Cause Analysis and Treatment of Abnormal Shear in Head Cutting Flying Shear of Hot Rolling

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Abstract: Precise shearing of flying shear plays a very important role in cost control of a hot-roll line. The malfunction of sensors which help to locate where to cut accurately makes it difficult to achieve this goal. This paper discussed in detail three key control processes in completing precise shearing. Possible causes of abnormal shear in production practice were analyzed, based on which the optimal signal switching control measures was put forwards. A monitoring system watchdoged the signals from sensor. If sampling showed that malfunction happened, a backup signal was used. Also the possible backup signals were discussed how to replace the breakdown devices. In practice, these measures obtain a good application effect in precise shearing. Mistakes in cutting are reduced to minimum.

1 INTRODUCTION

Flying shear is one of key equipments in hot rolling line, used to cut the lower temperature and irregular parts in strip ends after rough rolling. This procedure can prevent band steel from jamming in finish rolling process and reduce the impact on the mill rolls from the irregular part. Precise shearing can also help achieve effective improvement in the production.

Abnormal cut happens frequently in the head/tail cutting and cutting waste loss accounts for more than 1.5% loss of the whole process. When the head / tail enters the finishing mill, it is very easy to cause the serious accident of roll breakage. If abnormal shear frequency can reduce by 50%, loss will be lowered by 3%, and direct economic benefits of more than 6000000 RMB Yuan can be achieved.

2 THREE CRITICAL CONTROLS OF FLYING SHEAR PROCESS

A complete precise shear process can be gained by controlling flying shear to complete the following three key functions (OUYANG Xiang-xin, 2003): strip end tracking and calculation, strip speed tracking and control and shear blade position tracking and control (Masahiro Kayama etc, 1998).

2.1 Strip End Tracking / Calculation

As the basis of flying shear accurate cutting control, motion control unit must accurately track and compute the strip end position, in order to determine when the shear performing certain actions. It makes possible that the blade cuts into the strip at set length (distance to the strip ends) and moves with the bar until the strip is cut off (Jiro Jumayama etc,1996).

2.2 Tracking / Control Strip Speed

In order to ensure cutting blade touching the strip at right time, the component of velocity along the rolling direction must be kept consistent with that of the strip until the strip is cut, which requires the exact tracking and control of strip speed based on the strip end tracking and calculation. Drum flying shear with a crank is employed in this plant. The structure is shown in Figure 1. Space trajectory of shear blade in the cutting process is round, as shown in figure 2.

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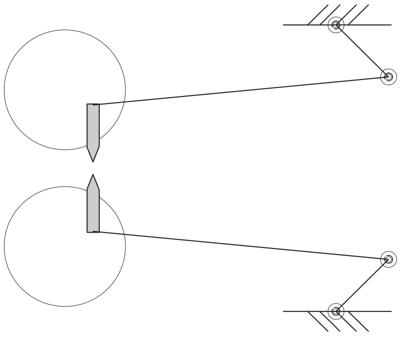

Figure 1: Sketch map of flying shear.

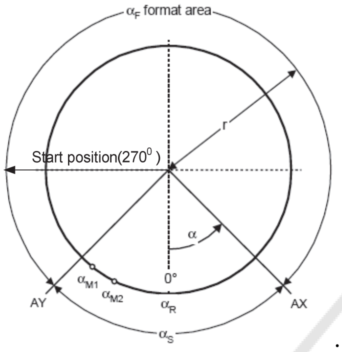

Figure 2: Trajectory of shear blade.

Velocity tracking is shown in equation:

$$Vc = K(2Lc - LR2 + r*\sin\alpha)/2Lc * VL/\cos\alpha \quad (1)$$

Vc - set velocity of shear, m/s,

K - leading or lag coefficient,

r - trajectory radius of shear blade, mm,

α - cutting angle calculated from the thickness of steel, °

Lc -circumference distance of blade in this stage, mm,

LR2 - distance between cutting point and flying shear, mm.

According to the position relationship between the cutting blade and strip, blade track is divided into four stages.

POS1: from Start position to AX in figure 3. The primary control target is to control cutting blade location based on the strip end position, which determines the accuracy of cutting length. At the same time, the control system requirements horizontal velocity of cutting blade at the end of the stage (AX) and the value is equal to that of strip , so the velocity control target has to be achieved - setting target speed according to the end position of band.

POS2: from AX to the 00 position in the figure 3. Because the blade has touched the strip, the actual cutting length is fixed, therefore in this stage the only control objective is to cut at the same speed with the strip.

POS3: from figure 00 positions to AY. In the same stage although blade has cut the strip, the blade is still with the strip. Therefore, the control goal is to follow the speed of the band.

POS4: from AY to Start position. The stage is a slow-down process, so position control is the only goal, which makes the blade stop in the starting position.

2.3 Tracking / Control Strip Speed

The following is formula of the position control:

$$P = 270° - (2Lc - LR2 + r*\sin\alpha)*(270° - \alpha)/2Lc \quad (2)$$

P-set position of blade

In POS1, position control can compensate for the shearing speed changes in following the actual speed of strip when the final position is unpredictable. So both speed control and position control is important in this stage. So blade cuts into bar steel at synchronous speed (horizontal) of strip in set cutting position, ensuring the flying shear can coherently finish cutting process even in velocity fluctuations.

In POS2 and POS3, position controller implements cutting, and there is only speed control to the blade.

In POS4, as mentioned before, there is only position control to the blade. So the output of the speed controller is always zero. Setting value is 270.

The system diagram is as shown in Fig.3.

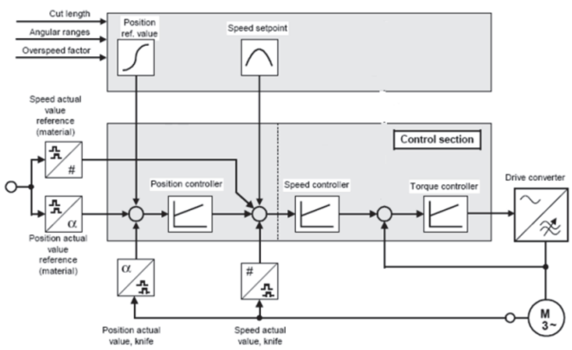

Figure 3: System diagram of shear control.

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3 ANALYSIS ON THE CAUSES OF TYPICAL ABNORMAL SHEAR

In practice, because of the influence of the cooling water, rolling vibration and electromagnetic interference, abnormal shear occurs mostly when the bar end calculation is not accurate caused by the abnormal signal gotten from the line.

3.1 Laser Velometer Measurement Abnormal

Due to poor field conditions and effect of water fog, or the velocimeter's own fault, signal is abnormal, as shown in Fig. 4.This situation mostly leads to missing cutting the head of the band.

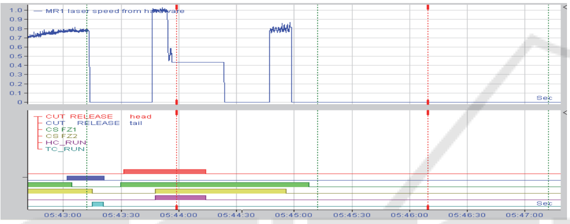

Figure 4: Abnormal signal from Laser velocimeter.

Signal from laser velocimeter for the strip speed in the shear region is a constant value. But sometimes the value suddenly drops to zero.

3.2 Measure Roll Tacho Measurement Abnormal

The feedback value waveform coming from feed roller encoder after clamping roller, which is used to strip tail length calculation and velocity tracking concusses, indicates the fluctuation of velocity. Waveform deterioration leads to inaccurate tail length calculation and tail cutting normal. The abnormal situation is shown in figure 5.

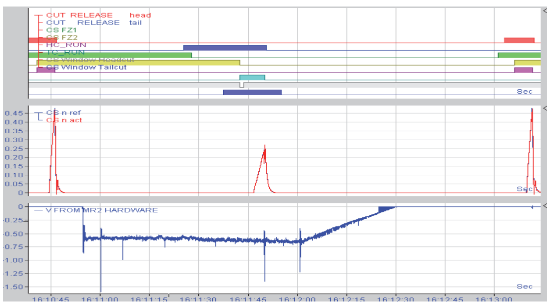

Figure 5: Abnormal signal from Measure roll tacho.

3.3 HMD FZ2 Measurement Abnormal

As is shown in Figure 6, the FZ2 and laser velocimeter is turned on at almost the same time, then turned off immediately. This is a early missing connection, leading to the subsequent flying shear early cutting. In the end, the blade misses cutting the head of band, because of the arrival of thermal field ahead of the actual situation.

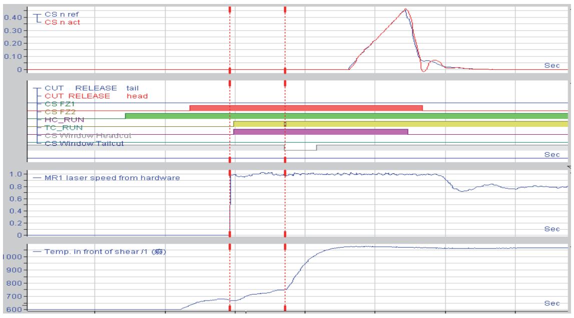

Figure 6: Abnormal signal from FZ2.

4 MEASURES

Abnormal shear is caused by the abnormalities of measurement in the field. In order to improve the cutting precision, a more reliable substitute signals must be found as a standby signal. When the main signals are abnormal, fast switching will use standby signal. According to this idea, the following measures are taken.

4.1 Measures 1: Switch the Abnormal Signal to Roller Speed from the Laser Velocimeter, When Cutting Head

A laser velocimeter is used to measure the actual speed of the strip in cutting head. Practice has proved, without considering the slip, speed signal from roller can be used to substitute the signal from velocimeter. By using logic judgment between laser velocimetry and roller speed, the abnormal signal from laser velocimeter can automatically switch to that of the roller speed. The following figure 7 shows the logic diagram:

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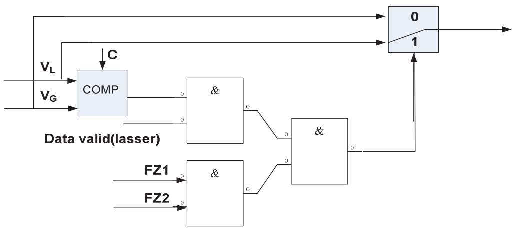

Figure 7: auto-switch between laser velocimeter and roller speed when cutting head

VL -real-time velocity of the strip, m/s;

VG-speed of the roller, m/s;

The measure is mainly programming in the TDC controller of flying shear and the signal from laser velocimeter is compared with threshold C, then logic judgment makes roller speed switch happen.

4.2 Measures 2: In Considering the Backward Slip Situation, using the F1 Velocity Instead of the Feedback Value from the Roller Encoder, When Cutting Tail

As shown in Figure 9, speed signal from F1 in finishing roll is most stable and not subject to environmental influence. But in the application the backward slip factor of steel in F1 rolling must be considered. Use the signals from velocimeter and F1 to get the real-time backward sliding coefficient and. Multiply the real-time F1 speed with the backward slip coefficient, then relatively stable strip speed is gained.

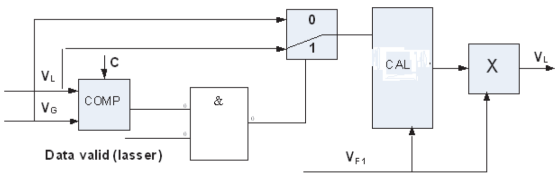

Figure 9: Real-time backward sliding coefficient calculate when cutting tail.

The calculation formula of simplified sliding coefficient:

$$K_L = V_L / V_{F1},$$

V_{F1}- speed of F1, m/s;

5 CONCLUSIONS

Based on the analysis of the causes of abnormal shear, the idea of using the signals of more stable to replace the existing signal in the cutting head and tail cutting process is put forward. In this way, abnormal signals are switched to reserved ones, and abnormal shear due to abnormal signal inputs was reduced to 0.32%. Meanwhile, down time of the equipments is decreased by 72% and production coefficient and production efficiency are improved as well.

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