Influencing factor and cost optimization for service life of KR impeller

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Abstract. The service life of KR impeller for one steel plant in Southern China is investigated in this paper. It is shown by site investigation and comparison analysis that there is still improving potential for the service life of KR impeller, whose influencing factor includes hot water temperature, rotating speed, stirring duration, refractory of working lining, internal metal core structure, fabricating process, blade structure, hot repairing process and material, desulfurizer composition, interval time between stirrings. If technical optimization is conducted based on the influencing factor, it is predicted that the service life of KR impeller in this plant can be enhanced from 230 heats to 300 or 400 heats, saving 0.4–0.6 RMB/t hot metal.

Keywords: Hot metal, KR, Impeller, Desulfurization.

1 Introduction

Chinese iron and steel industry has entered adjusting era. Under this circumstance, the steelmaking enterprise with lower cost and higher efficiency will survive or become the winner in this severe war.

In order to control the production cost, among many aspects, the consumption of spare parts is a key factor. As the key device of hot metal pre-treatment, KR desulfurization is now very popular in China. For KR, its stirring impeller is the key consuming and spare part. It would be a satisfactory result if KR can finish its task with higher service life of the impeller. For this purpose, firstly, the influencing factor should be found out.

Previous papers[1–12] show the service life of KR impeller would be influenced by some factors, such as fabricating process, metal structure, refractory material, length, diameter, shape, hot repairing process of the impeller, hot metal condition, desulfurizing target, desulfurizer composition, stirring duration, interval time between stirrings, rotating speed, torque and hot metal temperature, etc.

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2 Investigation and results

2.1 Investigation

Site investigation was conducted at one steel plant in Southern China. It has two sets of 210t KR, whose annual treatment capacity is 4.5 million ton per year.

All KR production data for 1.5 years were investigated and analyzed systematically. In this paper, we mainly study the influencing factors for the service life of KR impeller and comparison analysis would be conducted with other Chinese steel plants (hereinafter abbreviated as No.1~No.5 steel plant).

2.2 Results

Based on the site investigation, the service life of the impeller is about 200~230 heats/set.

Fig.1 shows the comparison of the service life of KR impeller between several Chinese steel plants. It is shown that the service life of KR impeller for this plant is near the average level, however, it is 270 heats lower than the excellent level (500 heats). So there is some optimizing potential for the service life of KR impeller in this plant.

![Fig. 1. Comparison of the service life of KR impeller between several Chinese steel plants.](image)

3 Discussion

Hereinafter, let’s investigate the influencing factors of the service life of KR impeller and the reason why it is lower than the excellent level.

3.1 Hot metal temperature

For this plant, after blast furnace tapping, hot metal is transferred by one type of ladle to converter for charging, which is called “single lade hot metal transfer solution”, reducing the temperature loss of the hot metal. As a result, the hot metal temperature (when the ladle
car arrives at KR station) is higher than normal level, leading to more corrosion of KR impeller and lower service life than the excellent level.

Fig. 2 shows the comparison of ratio of temperature range of KR input hot metal. It is shown that the temperature of hot metal entering KR station of this plant is much higher than No.5 steel plant, taking up 71.2% when the temperature $>1390^\circ$C. This is one of the reasons why the service life of KR impeller of this plant is lower than No.5 steel plant.

**Fig. 2.** Comparison of ratio of temperature range of KR input hot metal.

### 3.2 Rotating speed of KR impeller

Fig. 3 shows the comparison of rotating speed (average value) between several Chinese steel plants. It is shown that the rotating speed of KR impeller of this plant is lower than No.4 and No.5 steel plant, weakening the dynamic condition for desulfurization, increasing stirring duration, reducing the service life of KR impeller. Among these plants, the rotating speed of No.4 plant is higher (120 r/min), whose service life of KR impeller is 330 heats/set, higher than this plant.

**Fig. 3.** Comparison of rotating speed between several Chinese steel plants.
Fig. 4 shows the ratio of rotating speed of KR impeller of this plant. It is shown that the ratio of 91~100 r/min is the highest, taking up 64.52%; the ratio of 81~90 r/min takes up 29.02%. So, there’s nearly no heats higher than 100 r/min, and there’s low speed range (40~80 r/min) taking up 5.58%. So, within design and safety allowance range, the rotating speed should be enhanced as high as possible. Generally speaking, rotating speed should be lower for the newly replaced impeller, and after some working period, it can be enhanced step by step, increasing the stirring intensity, reducing the stirring duration and enhancing the service life of KR impeller.

Fig. 4. Ratio of rotating speed (r/min) of KR impeller of this plant.

3.3 Stirring duration

It has been discussed in chapter 3.2 that the rotating speed of KM impeller of this plant is relevantly lower, increasing the stirring duration, reducing the service life of KR impeller. Fig. 5 shows the ratio of stirring duration of KR impeller of this plant. It is shown that the stirring duration of 6~10min takes up 69.75%, and 11~20min takes up 7.39%, which further explains the reason of lower service life of KR impeller of this plant.

Fig. 5. Ratio of stirring duration of KR impeller of this plant.
3.4 Other influencing factors

Besides the influencing factors shown by site investigated data above, based on the research achievements of iron and steel industry, there are other influencing factors for the service life of KR impeller:

1) Refractory of the working lining of KR impeller: it is shown by previous report\cite{5, 6, 11, 12} that the performance of anti-scouring, thermal shock resistance and anti-corrosion of KR impeller can be enhanced by adopting the steel fiber reinforced mullite – corundum refractory castable.

2) Internal metal core structure: it is shown by previous report\cite{1} that the stress in the bonding surface and convex part caused by the mismatch of thermal expansion between the metal core and the refractory working lining can be relieved by adopting the metal core structure with an arc transition surface and a layer of buffer coating on the metal plate surface.

3) Fabricating process: it is shown by previous report\cite{2} that the performance of KR impeller can be improved by adopting reverse knot casting process and baking process according to different temperature range.

4) Structure of blades: it is shown by previous report\cite{2} that the service life of KR impeller can be enhanced by adopting three-blade with larger size. And previous report\cite{6, 7} shows that adopting larger diameter of blades with curved surface can enhance the desulfurizing efficiency, shortening the stirring duration, and accordingly enhancing the service life of KR impeller.

5) Process and material of hot repairing: it is shown by previous report\cite{1} that the thermal healing of damaged working lining can be promoted by using the hot repairing material consisting of flint clay and three-level high-alumina clinker and pressing repairing process, enhancing the service life of KR impeller.

6) Desulfurizer composition: it is shown by previous report\cite{10} that in order to avoid corrosion on impeller by CaF$_2$ included in the traditional desulfurizer, one new type of F-free desulfurizer (mainly consisting of CaO, combined with alumina slag as desulfurization catalyst) can be adopted to enhance the desulfurizing efficiency and service life of KR impeller.

7) Interval time between stirrings for desulfurization: it is shown by previous report\cite{10} that the service life of KR impeller can be enhanced by reducing the interval time between different heats which can speed up the production to reduce the thermal shock of the impeller.

4 Conclusions

Based on above, conclusions can be drawn that the influencing factor of the service life of KR impeller includes: hot water temperature, rotating speed, stirring duration, refractory of working lining, internal metal core structure, fabrication process, blade structure (numbers, shape, size, etc.), hot repair process and material, desulfurizer composition, interval time between stirrings.

In order to enhance the service life of KR impeller, based on the desulfurizing target and production safety, combined with the influencing factors discussed above, optimizing measurements listed as below can be conducted:

1) Under the pre-condition of making sure of the desulfurizing effect, hot metal temperature should not be too high;

2) To raise the rotating speed of KR impeller to enhance the stirring intensity, reducing the stirring duration;

3) To improve the fabricating process, refractory for working lining, internal metal
core structure, hot repairing process and material;
4) To make some innovation on the blade structure, such as the shape, size, etc.
5) To improve the desulfurizer composition, adopting F-free desulfurizer.
6) To speed up the desulfurizing treatment, reducing the interval time between different heats and thermal shock of the impeller.

By the measurements above, it is conservatively predicted that the service life of KR impeller in this plant can be increased from 230 to 300~400 heats/set, reducing the operation cost of impeller by 0.4~0.6 RMB/t hot metal at least, totally saving 1.7~2.6 million RMB annually, creating huge economic benefits, enhancing the cost competitiveness of the steel plant.

References