International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 6, Issue 1, January 2017)

To Identify the Root Cause for Mould Level Fluctuations in Continuous Casting of Slab

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Abstract **-Mould level Fluctuation is one of the common problems in continuous casting of Slab. Some fluctuations in the smaller range are inevitable and are generally allowed if they are within standard tolerance limits . But Some fluctuations are of bigger range and are beyond tolerance limits and are not allowed , which if allowed would have impact on the quality of cast product . These restrictions drive any Metallurgist to trace the root cause for this bigger range of fluctuations. We as Metallurgists in the quest to trace cause had also used an innovative approach to identify the cause for MLF using Fast Fourier transform of drives currents and MLF. Some more probable reasons were analysed in detail and is proposed and presented in this paper.**

Keywords-- **Mould level fluctuation, Clogging, MLF, Stopper mechanism, Level sensor.**

I. INTRODUCTION

Mould level Fluctuation is the deviation of mould level in positive and negative range which may or may not be periodic . More MLF in the bigger range will cause entrapment of mould slag and affects the surface quality of the product . Their occurrence depends on many factors which will be discussed in detail below .

II. ANALYSIS OF DIFFERENT PARAMETERS

1. Stopper mechanism issues:

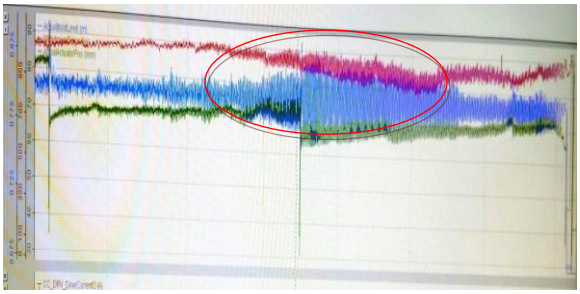

Fig 1. Case 1 MLF trend (Stopper mechanism)

Case 1: Consider above figure, where the green trend represents stopper position and the blue trend represents Mould level fluctuation. In the encircled region , one can witness that after flushing of the stopper (sudden drop in green line trend), the MLF got increased which makes clear that this flushing could have disturbed the mechanism which had weak flaws in its functioning before, and probably MLF got increased thereafter. It is also seen that later after some time MLF got normal with gradual rise in stopper. In such cases, Stopper mechanism needs to be checked for some wear or probably bearing and shaft alignment problem .

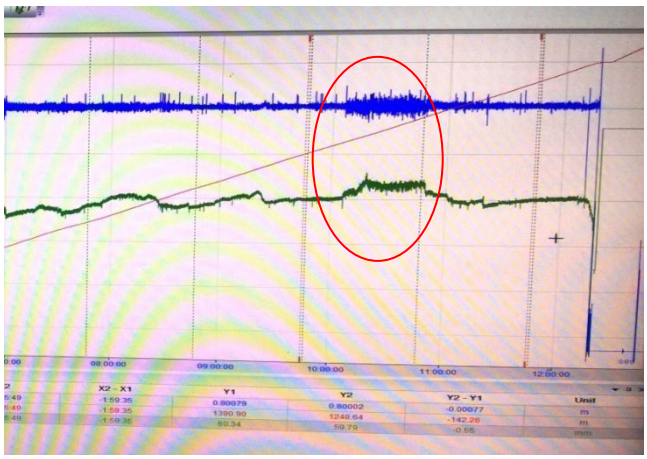

Fig 2 . Case II MLF trend (Stopper mechanism)

In the above figure, the green trend is Stopper position and the Blue trend is MLF. In the encircled region, one can witness the MLF behaviour with rise in stopper position. MLF got increased with rise in the stopper position and when the stopper was brought down by interrupting casting speed, the MLF also got reduced. If one confronts this case, it is recommended to check the bearings for it they have worn out and also the strength of bearings or probably misalignment of shaft with bearings.

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2. Level sensor or oscillator communication problem:

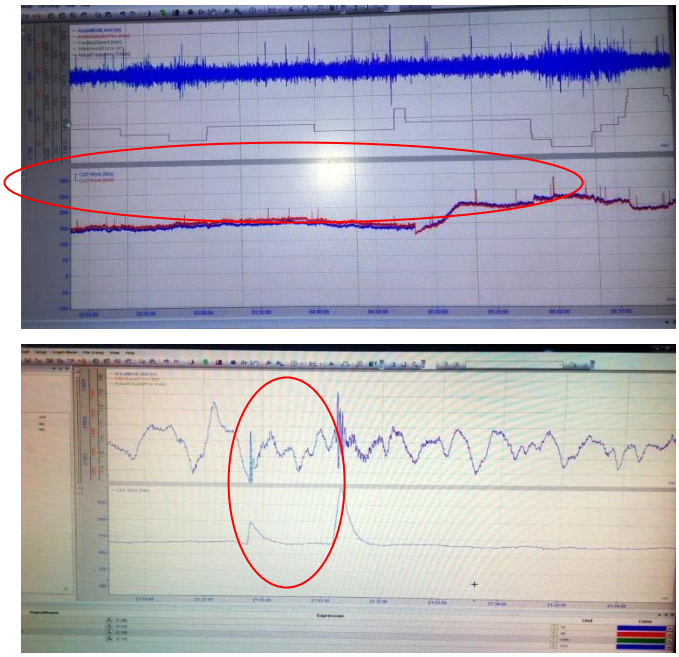

Fig 3. Mould level peak due to signal Interference

In the above figure, it is shown by encircling ,that if there exists any communication problem between the level sensor or oscillator and the Control PLC , then such irrelevant peaks are observed. This peaks are just displayed due to communication problem and no such adverse effect will be seen physically in the mould level. In this case the raw feedback from the level sensor and the Oscillator , also from the PLC had to be checked and compared with the Control or Common / Strand PLC . If the raw data itself had peaks then it is communication problem with the cabling or other feedback. If the raw data is clear from peaks, then the problem could be with interface of PLC. This has to be rectified by the Electrical concern.

3. Clogging:

Clogging is deposition of AL2O3 inclusions on the well block of Stopper seat or on the SEN (Submerged entry Nozzle) wall. Clogging is common in Aluminium killed grades and the deposition which clogs get released with time depending on the Steel cleanliness.

As this deposit is released suddenly, this will hamper the mould level or it disturbs causing MLF.

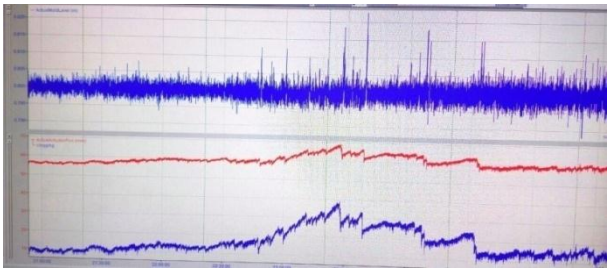

Fig 4 . Mould level fluctuation due to clogging

In the above figure the blue trend in the upper part represents the MLF and the blue trend in the lower part of figure indicates Clogging index . It is seen that as the clogging index drops suddenly each time , the Mould level also had corresponding peak . This peak is the result of clogging release, this can be avoided by good secondary steel making and ensuring steel cleanliness.

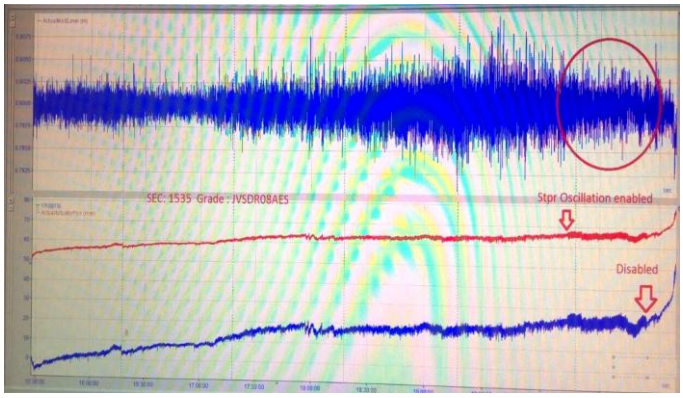

Fig 5. MLF reducing due to Stopper Oscillation

The above figure is a different case of clogging phenomena. Here with the gradual rise in stopper , MLF also increased . In this case the clogging was affecting the flow behaviour of molten steel continuously. Once stopper Oscillation was enabled, the clogging was released in smaller amounts based on oscillation intensity and this gradually reduced MLF which is clearly shown in the figure

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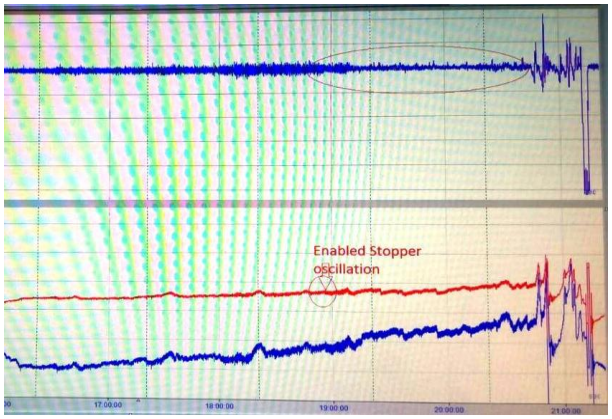

Fig 6 MLF reducing by Stopper Oscillation

Another such example of same clogging phenomena as discussed in the previous, the figure above is self explanatory.

4. Machine related issues :

Mould level fluctuation due to machine could be from bulging. When discussing machine related, we need to know two cases of bulging, Steady and unsteady bulging.

a) Steady bulging: Bulging which does not vary with time is steady bulging.

b) Unsteady Bulging: Bulging which varies with time and is not constant is unsteady bulging .

The above cases of MLF by bulging can be identified by use of FFT (Fast Fourier transform). In this FFT, the MLF will have a peak at one frequency or set of frequencies. By the range of frequencies one can identify, what kind of bulging is causing MLF.

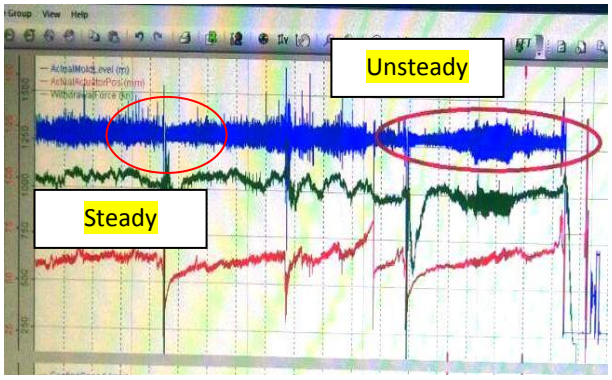

Fig 7. Mould level fluctuation due to steady and unsteady bulging

In the above figure, Blue represents MLF and green represents Withdrawl force variation.

It is clear from the real time data, that Steady bulging is constant and doesn't change with time and unsteady bulging is time dependent and varies with time. Any type of MLF due to bulging can be confirmed with the Withdrawl force variation matching with the MLF.

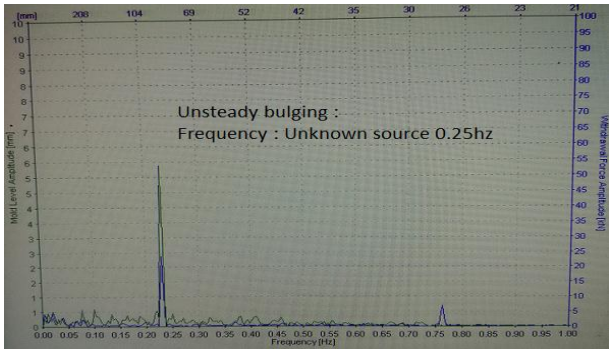

Fig 8. Online FFT of MLF and withdrawl force

In the above figure the FFT spectrum clearly displays the unknown frequency of Mould level which is an indication of unsteady bulging. By our experience we have traced that if the mould level peaks are generated with frequencies in between 0.25 to 0.6hz. It is then we consider it as unsteady bulging.

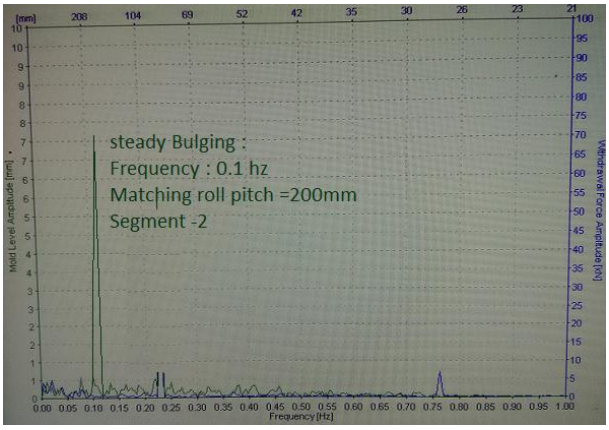

Fig 9. Online FFT of MLF and withdrawl force

In the above figure, FFT had generated Mould level peak and withdrawal force peak at 0.1 Hz, which matches the roll pitch of segment no 2. From this one can plan for roll gap checking in that segment and after confirming roll gap is beyond limits, can plan segment change. If the mould level peaks are generated with frequencies in between 0.05 to 0.1 Hz. It is then we consider it as steady bulging coming from the machine from said segment.

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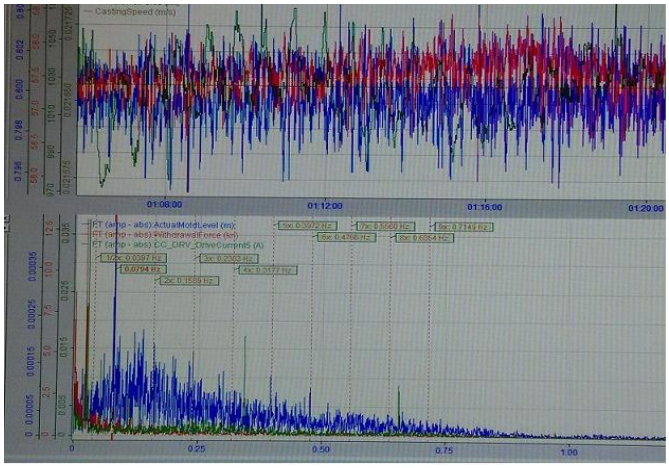

Fig 9 : Offline FFT to identify segment roll problem

In the above figure, one can notice the sharp peak in lower part of the above figure in FFT view. This is an indication of Roll bend. The frequency of roll bend is more often observed in the range of (0.1 to 0.18 hz). It has higher frequency because, each one full rotation of roll will affect the mould level fluctuation, and is constant with time.

III. Conclusion

Mould level fluctuations are caused by any one of four common reasons:

1. Stopper Mechanism problem
2. Level sensor or Oscillator communication problem
3. Due to Clogging
4. Due to machine related problems (Steady and unsteady bulging)

Clear observation of MLF, will help us trace the root cause, which probably is one of four reasons stated above. In the above reasons, Stopper mechanism problem and Level sensor problem are easily identified by the operator. And if the MLF is from clogging, we will find sudden mould level rise and drop peaks with every flush of stopper.

But if the MLF is expected from the machine, it would be difficult to identify by mere observation. Use of FFT for mould level with summary of segment drive force or torque , will ease our identification and also help us trace the cause at the earliest .

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