

VIBRATION AND NOISE REDUCTION OF TRANSFORMERS



PTTX'S ARTISAN SPIRIT OF "DARING TO BE THE FIRST"

Having conducted multiple experimental research studies on the factors that cause core vibration, and following our "artisan spirit", PTTX has put forward solutions and guidance for the transformer core industry that address a technological issue of vibration and noise reduction. This paper introduces the contributions made by PTTX in the industry – optimization of silicon steel sheets processing performance and core assembly parameters.

In recent years, with the continuous expansion of power networks and urban development, it is becoming more and more common for small and medium-sized transformers to be installed in residential and commercial areas or other application scenarios. These transformers generate noise pollution, affecting the lives of residents nearby. Therefore, vibration and noise reduction have become a special concern in the transformer industry and other supporting industrial chains.

According to research studies, transformer noise is mainly caused by the vibration of the transformer and its cooling system, and its intensity is associated with the transformer capacity, silicon steel sheet materials, core structure, magnetic flux density, and vibration performance of the cooling unit.



In fact, the vibration of transformers is mainly caused by core vibration, which is brought about by the following two factors:

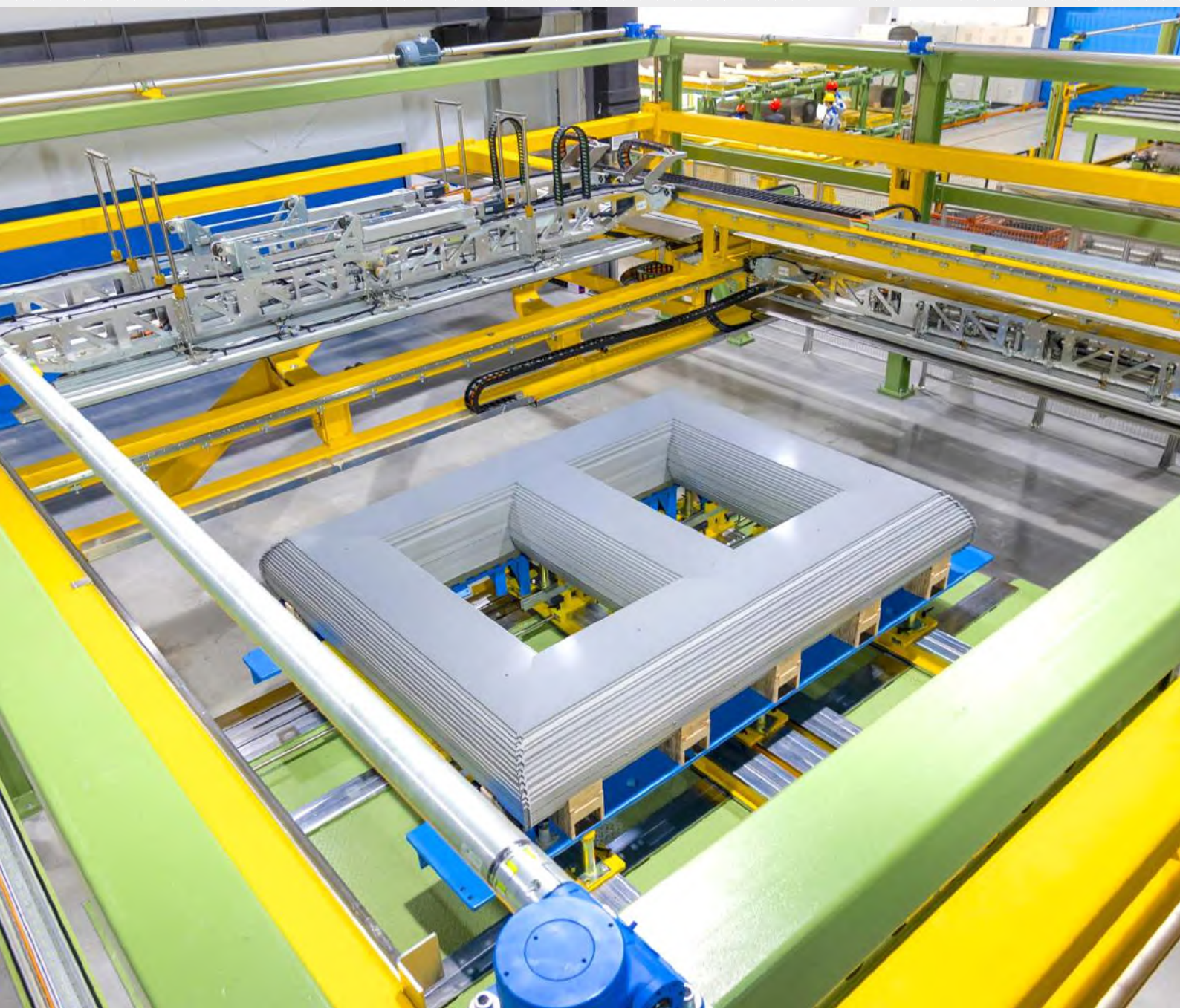
1. The first is the core vibration due to the magnetostriction of the silicon steel sheet;
2. The second is the longitudinal traction force caused by the distortion of the magnetic line of force at the joint of iron core and the side thrust caused by an uneven magnetic flux distribution in the iron core between silicon steel sheets.

In view of these two main factors of influence, PTTX has concentrated our efforts on optimizing the processing performance of silicon steel sheet material and the assembly process of iron core, thus providing guidance and making explorations for the technological transformation and environmental protection production in the transformer core industry.

Internal stress and magnetostriction reduction of the silicon steel sheet by automatic and serialized production

PTTX cores are made of high-quality cold rolled grain-oriented silicon steel sheets insulated by mineral oxide. In the actual application of the silicon steel sheet, a lot of care is paid to the influences of the magnetostriction and magnetic conductivity on the finished core products. Therefore, special measures are taken to mitigate the influence of processing on the silicon steel sheet in terms of stress characteristics, end flatness and thickness uniformity.

Magnetostriction is the root cause of core noise. In this regard, PTTX has invested over \$46.3 million to build a smart core factory able to maintain constant temperature and humidity, which has become our country's leading demonstration center in the transformer core industry. In the factory, smart stereoscopic warehouse logistics devices are used to provide full process automation from the storage of electrical steel raw materials to the stacking of finished core products. During the process, soft-contact procedures are used to handle all electrical steel materials – this means that we do not use a crane to lift products and our personnel is not involved in direct production or touches the electrical steel during the entire process. This helps reduce the generation of silicon steel sheet stress, thus ensuring the flatness and thickness uniformity of the end surface and reducing the joint by stacking steel sheets one by one, all of which results in noise reduction.





In addition, the serial production mode of “edge-yoke-edge-yoke-column” for the cut-to-length line of fully assembled cores denies the “two-step” mode of the traditional core sheet production (upper/lower yoke, left/right/center column), thus minimizing the issue of thickness difference of five columns existing in the traditional core sheet production mode. While ensuring the uniform thickness of silicon steel sheets, the slitting machine set is equipped with on-line iron loss and thickness detectors, intelligent stereoscopic warehouse logistics equipment and fully automated packaging line for fixed-size silicon steel sheets, which further reduces the influence of human factors on the performance of silicon steel sheets and helps achieve vibration reduction.

Compared to the traditional process, PTTX uses lean, serial, and smart automatic production devices that reduce all the process coefficients by 5% in silicon steel raw materials, iron core manufacturing and assembly, helping us meet our customer needs and reach product performances.



Assembly parameters re-defined based on multiple research

PTTX technology R&D team carried out the analysis of the relationship between core assembly parameters and clamping force between silicon steel sheets, as well as the mechanical analysis of the cores under pre-tightening torque assembly conditions and binding process conditions. The results led to the conclusion that the clamping force between iron core pieces can be controlled by assembly parameters.

PTTX also conducted research on the influence of pre-tightening torque and binding process on core vibration. The results showed that the core assembly parameter is associated with the core capacity in a qualitative way. With the increase of core capacity, the pre-tightening force of core assembly, assembly torque and the number of binding strips increase as well, while the spacing of binding bands decreases.

Based on the above findings, PTTX performed analytical statistics on the structural parameters and assembly parameters of different types of cores produced. Taking the dry-type transformer core as an example, the bolt torque and binding parameters were determined for various types of cores with capacities from 100 kVA to 800 kVA, 800 kVA to 2,000 kVA, and 2,000 kVA and above.



Through tests PTTX established that in the actual production, considering the on-site equipment and materials in the workshop, adopting different assembly parameters on corresponding cores with different capacities can effectively control the vibration and noise of the transformer core, improve the qualified rate of products and reduce economic losses caused by rework, which is of great significance for achieving lean production of transformer core assembly and improving the production efficiency.

Cooperation between universities and industry is a practice PTTX has always followed since its establishment. The company established a long-term cooperative laboratory with Xi'an Jiaotong University. Since 2016, the company has played an exemplary role in the Study on Vibration and Noise of Core Process Holes, Research on Influence of Pieces Stacking Method on Core Noise of Dry-type Transformer, Experimental and Simulation Study on Influence of Bolt Tightening Sequence on Transformer Core, Experimental Study on Influence of Bolt Torque on Transformer Core and Research on Influence of Assembly Parameters on Transformer Core Vibration. The technological advancement steps that have been studied and demonstrated can serve as the guidance for the development of the industry.

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