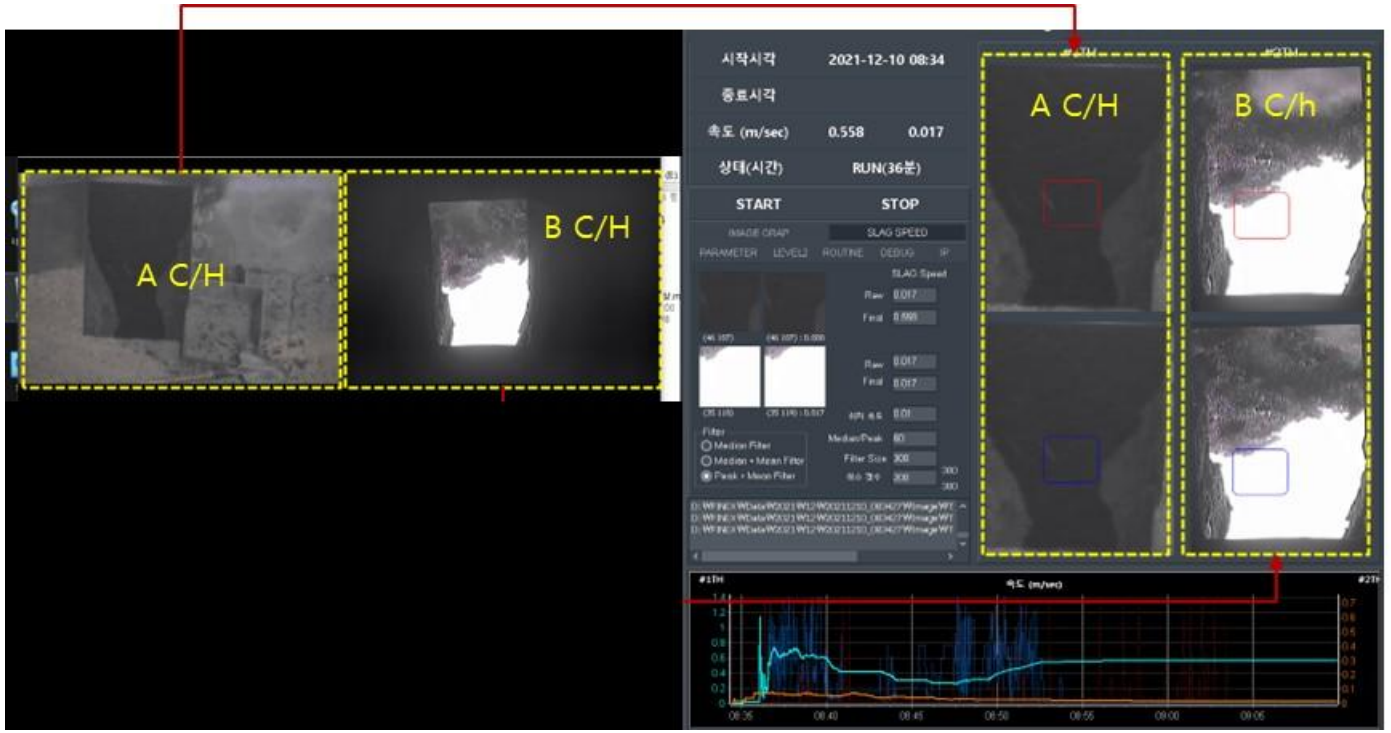


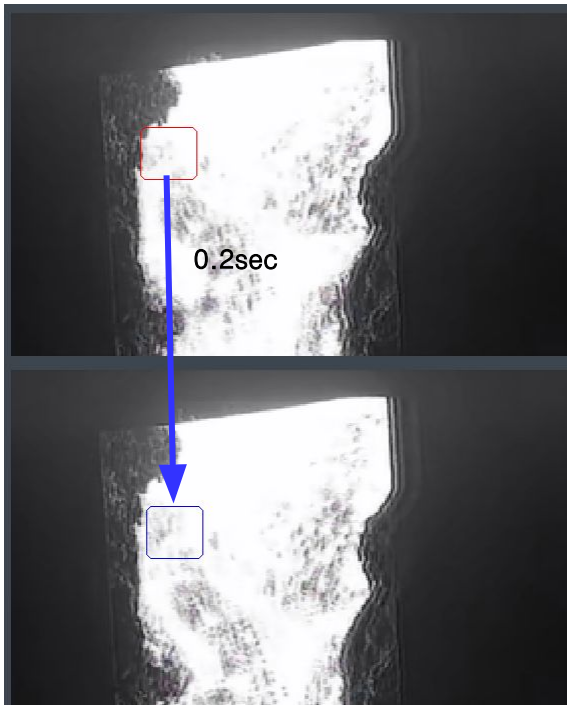
■ System without laser marking device

○ CCTV image without laser making device was used to calculate slag flow rate at #2 FINEX

○ Same methodology was tried with slag surface velocity measurement at #3 FINEX

: Slag surface particles were tracked in every 0.2 seconds

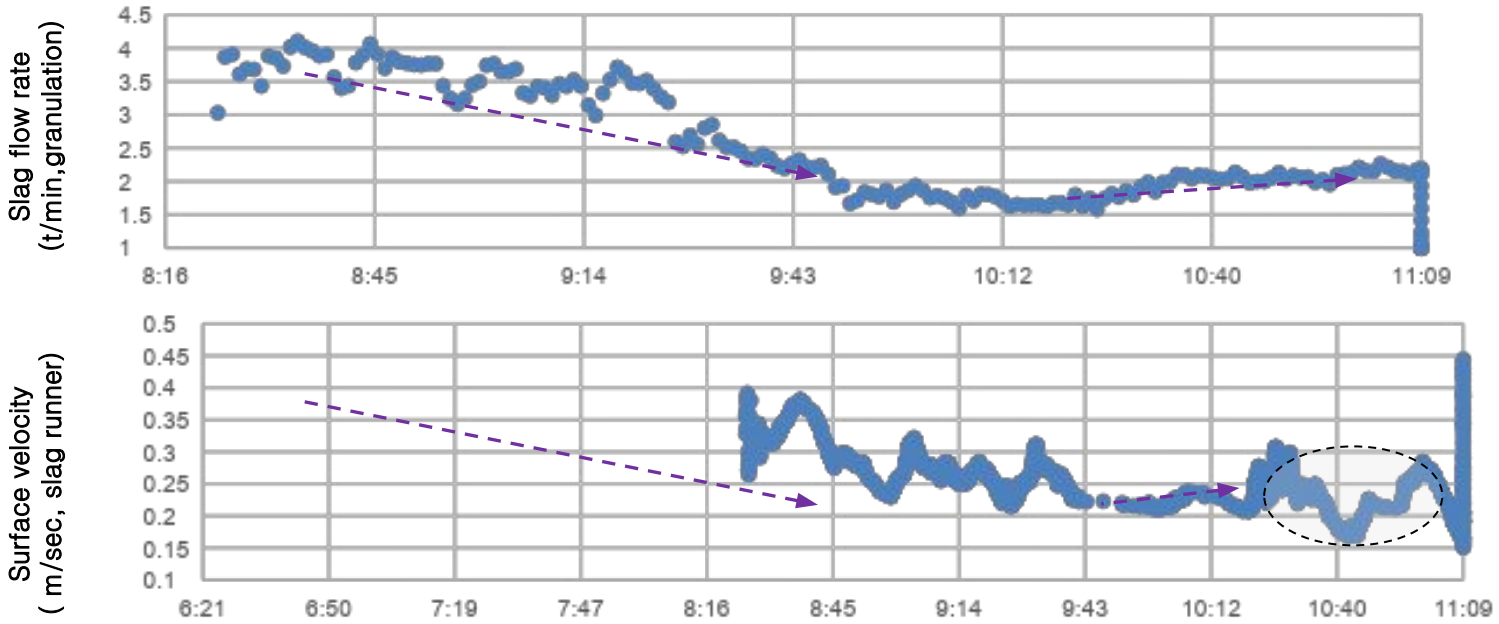




■ Slag flow rate calculation result : #2 FINEX

○ Trend of slag flow rate by granulation data and surface velocity is similar

○ Correlation factor should be derived between two parameters by data of several taps



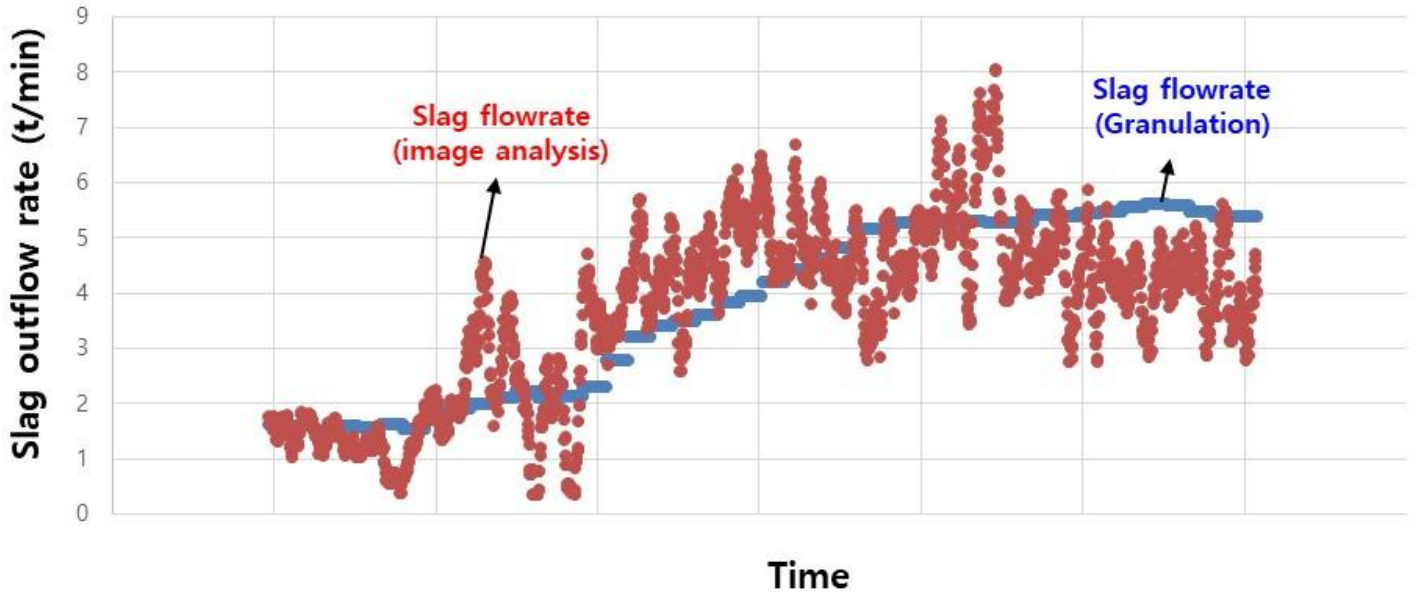
■ Slag flow rate calculation result : #2 FINEX

○ Difference in tap accumulated slag mass between image analysis based value and granulation data based

value was 7%

○ Image analysis based flowrate data is not stable so it is hard to use as an on-line data

: Laser + Camera is better option if laser is installable at cast house



Conclusion

○ Image analysis method was developed to measure slag flow mass at slag runner where slag is liquid state

○ Camera with or without Laser marker was installed in cast house for slag flow rate calculation.
By image analysis method, slag flow rate was monitored continuously and slag level could be calculated based on slag out flow rate data

○ By image analysis method, on-line slag flowrate data can be achieved without time delay and independent
of slag water granulation.

○ Accuracy of the system was found to be more than 95% which was verified by comparing calculated data
with water granulated slag weighing data

○ Although flowrate can be calculated without line laser marker, combining line laser with camera was found
to be a best option because of data stability

Thank you!