Examination Method of Duplex Stainless Steel Based on TRIZ

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Abstract. Examination method of duplex stainless steel is considered as study case, and TRIZ contradiction matrix theory, 40 inventive principles and substance-field model are synthetically utilized to solve examination problems. Methods of two-phase microstructure examination of duplex stainless steel with TRIZ methods are analyzed. Finally the practical application of TRIZ and the superiority of TRIZ theory are validated.

Introduction

To research the relationship among component, structure and property is one of the important missions of the physical metallurgy. And the depth of research depended on the capacity of identification of the inner structure of the metallic material. Therefore metallographic examination is one of the most important segments in the field of metallic material science.

On research or application of metallic material, there are two important aspects. First, the result of the structure and the property of metallic material depended on the component. If it is going to be improved, lots of physical and chemical inspections have to be done. Second, the relation and changing laws among component, structure and property are proved by large amount of physical and chemical inspection too. Therefore the metallographic examination is very significant and useful in the above aspects. In conclusion, in the field of research or application of metallic material, metallographic examination is very necessary.

Liu[1] proposed a new method about examination on the heterogeneity of ledeburite eutectic carbide. This new method tried to increase efficiency and streamline the examination processes. E. Schaberger[2] tried to use the electrolysis etching method to make the electrolyte for aluminum alloy-Barker 70 use in the die casting magnesium alloy-AZ91HP. And it was success in revealing the colorful grains and the dendritic crystal inside the grains. Yuan[3] described the metallographic examination key point of the 18-10 stainless steel. Obviously, methods in this field are mainly based on the experiences and some traditional methods such as brainstorming method or trial-and-error method. TRIZ theory is not widely used in this territory.

Case Study

Microscopic metallographic examination and analysis are the important methods to study the inner structure of metallic material. By measuring the 2D metallographic phase, the 3D morphology can be calculated and confirmed. After that, the relationship among alloying component, micro structure and mechanical property can be built. And it can provide the reliable data for the estimate and usage of the metallic material. In general, microscope is the most common instrument for microscopic metallographic examination. By this instrument, the treated specimen will be observed. For different material, different micro structure will be found inside the microscope. By observing the metallographic phase, the research and analysis for the metallic material can be carried out.

In the past, most analysis on metallographic examination is qualitative analysis. It is said that people can only judge the component phases of the metallic material but cannot judge the quantity of each phase. Usually people make the judgment by their theoretical knowledge and working experience. For example, Fig.1 and Fig.2 were from different materials, one is iron and the other is

stainless steel. But they are very similar. Fig.1 is the iron metallographic photo and Fig.2 is the stainless steel metallographic photo, and there is one phase in Fig.1 but two in Fig.2. For the iron, 99% of the structure is the ferrite, it is no need to study the content of iron. But for the stainless steel, there are two phase inside (ferrite and austenite), and the proportion of each part will affect the property of the material obviously. Therefore it is necessary to study and tell the content of each phase in the field of stainless steel. But if we have these black and white photos only, boundary of ferrite and austenite can be seen and ferrite and austenite can be told. But what the proportion of each one will be a big problem and it seem to be a very tough.

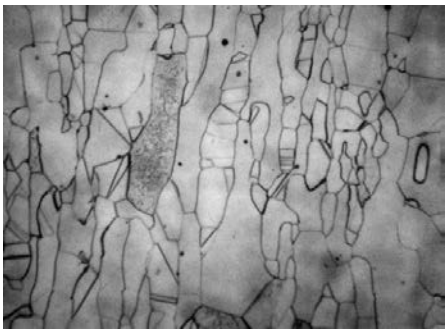

Fig.1 Metallographic Photo of Iron

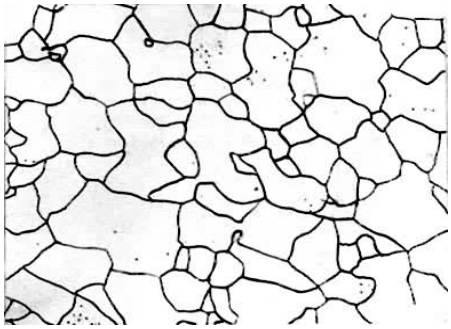

Fig.2 Metallographic Photo of Stainless Steel

Solution of TRIZ

If the problem is considered to be a Su-Field model, then transfer the specific problem into the Su-Field model problem is the first step. The procedures are as follow[4,5]:

1) Identify the component of the Su-Field model.

According to the above case and the TRIZ theory, the metallographic phase, eyes and visual field are identified to the S1, S2 and F1.

2) Build Su-Field model

In this case, the key point is that boundary of the ferrite and austenite can be seen but these two phases cannot be told and the quantities of each one cannot be calculated. To solve this problem with TRIZ method, we can build the sketch map of Su-Field model as shown in Fig.3. In this case, three components of the Su-Field are all complete, but the interaction of them is not efficient enough. This situation belongs to Type 4 of the general solution of the Su-Field (Insufficiency model).

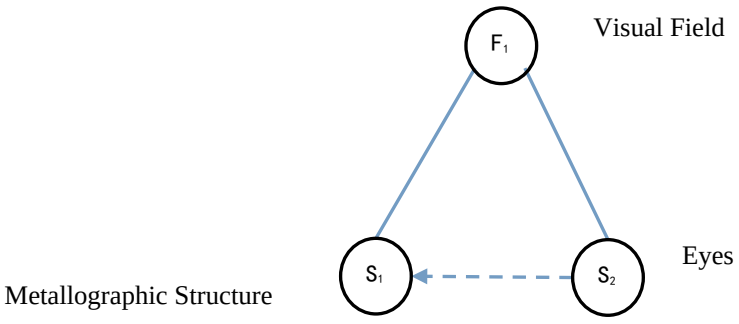

Fig.3 Su-Field model

3) Confirm the general solution of Su-Field model

According to the general solution of the Su-Field model type 4, the second field should be added to reinforce the useful effect. Su-Field model is as shown in Fig.4. Then the suitable field for this model should be selected. Usually there are many fields can be selected, such as gravitational field, electromagnetic field, nuclear field, mechanical field, chemical field, and heat field. For this case, tell the difference between ferrite and austenite, and confirm the quantities of each phase are the final objective. But base on the black and white metallographic photos, it is difficult to tell the ferrite and

the austenite because their shapes are very similar, only boundaries can be found. In this situation, 40 innovation principles can be referred and then No.32 innovation principle (color change) may help to solve the problem. In this case, it is difficult to tell these two phases when observing them with microscope because the shape and color of these two phases are almost the same. But if the color or the shape is different, that will be easy to tell. However the micro structure of the metallic material cannot be change in room temperature, the shape of these two phases cannot be changed when they are observed inside the microscope. Then another aspect can be considered. The color of these two phases can be changed if pretreatment are done on the specimen. Since different micro structure has different component, it may possible to make ferrite phase and austenite phase into different color.

By the consideration above, the chemical field should be added to the model that is shown in Fig.4, and the chemical perform the dyeing effect. After adding the chemical field, the insufficient effect from eyes (S2) to metallographic phase (S1) may change into anticipant effect. It means that two phases can be told inside the microscope by eyes. By dyed with the chemical solution, the ferrite change into red color and the austenite keep original color, it is as shown in Fig.5. The chemical solution composes by potassium ferricyanide 10-15g, potassium hydroxide 10-30g, distill water 100ml.

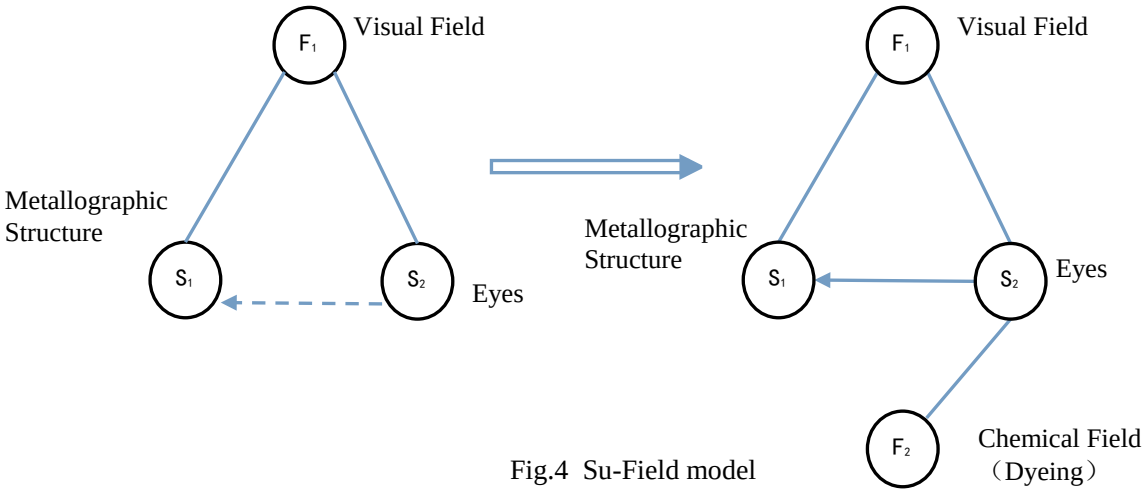

Fig.4 Su-Field model

According to the Su-Field model, the method to tell the ferrite and austenite was found. On the next step, quantities of two phases should be calculated. Thus the problem above should be solved further with TRIZ.

From the Fig.6, if the proportion of the area of the black and white color can be calculated, then the quantities of two phases can be calculated either. However, calculate the proportion of the area of the black and white color by human eye is impossible, or the data accuracy will be very low. If a high accuracy data is needed (proportion of black and white area), the image of Fig.6 can be measured by some other method and calculated by higher mathematics method, but this will take a lot of time. Therefore, TRIZ theory should be used sequentially to find out some solutions.

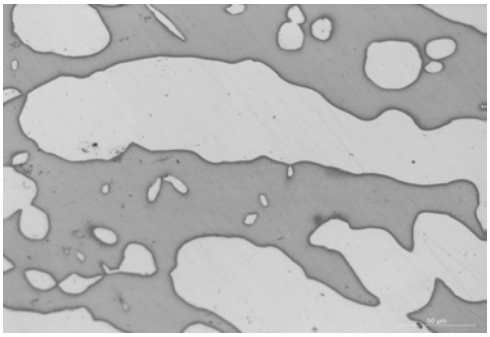

Fig.5 Metallographic Photo of Duplex Stainless Steel

To solve the problem above, 40 innovation principles of TRIZ can be tried. The first step to use the 40 innovation principles is that find out at least one pair of technical contradiction in this case. As described in section 1, technical contradiction means two parameters which restrict each other. In this case, measure accuracy and measure speed are the two parameters. If high accuracy is need, the period of measurement will become very long, but if the period of the measurement is very short, the measurement result may not be satisfied. And the measure accuracy and measure speed may correspond to the 9th and 28th items of contradiction matrix. They are speed and the accuracy of measurement. The correspond innovation principles of 40 principle innovations are the 28th—mechanical system instead，32th—Color change， 1st—division，24th—medium. From the principles above, the 1st one—division principle is the easiest one to be realized. The definition of division means：1、separate one thing into two parts. 2、separate into parts that can be assembled easily. 3、Increase the separability.

As a result, Fig.5 can be separated into some area which is shown in Fig.6, point of intersection from every two lines distribute all over the photo averagely. The regular of calculating is shown as follow, if the point of intersection lie on white area, the white area +1, if the point of intersection lie on the black area, the black area +1, if the point of intersection lie on boundary of two area, black area and white area +0.5 each. After finishing the above jobs, proportion of black and white area may be obtained. In conclusion there are two advantages. First, it is easier to calculate. Second, accuracy of the result may be increased.

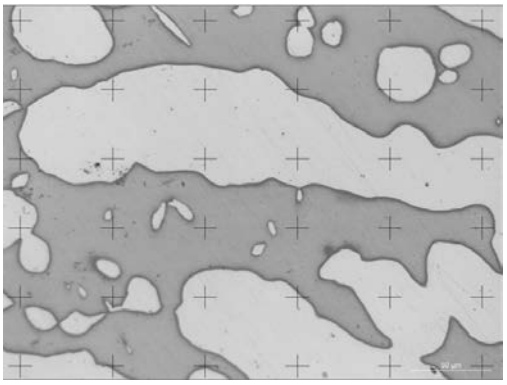

Fig.6 Metallographic Examination Photo of Duplex Stainless Steel

Conclusion

By using the principles of TRIZ, available solutions are found. Dyeing method is used. To distinguish the ferrite and the austenite, No.32 innovation principle of the 40 innovation principles was used, and a new substance was added to the Su-Field model to solve the insufficient effect. Then two phases in the stainless steel can be told. The methods are performed with microscope, it is suitable for the local scope research.

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