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Application News

Microfocus X-Ray CT System inspeXio™ SMX™-225CT FPD HR Plus

An Example of Observing Reduction Gear Using the Microfocus X-Ray CT System

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User Benefits

- The internal structure of reduction gears, such as gear teeth, etc. can be measured non-destructively, which is useful for improving designs.
- The porosity of parts can be analyzed quantitatively, which is effective for quality inspections of prototypes and shipped products.
- Identifying issues by visualizing internal foreign matter and analyzing defects contributes to ensuring the reliability of reduction gears.

■ Introduction

A reduction gear, also known as a speed reducer, decelerator, or gear box, is an important part for reducing and transmitting the rotational speed of a motor. It is indispensable for equipment using motors, such as automobiles, electrical appliances, like washing machines, and elevators. For safe operations of such equipment, highly reliable and highly durable reduction gears are necessary. However, reduction gears may not operate properly if defects occur during operation if they are contaminated with foreign matter. When checking internal parts, it is necessary to dismantle the reduction gears, which takes time and effort, and may damage parts. But by using an X-ray CT system, foreign matter or defects inside a reduction gear can be detected non-destructively.

This article introduces an example of observing and analyzing the interior of a reduction gear using the inspeXio SMX-225CT FPD HR Plus Microfocus X-ray CT system.

Fig. 1 inspeXio™ SMX™-225CT FPD HR Plus

■ Imaging of Reduction Gears

In this case, a parallel shaft reduction gear of size about 60 × 60 × 70 mm was imaged, as shown in Fig. 2. Its interior was composed of parts, such as a housing, gears, bearings, and shafts. All these parts were made from metal, so high-intensity X-rays were required to observe their interiors. The main imaging conditions used are shown in Table 1. In this case two patterns of CT imaging were performed, overall and magnified. Their respective fluorescent images are shown in Fig. 3.

Fig. 2 External View of the Reduction Gear

Table 1 Imaging Conditions

Item		Overall Image	Magnified Image
Tube Voltage, Tube Current		220 kV, 400 μA	
Imaging Conditions	Number of Views	2400	
	Average Number	1	
	Exposure Time	Short	
Imaging Time		40 min	
Field of View (FOV)		φ 104 × 74 mm	φ 55 × 39 mm
Voxel Size		0.102 mm	0.054 mm

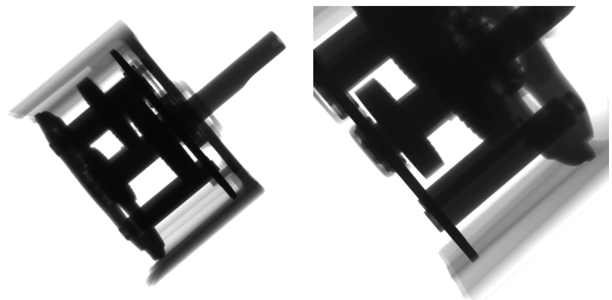

Fig. 3 Fluoroscopic Image (Left: Overall Image, Right: Magnified Image)

■ CT Observation

The CT imaging data was observed in cross-section, as shown in Fig. 4. This made it possible to check the shape of the parts, the status of contact of the gears, the presence of porosity in the interior of the housing, etc.

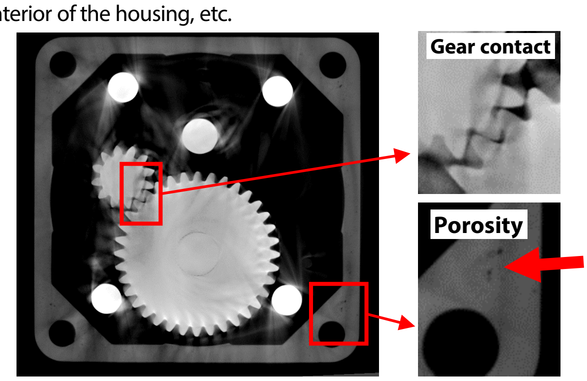

Fig. 4 Cross-Sectional Images

Next, more detailed analysis was performed using the software VGSTUDIO MAX to evaluate the contact between gear teeth, observe foreign matter, and analyze the defects.

1. Evaluation of Gear Teeth Contact

Backlash in the gears was measured using the dimensional measurement function. It was possible to confirm that there was backlash of about 0.16 mm, as shown in Fig. 5. By using the CT data in this way, the backlash in the overall assembled state could be accurately measured and the quality of the product in a state close to its actual state determined.

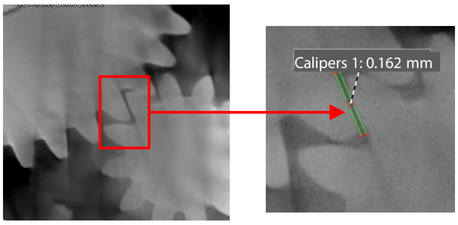

Fig. 5 Measuring Backlash

2. Observation of Foreign Matter

Two particles of iron sand of diameters 1 to 2 mm were deliberately introduced into the interior of the reduction gear, and this foreign matter was observed, as shown in Fig. 6. Fig. 7 shows 3D images taken from the same angle for comparison with and without foreign matter. The bottom of Fig. 7 shows an image with foreign matter included, and the location of the foreign matter detected by the method described later is indicated by the arrows. It is possible to see the foreign matter in the cross-sectional image, but it is difficult to determine its accurate position in the X, Y, and Z coordinates, which demonstrates that it is difficult to identify foreign matter.

Therefore, in Fig. 8 the two particles of foreign matter are shown colored in the cross-sectional views. This makes it possible to identify the foreign matter in the 3D images, and confirm the location and size of the two particles of foreign matter at once, which was difficult in Fig. 7.


Fig. 6 Iron Sand (The Circled Particles were Added)

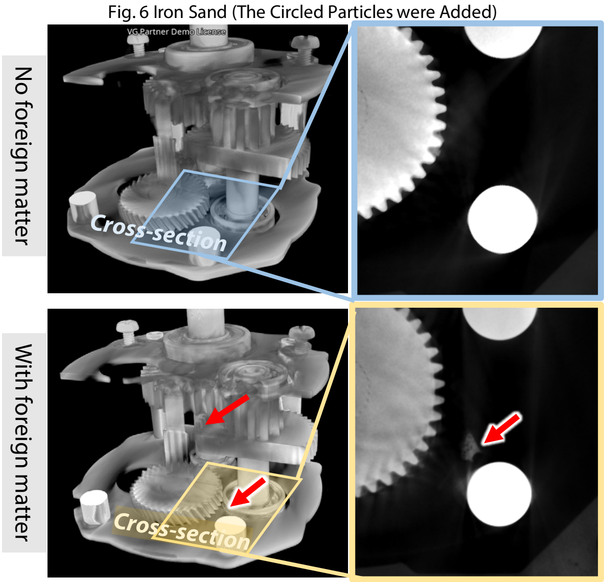

Fig. 7 Observation of Foreign Matter (Foreign Matter is Indicated by the Arrows)

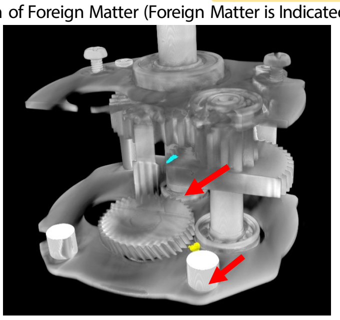
Fig. 8 Foreign Matter Colored

3. Porosity Analysis

In the cross-sectional view shown in Fig. 4, the presence of porosity is confirmed close to a bolt hole in the housing. Therefore, both the overall image and the magnified image data were analyzed for the presence of defects. This analysis can be performed automatically with just a simple setting, so the size, position, and number of pores can be easily determined. Fig. 9 shows an example of analysis in which the volume of pores is indicated by color.

Comparing the number of pores, 149 were detected in the overall image, and 285 were detected in the magnified image. The minimum pore size was 8.2×10^{-3} mm^3 in the overall image and 4.4×10^{-3} mm^3 in the magnified image. As can be seen from Table 1, the resolution is higher in the magnified image, and it is possible to detect porosity in more detail.

In addition, the relationship between the volume and number of pores can be displayed in a graph, as shown in Fig. 10. With the magnified image it was possible to detect more pores that were smaller than 0.05 mm^3. On the overall image more pores greater than 0.05 mm^3 were detected, but the resolution was lower, and there is a possibility that noise around the pores was included.

By adjusting the magnification factor and the imaging conditions in accordance with the objectives, foreign matter observation and defect analysis can be more efficiently performed.

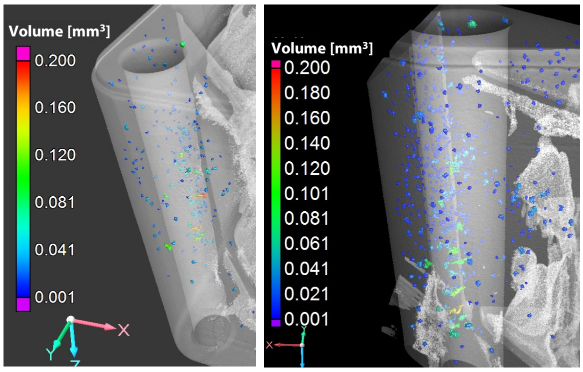

Fig. 9 Analyzing the Presence of Defects
(Left: Overall Image, Right: Magnified Image)

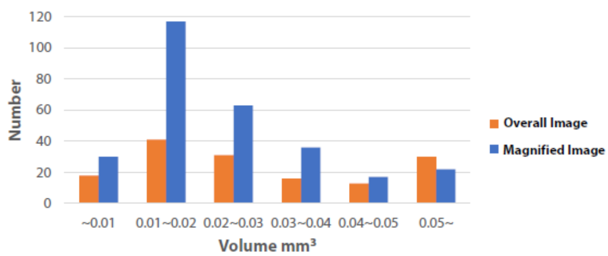

Fig. 10 Pore Volume and Number Detected

■ Conclusion

Reduction gears are used in various fields, and it is important to ensure their reliability. This article describes CT imaging of a parallel shaft reduction gear using the inspeXio SMX-225CT FPD HR Plus Microfocus X-ray CT system. It demonstrated that it is possible to measure the backlash of the gears, observe the inclusion of foreign matter, and detect porosity in the housing by analyzing the CT images.

By using X-ray CT imaging in this way, it is possible to non-destructively evaluate metal parts that have complex internal structures, such as reduction gears. In this way, abnormal parts and defects can be easily detected at the manufacturing stage, thereby improving quality control. In addition, design improvements can be made based on the inspection results, thereby contributing to improvement of product safety and reliability.

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