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DELIVERING QUALITY SCIENCE TO THE WORLD

# Eddy Current Testing Research

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*Abstract: Non-destructive testing utilizes different physical and chemical principles to test various test pieces without compromising their performance to determine the integrity and reliability of the test piece. Due to the many advantages of non-destructive testing, it can be rapidly developed in modern times, and becomes a necessary means to ensure product quality and maintain safe operation of equipment. Because non-destructive testing is based on different principles, it presents a variety of tests, including eddy current testing (ET), radiographic testing (RT), penetrant testing (PT), magnetic particle testing (magnetic particle detection). Testing, MT), ultrasonic testing (UT), other detection techniques.*

*Keywords: Non-destructive testing; Eddy current; Non-contact power.*

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## 1. INTRODUCTION

Eddy current testing is a non-destructive testing method based on the principle of electromagnetic induction. It is suitable for conductive materials. It has the following characteristics: non-contact detection, which can penetrate non-conductor coating, can remove grease on the surface of parts. In the case of carbon deposition and protective layer, the detection and detection can be carried out without any trouble. The sensor can be tested at a high temperature, and the sensor can be extended to a distant operation, so that the narrow area and the deep whole wall of the workpiece can be detected on the surface or near surface. The detection sensitivity of defects is high, and has a good linear indication within a certain range, and can evaluate defects of different sizes. Since the detection signal is an electrical signal, the detection result can be digitized, and the processed result can be stored. , reproduction and comparison of data.

As one of the five conventional non-destructive testing methods, eddy current testing has a wide range of applications in various fields. However, for the detection of complex topography workpieces, conventional eddy current testing is not only time-consuming and laborious, but sometimes impossible to apply at all because of structural limitations.

Array eddy current testing technology is a new non-destructive testing method developed in recent years with the development of computer technology and digital signal processing technology. This technology is specially designed by eddy current coil structure, and with the help of computer powerful analysis, calculation and processing functions. Achieve fast and flexible detection of workpieces. The utility model has the advantages that the detection probe has a large coverage area and high detection efficiency; the detection probe is arranged by a plurality of independent coils, and has uniform detection sensitivity for linear defects in different directions; and the probe shape is performed according to the size and shape of the detected component. The design can directly form a good electromagnetic coupling with the tested parts, without the need to design and manufacture complex mechanical scanning devices. With the help of MEMS and flexible printed circuit board micro-sensor arrays made by flexible manufacturing systems, dynamic detection can be transformed into "quasi-static" detection, which improves the reliability of detection. By transforming the structure type of the eddy current array sensor and adjusting the penetration depth by combining the double multi-frequency excitation method, the interference can be suppressed and the signal-to-noise ratio can be improved. In addition, the eddy current array sensor is flexible and versatile, making it easy to detect parts with complex surface shapes. Therefore, eddy current array detection technology has become a common research hotspot of sensor technology and non-destructive testing technology.

## 2. NON-CONTACT POWER TRANSMISSION TECHNOLOGY

In the early 1990s, the team led by JT Boys of the University of Auckland in New Zealand took the lead in conducting in-depth research on non-contact power transmission, and named the non-contact power transmission technology using electromagnetic coupling principle as Inductively Coupled Power Transfer. (ICPT), developed a contactless power supply system for tour buses [1]. After more than ten years of unremitting efforts, the technology has made significant progress in theory and practice, which has aroused widespread concern in the academic and commercial circles, and gradually productized. Foreign research on non-contact power transmission is mainly in the direction of high power [2, 3], and focuses on product research and development. In 2007, the team at the Massachusetts Institute of Technology used the principle of electromagnetic resonance to illuminate a 60-watt bulb with a power of 2 meters outside the space, and the power transmission efficiency was 40%. The research of this technology opened up the radio energy technology. A new phase of transmission [4]. In 2009, the University of Auckland proposed a new method for maximizing power transmission based on optimized mutual inductance coupling coefficient, and expounded the way to improve the transmission power of ICPT system from a new perspective [5]. In 2011, the ICPT research team of the University of Auckland pointed out that it is difficult to control the output voltage of the inductively coupled pickup circuit. A new series resonant inductive coupling pickup circuit was proposed, which effectively solved the controllability of the output voltage of the pickup circuit and verified the ICPT through experiments. The system transmission power can reach 1.2kW [6]. In 2016, Karthik Kandasamy and others proposed two modular battery systems for electric vehicles. The ICPT system was used to couple electric energy to multiple battery modules. The experiment used a 1.5kW prototype system to design a 24-80kW battery system. Controllability of output power [7].

Domestic research on non-contact power transmission technology started late. The first report on non-contact was published by Professor Li Hong in 2001. The principle and application of radio energy transmission technology were systematically described in domestic journals [8]. Since then, a small number of universities in China have started research on non-contact power transmission technology, and have attracted more and more attention from the Chinese people. After more than ten years of research and development, non-contact power transmission technology has made major breakthroughs in key technologies, and some wireless power supply electronic products have been introduced. Among them, Chongqing University's achievements in the research of this technology are particularly outstanding. The research team led by Professor Sun Yue of Chongqing University made a detailed and in-depth study of the technology, which overcomes the key technical problems of non-contact power transmission [9-13], establishes a relatively complete theoretical system, and takes the lead in the development. A non-contact power supply device has an output power of 600-1000 W and an efficiency of 70%. Academician Yan Luguang from the Institute of Electrical Engineering of the Chinese Academy of Sciences proposed the coupling characteristics, stability and performance analysis methods of the system under inductive coupling mode. The results show that the secondary compensation can greatly improve the power transmission capacity of the system, while the primary compensation is significantly reduced to the primary. The power system's apparent power requirements reduce system cost [14, 15]. Professor Yu Jiejie from Tsinghua University conducted an in-depth study on the wireless charging method of implantable medical instruments [16].

## 3. BUOY NON-CONTACT POWER TRANSMISSION TECHNOLOGY

From the application of non-contact power transmission in marine buoys, there are few devices related to international productization. In 1994, the University of Wisconsin in the United States studied the inductive coupling transmission based on the mains frequency AC, because the frequency of the power used for transmission is low, which leads to a large space for the transmission of the core components, which is very inconvenient to use [ 17]. In 1997, the SACLAN Research Center studied the energy replenishment method of the towed sensor, but the disadvantage is that the other half of the chain is closed by seawater to form a conductive loop, which has large energy loss and low energy usage [18]. In 2007, Daisaburo Yoshioka et al. of Chongcheng University in Japan proposed a non-contact power and data transmission system for anchoring buoy underwater sensors, but the transmission power is only milliwatts [19].

In China, Zhang Qiang et al. proposed a new transmission system, designed a transmission cable and an electromagnetic coupler, established a mathematical model of the transmission system, and proposed a method to optimize transmission efficiency. In theory, a method for reducing the inductance of the transmission cable is proposed and proved [20]. In 2015, Xiao Linling and others proposed a real-time measurement method, which enables the system to monitor and adjust in real time after the natural resonant frequency changes with the component parameters, and works in the resonant state to reach the maximum value of transmission power and efficiency [21].

## 4. RESONANCE COMPENSATION TECHNOLOGY

The compensation resonant circuit can increase the induced current or voltage, reduce the reactive power of the system, and improve the power transmission capability. At present, a large number of literatures have discussed the compensation resonant circuits with different structures on the primary and secondary sides of the ICPT system from various angles. The characteristics of power transmission and frequency stability of the constructed resonant circuits are studied.

The literature [22] analyzes the system characteristics of the secondary series and parallel resonance, and studies the PWM voltage regulation control method of the pickup. In [23], the influence of parallel or series compensation topology on system performance on the primary and secondary sides of the system is analyzed and studied. The selection of the primary compensation method has a lot to do with the application. For systems with a long track coil on the primary side, since the track voltage is very high, it is more suitable to use series compensation, so that a controllable power supply voltage is used. For a centralized primary coil, the current in the line is usually large, and the parallel compensation method is suitable.

When the compensation circuit is used for both the primary and secondary sides, the system becomes a high-order system. When the quality factor of the original and secondary compensation networks is not properly selected, there will be divergence. Especially when the quality factor of the primary circuit is smaller than the quality factor of the secondary circuit, or the two are equivalent, the system is likely to be unstable [24, 25]. At this point, the system must be thoroughly analyzed for stability to ensure stable oscillation of the system without frequency changes.

## 5. CONCLUSION

The literature [26] analyzed the secondary series and parallel impedance. When the secondary parallel resonance, the reflected impedance is approximately proportional to the load resistance value, almost independent of the resonant frequency. The concept of converter resonance compensation combined with series-parallel compensation is proposed to reduce the power factor, but this paper does not give a specific implementation.

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