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ON-LINE PUNCHLESS DETECTION OF LASER WELDING PART OF COLD-ROLLING STEEL STRIP

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Abstract: The punchless welding point detection system using laser diagnostics for continuous strip production line has been developed. At the entrance of the steel strip production line, the preceding and following coils are welded for continuous processing. The welding point detection and tracking of the position is essential for the setup change of various important processing facilities according to the specifications of the coil under processing. Conventionally the hole is punched for on-line detection of the welding point by transmission and detection of light. But the punched hole causes several disadvantages such as decrease of productivity, generation of flaws, breaking of high steel strip. There are mainly three types of welding of coils; flash butt, laser and mesh seam welding. The punchless welding point detection system for laser welding has been developed and tested in real production line. The welding point is detected by measuring the change of reflected light distribution due to welding part and high speed temporal analysis of the measured reflectance signal.

1. INTRODUCTION

In cold-rolling mill of steel works, the preceding and following coils are welded for continuous processing of steel sheet. The detection and position tracking of welding part is essential for the automatic setup change of various important processing facilities according to the specifications of the coil under processing. Conventionally the hole is punched for on-line detection of the welding point by transmission and detection of light. But the punched hole has following problems/disadvantages; the strip in entrance of processing line should be stopped for punching process(productivity decrease) and various type of flaws can be generated due to under burr of punched hole. Also, it is one of the originations of strip breaking of high carbon/thin steel strip and so on. There are mainly three types of welding for coils in cold-rolling mill; flash butt, laser and mesh seam welding. The punchless welding point detection system for flash butt welding has been developed and applied to real production line. In case of flash butt welding, the bead formed during welding is trimmed to prevent, for example, the damage of working rolls. The trimmed welding part has different reflectance, roughness and flattness. Therefore the welding position can be detected by measuring the change of reflected light distribution and high speed temporal analysis of the measured refdlectance signal. The punchless welding position detection system has been already applied to real production(PCM) of POSCO.

Among the type of welding, nowadays the laser welding is dominant in colding rolling mill. The profile of laser welded part of steel strip is largely different with that of flash butt welding. Accordingly, the distribution of reflected lights of laser welded part is also different. Therefore it is needed to develop the detection technology for laser welded part.

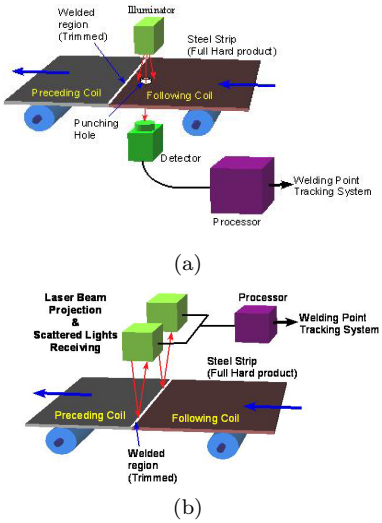
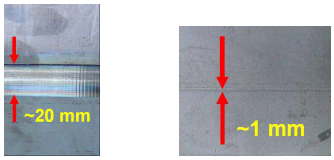


Fig. 1. Punching type welding position detection(a) and punchless detection(b) of flash butt welding

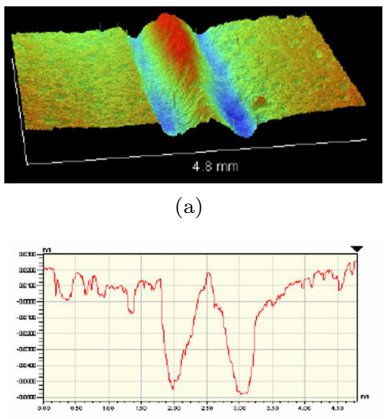
2. 2. PRINCIPLE OF WELDING POSITION DETECTION

As mentioned above, the profile of laser welded part of steel strip is largely different with that of flash butt welding, as shown in figure 2. The width of laser welded part is very narrow(1 mm) compared to the width of flash butt welded part and the profile is microscopic as shown in figure 3. In figure 3, the profile of laser welded part of electrical steel sheet is shown. According to the measured profile, the depth of welded part is bellow about 50μm. Considering



(a) (b)

Fig. 2. The profile of welded part of flash butt welding(a) and laser welding after pickling(b)



(a)

(b)

Fig. 3. Profile of laser welded part of electrical steel sheet; 3 dimensional measurement(a) and depth profile(b)

the microscopic profile of laser welded part, it was expected that on-line detection of welded part in real production line will be very difficult . In addition, the reflectance change of welded part is very small after pickling. Therefore the change of main direction of reflected light, instead of change of reflectance itself, should be exploited to detect the welded point. For example as shown in figure 4, change of main reflection direction can be monitored by using linear array detector.

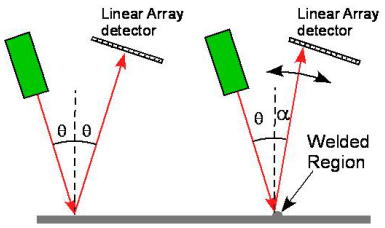


Fig. 4. Change of main direction of reflected lights due to the profile of welded part

3. DESIGN OF DETECTION HEAD

The main problems of on-line detection of welding position are low signal level of welded part and large signals from strip surface itself. The signal level of welded part is determined by profile of welded part. To obtain large signal from microscopic profile of welded part using the change of reflection direction, very small focused laser beam with diameter much smaller than the width of welded paer(1mm). But if the circular focused laser beam is used, there are so large continuous noises caused by microscopic structure (roughness) of strip surface. To minimise the noise signals caused by roughness and maximize the signal from welded part which has the shape of narrow strip along the width direction of steel strip, laser beam was focused on steel strip with narrow line shape. Also, to remove the low frequency reflectance change of strip surface, two successive laser beam lines with orthogonal polarization direction were used. The signal from each laser line beams are subtracted. The schematic diagram is shown in figure 5.

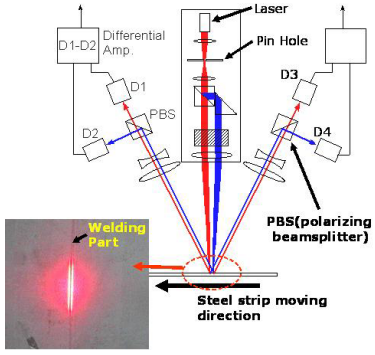


Fig. 5. Schematic diagram of detection head for laser welding position

4. TEST RESULTS IN REAL PRODUCTION LINE

The laser welding position detection system was installed in PCM line of Pohang steel works. According the on-line test results, the detection power was about 98-100%. The testing powers are different according to the kind of steel strips. The optimization of detection and signal processing algorithm for stable detection regardless of steel type is in progress.

5. CONCLUSION

The laser diagnostics for on-line detection of microscopic laser welded position. Using two succesive narrow line beam method, signal S/N ratio was improved largely. According to the test results in PCM line, the detection powers were very high and possibility of application to real production line was confirmed.

REFERENCES

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