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Influence of Rolling Force and Roll Gap on Thickness of Strip

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Abstract. The automation control system is of great significance and efficient to control the thickness precision in hot strip rolling process. In this paper, the relationship among thickness, rolling force and roll gap in hot strip rolling process was studied. The reason for the bad hit rate of thickness for the first format-changed blank was analyzed. The adjustment of thickness in the hot rolling process was also studied. The decrease of rolling force and the increase of roll gap can increase the exit thickness of the hot-rolled strip. As the thickness control system and mechanism for hot rolling process are complicated, there are much work need to be done.

1. Introduction

In 1924, a hot strip rolling line of 1470 mm was established in America, from then the hot strip rolling technology has a long history of more than 90 years [1]. In November 1971, Nippon Steel established a 2235 mm hot strip rolling with computer controlled system, which is a typical advanced design and technology [2]. In 1978, Wuhan steel company has import the first 1700 mm hot rolling strip production line with strip hot rolling computer control system [3]. The application of process automation system significantly improve the efficiency of the strip hot rolling and is advanced in the modern computer control system. At the same time, using the process automation system can improve the thickness control precision and ensure the product quality [4-5]. Thickness precision is one of the most important quality indexes in the area of hot strip. Much effort has been devoted to control the strip thickness precisely. And the method to control the thickness is an important research in the rolling automation [5-7]. According to a hot rolling line in Shougang company, much attention has been paid to the accuracy of thickness control, such as theoretical research, optimization development, data analysis and other parts. In order to control the thickness precisely with the help of computer control system, some work has been done, such as collecting and summarizing thickness related data form the log, pdo, pda and other profiles generated from level 2 computer system, studying the theory of thickness variation of hot rolled strip, analyzing the relationship among thickness and other factors and so on.

2. Materials

In this rolling schedule, the steel 64A02 was used. The blank of 64A02 was usually used for building, kitchen utensils, tableware, vehicles, household appliances and so on. In our industry, the hot rolling strip was produced. The entry thickness in first finish rolling stand is about 45 mm, and the exit thickness of strip in the last finish rolling stand is about 3.5 mm, which is the target thickness for our customer. However, the thickness mentioned above should consider the effect of temperature. At the elevated temperature, the thickness of 3.5 mm can be converted to a hot-stated value of about 3.54, by multiply the coefficient of thermal expansion. The coefficient of thermal expansion is about 1.01 at that elevated temperature.

3. Experiments

The transfer bar was transferred to finish rolling stands. There are 6 stands in the hot rolling stage. In this stage, more than 10 blanks was rolled. After the hot rolling process, the thickness was measured by X-ray measurement equipment. At the same time, the rolling force of each stand was also measured and recorded in the computer. Then we can get these data from the log, pdo, pda and other profiles for further analysis. As we all know, the accuracy of thickness is of great significance, and there are so many problems need to be explained and solved. If the thickness accuracy can be accurately controlled or improved, the sale can be enhanced. So it is necessary to analyze the data about the thickness, rolling force, roll gap and the relationship among them.

Table 1 shows the thickness related data for these three blanks. The type of steel is 64A02, the target width is 1198 mm, the target thickness is 3.5 mm, and the average thicknesses for these three strips are 3.301, 3.504 and 3.502 respectively. The hit rates of thickness for these three strips are 0.26, 92.5 and 78.5 respectively. The final rolling temperatures for these three strips are 876.1, 881.4, and 879.2 respectively. The inherence modes for these strips are Long, short and short respectively. As the first one has a different size from the last one, so the hit rate of thickness is low. The second one learned from the first one, and got a better hit rate of thickness. As is shown in Table 1, the hit rate of thickness for the first blank is 0.26, which is a little low. And the second one has a high hit rate of 92.5. This is to say the computer system adjusted the coefficient of the model, and some data were changed, so the average thickness was improved to 3.504 mm. The third one also has a good average value of 3.502.

In order to analyze the reason for the variation of thickness. Some other two important factors, namely rolling force and set roll gap, were selected and given in Table 2 and 3.

Table 1. The information for the first three blank

No.	Steel grade	Target width	Target thickness	Average thickness	Hit rate	Rolled temperature	Inherence mode
1	64AO2	1198.	3.50	3.301	0.26	876.1	LONG
2	64AO2	1198.	3.50	3.504	92.50	881.4	SHORT
3	64AO2	1198.	3.50	3.502	78.50	879.2	SHORT

Table 2. The rolling force for the first three blanks.

Rolling force of head	1	Calculated [MN]	33.131	28.75	24.759	21.447	16.58	14.065
		Actual [MN]	27.557	23.68	21.463	18.592	14.462	12.502
		Deviation (Cal-Act)	5.574	5.07	3.296	2.855	2.118	1.563
	2	Calculated [MN]	25.561	23.93	19.576	17.518	13.907	11.752
		Actual [MN]	25.345	23.739	19.889	16.635	13.444	11.345
		Deviation (Cal-Act)	0.216	0.191	-0.313	0.883	0.463	0.407
	3	Calculated [MN]	26.287	23.541	21.661	17.36	12.702	11.033
		Actual [MN]	25.812	23.573	21.056	17.236	12.69	11.311
		Deviation (Cal-Act)	0.475	-0.032	0.605	0.124	0.012	-0.278

Table 3. The set roll gap for these three blanks.

			F1	F2	F3	F4	F5	F6
Roll gap for	1	Set roll gap [mm]	22.596	13.137	7.227	4.47	2.622	2.418
the stands	2	Set roll gap [mm]	23.791	13.282	7.872	5.04	3.001	2.814
	3	Set roll gap [mm]	23.678	13.69	7.561	4.878	3.169	2.924

4. Analysis and discussion

It can be seen from Table 1 that the inherence mode of the first blank is Long term inherence. Because this blank changed the format from the last one. Even though the steel grade is the same as the last one 64A02, the change of format led to the long term inherence. However the inherence result is not good, even shows a large variation from the reality. However, the second one and the third one show the good result, and the inherence modes are short term inherence respectively. After the check for the inherence. It can be known that the second one learned from the first one, and the third one learned from the second one. The first one learned from the NeuralNet. This should be why the first blank has a bad thickness distribution.

The thickness of the hot rolled slab can be analyzed by P-H diagram, as shown in Fig. 1. In this figure, the left two lines represent stand modules, and the right two lines represent material modules. The h indicates the target exit thickness. This figure is a schematic diagram used for further analysis.

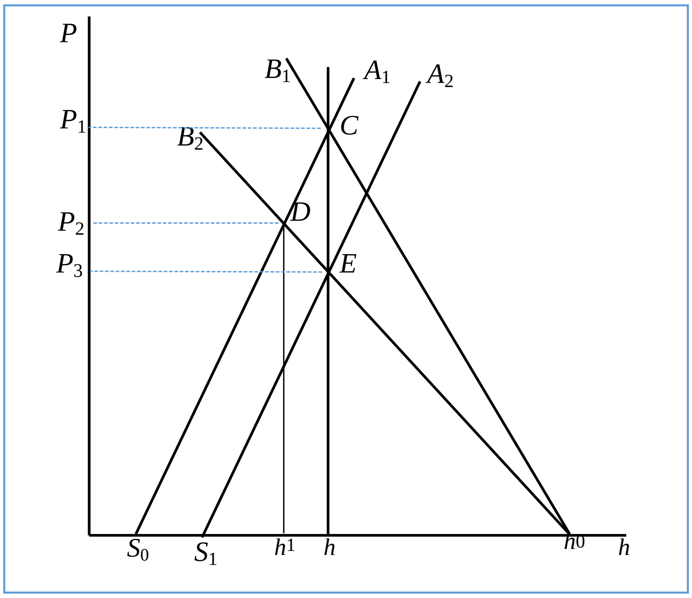

Figure 1. P-H schematic diagram for thickness variation analysis

The thickness is mainly controlled by rolling force and roll gap. It can be seen from Table 2 the deviation between calculated and actual result of rolling force for the first one is very large. The deviation for the second one and third one is small. At the same time, the calculated result of rolling force for the second one is less than the first one. The set roll gap for the second one becomes larger from the first one. The adjustment of rolling force and roll gap generated a good result for the second slab. According to the P-H diagram, it can be concluded the material modules for the first slab were set as the false ones. After the first roll process, the control system detected this error, and changed the material modules, so the second one and third one have the good thickness distribution. In the P-H diagram, the line B1C was drawn as the first material modules, it has a large slope, which indicates a large material module. The line B2D was drawn as the new material modules after adjustment of computer system. It has a relatively small slope, which indicates a small material modules. In order to check the material modules set by the

Level-2 computer system, the stand and material modules were output into the log profile. The data were summarized in Table 4. It can be seen that the precise material modulus set is of great significant for the thickness control in hot rolling process. At the same time, the rolling force and roll gap have great effect on the slab thickness. The decrease of rolling force and the increase of roll gap can increase the exit thickness of the slab.

Table 4. The stand modules and material modules obtained from computer control system

Sample	Modules	F1	F2	F3	F4	F5	F6
1st	Stand module [MN/mm]	6.158	5.933	6.291	5.734	5.532	5.556
	Material mod [MN/mm]	1.723	2.917	3.714	7.505	9.565	17.073
2nd	Stand module [MN/mm]	6.194	5.953	6.306	5.649	5.551	5.534
	Material mod [MN/mm]	1.33	2.253	3.247	6.145	8.265	15.531
3rd	Stand module [MN/mm]	6.194	5.951	6.284	5.648	5.483	5.522
	Material mod [MN/mm]	1.368	2.27	3.416	5.733	8.599	15.298

5. Summary and Conclusions

In this paper, the data about thickness for the hot rolling slap were presented and analyzed. The slap firstly changed format tends to have a bad thickness distribution, due to the inherence study. The application of material modules affect the exit thickness of slap significantly. The rolling force and roll gap have a remarked influence on the thickness. The decrease of rolling force and the increase of roll gap would increase the thickness of slab.

6. References

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