17th World Conference on Nondestructive Testing, 25-28 Oct 2008, Shanghai, China

An Overview of the Rapidly Developing Non-destructive Testing Technology in China

Rong S GENG

Beijing Aeronautical Technology Research Center, Beijing 100076，China

E-mail: gengrs@sohu.com

Abstract

The paper overviewed the current state of NDT development in China and its main achievement in the past 30 years since the foundation of Chinese Society for Non-destructive Testing(ChSNDT)in 1978. The achievements of NDT applications in some industrial sectors, such as in special equipment areas, in oil and gas pipeline industry, in nuclear power plants, in railways, and in aviation industries were introduced in detail. The paper discussed also the future development of NDT in China and challenges faced by Chinese NDT community.

Keywords Non-destructive Testing(NDT) Engineering Project Special Equipment Aviation Industry Nuclear Power Plant Railway Oil and Gas

1 Introduction

Public safety and sustainable development of economy are the common concern for all countries, especially for the developing countries. Non-destructive testing (NDT) can to a great extent play a significant role in this respect. Since the foundation of Chinese Society for Non-destructive testing (ChSNDT) in 1978, especially in the recent 10 years, the overall nationwide NDT level in China has been raised dramatically in all main industrial sectors as a result of the sharp increment of financial support from the government. The research and technical teams in these industrial sectors, by taking the advantage of rapid development of economy and demand for large engineering projects, integrated themselves into key state programs and projects, and strove to maintain sustainable development for the NDT teams. In those main sectors, such as Special Equipment (pressure vessel, pressure pipes, underground oil and gas pipelines, large entertainment facilities, etc), Nuclear power plants, Railways, Aviation and Aerospace, NDT technology received even more attentions, and achieved encouraging outcomes. On the whole, the NDT technicians and engineers, by relying on their own endeavors, possessed the ability to face major technical challenges encountered in large state key project and were able to meet the requirement of large engineering project.

The past 30 years was the golden age of the new market-oriented economy in China, from which the NDT community benefited quite a lot. Many well known foreign NDT companies and manufacturers set up their agents and offices in many Chinese cities to promote sales of their products in order to share the market in China. It brought forward up-to-date NDT technologies into Chinese NDT market, on one hand, and it also exerted a great impact onto Chinese domestic products and manufacturers, on the other. Based on this background, the past 30 years witnessed the most rapidly developing period for Chinese NDT products and manufacturing level[1].

ChSNDT paid more attention to the training and certifying of NDT personnel based on internationally recognized standards and codes, and made significant contributions to the harmonization of world NDT communities. China is most likely the country who has the most certified NDT personnel and NDT teams. More than 30 thousands certificates were issued by ChSNDT, and a great more were issued by other industrial sectors, such as The Special Equipment, Nuclear power plants, Railways, Aviation and Aerospace, etc. China is on the advanced level in basic NDT theory studies, in NDT equipment development and manufacturing, and is on the top in carrying out NDT training, education and popularizing. Each year, not only many undergraduates, but also postgraduates (MSC, PhD) in NDT field graduated from universities and colleges. Although many advanced high end NDT equipment still relies on importing from western countries, most NDT facilities to meet the demand of the market are manufactured by in-land enterprises[2].

2 An overview of NDT development in some main industrial sectors

2.1 The Special Equipment, Oil and Petro-chemical Industries

The Special Equipment is referred to those closely related with public safety, such as boilers, pressure vessels, pressure pipelines, escalators, lifters, entertainment facilities. These equipments form part of infrastructures, and their safety is directly related with the public safety, and is also related with the society stability and economy safety. For example, the underground oil and gas pipelines in the cities are more or less aging and subjected with corrosion damages. Whenever a leakage of gas pipeline occurs, both people's daily life and economy shall be greatly threatened. Researchers and engineers in this field, especially those of Chinese Institute of Special Equipment, achieved breakthrough results through their insistent efforts of several decades. Their achievements included back scattering Campton scanning system for pressure pipeline with thermal cladding materials, thermo-elastic infrared imaging system for high temperature and high pressure pipes, in-line AE inspection system for pressure vessels. People in this institute viewed the safety of special equipment as a systematic engineering project, and they paid attention not only to the development of testing facilities, but also to safety and risk assessment, and to the inspection code and criteria as well. In recent 20 years, they undertook more than 160 key technical projects, and achieved more than 90 important research outcomes, making outstanding contributions for the enhancement of safety of special equipment in China[3].

The NDT level in petro-chemical industry sector was also greatly improved. The engineers working in the field of pipeline developed Φ377mm pipeline magnetic leakage inspection system, which could meet the requirement for the inspection of pipelines with diameters between Φ273-Φ720mm[4]. In order to meet the demand of rapidly developing pipeline inspection, while importing ultrasonic phased array system, researchers in The Pipeline Institute of CNPC together with engineers in other institutes developed their own ultrasonic phased array system with intellectual properties of their own. The product was said to enter phase of field experiment and applications [4].

2.2 Aviation industry-great role played by NDT

The integrity of airplanes is always a major concern of and great challenge to NDT workers in aviation industry. The most advanced NDT equipments have always found applications in advance in air industry. It is by no means exaggerated to say that the safety of aviation relies solely on the NDT[5].

The NDT can do a great job for the air industry. A recent example was its application in the whole process of full scale fatigue test of an aircraft (FSAFT) for the evaluation of service

life based on flight hours of corresponding aircraft group. The FSAFT was also very important for the safety of lead aircrafts of the group. The non-destructive testing carried on the whole fatigue test period was essential for the understanding of the initiation and growth of fatigue cracks in critical parts of the aircraft. Unless proper measures were taken before a critical crack size was reached, the fatigue test might be subjected with a failure. In addition to conventional NDT means, such as UT, ET, RT, MT, PT, endoscope and magnetic memory test, the AE technique was used to monitor most of critical structures inaccessible for the conventional NDT. All these measures played a significant role in determining the aircraft life, its maintenance and overhaul cycles, and especially for future modification and improvement of the aircraft.

FSAFT was a compression of the time scale for aircraft service. It was appropriate to say that NDT carried in the fatigue test was fully representative of the NDT in its life-long period of the aircraft group, and that it was a text book of field NDT of the aircraft, and also a guideline for the instruction of future NDT procedures.

Due to the requirement for real time and in-time monitoring during whole FSAFT, and due to the test being only once and non replaceable by another extra aircraft, the challenges and the extent of the risk faced by research workers in this respect were extremely high. Although much research work was reported before for the NDT monitoring in fatigue test, little was involved in a complete test for full scale aircraft on a time span of as long as 3-4 calendar years being involved. Researchers and technicians in Beijing Aeronautical Technology Research Centre, were reported to have achieved great success in the early prediction of critical cracks in crucial structures of the aircraft under test in a just finished FSAFT. Their work played a key role for the determination of the service life of the aircraft group, and was reported to bring extremely high benefit for the economy[6].

2.3 nuclear power plant (NPP)

A modern society has very high demand for electricity, and requires for green and clean energy. China is raising the proportion of electricity produced by nuclear power plant, which is an important strategy for reducing pollution and realizing sustainable development of nation economy. Through continuous effort of generations, China now has the ability to develop and manufacture NDT facilities for inspecting key elements in NPP independently, and to carry out in-service inspection required by codes and specifications of NPP. Typical NDT instruments for NPP manufactured by Chinese engineers are: (1) automatic ultrasonic inspection system for reactor pressure vessels, an integrated system of mechanical scanner, electronic tester, multi-channel ultrasonic flaw detector and computer, which can be remotely controlled; (2) multi-frequency eddy current detector for heat exchanger tubes of steam generators, capable of automatic data acquisition and processing with high extent of automation and detection ability [7].

2.4 railways

It was already six times to speed up the railway transportation since April 1st, 1997. The safety of railway products has very close ties with the public and is hence the guarantee factor for railway transportation. The NDT technology related with railway safety has drawn much attention and concerning. Researchers and engineers working in railways made outstanding contributions by their following achievements: (1) 80 km/h in-service rail track flaw detector, which was one among the most advanced equipment in the world; (2) independently developed NDT equipments for rail axels, wheel hubs and felloes, and the automatic ultrasonic flaw detector for wheel felloes being developed as early as the end of 20th century;

（3）application of infra-red automatic pre-waning system of rail wheel axels for all railways, carrying on 24 hour monitoring of wheel axels [8].

The NDT applications in other industrial sectors were also very fruitful, and were not be included in this paper for brevity.

3 Future development of NDT technology in Chinese market

3.1 rebuild domestic NDT market based on a high technical platform

In order to make a big step forward, one should take advantage of the rapidly developing economy, of the existing new technologies and new sensor physics that might offer unique opportunities for the development of new methods and techniques, resulting in new NDT products. NDT engineers should use existing design and technology platforms, of both China and other countries, to create new NDT techniques and applications that were internationally accepted, but specific in respect to the domestic market. Consequently, we need long-term international partnerships that might accelerate the innovation dynamics by combining available knowledge and resources.

3.2 work for large and/or key state engineering project

The NDT is characteristic of application and engineering project oriented technology. The promotion of NDT development must be under consideration together with the overall circumstance of the national sciences and technologies. As a scientist or engineer working in NDT, one must have a clear picture about the mainly concerned projects by the nation and keep it in one's mind. Special attentions should be paid to those projects related with new materials, new energy sources, urgent demand of national economy and defense, and public safety. There are of course many theoretical problems to tackle, the more important point is however always its application in main industrial sectors because of the very strong practical application background of NDT technology. Those who work in sectors related with public safety should put their major interest on securing the safety of pressure vessels, underground pipelines and oil and gas tanks. Those who undertake in aerospace and aviation should lay their main interest on increasing the safety and reliability of major space shaft, major airplanes or aircrafts.

3.3 Image display

Image display is a very important step and it has properly the final saying on the quality of the NDT facility [9]. Many ancient sayings emphasize the role of images and pictures. "One picture is worth of thousand of words", "One believes the most what he had seen other than what he had heard of", and "Seeing is more beautiful", etc.

It is because the visual inspection can supply information which one can see that makes it widely used in every industrial branch. Visual inspection is very important in the airline industry, and accounts for most of the inspection tasks in search for cracks and corrosion. Light guiding systems (endoscopes) have been developed for looking in areas where direct eye inspection is not possible. So, the video endoscopes with the picture displayed on high resolution screen are widely used for the inspection of turbine and airframe of military, business and commercial aircraft and helicopter. They are also widely used for pipelines.

When one looks at the Chinese domestic NDT market, one has no difficulty in finding that dominant NDT instruments are signal based displaying mode (such as echoes, amplitude and phase, films etc), not image based displaying mode. So, here is one of the catching points, that is to use a high technical platform, the image platform, to design, develop and manufacture domestic NDT instruments and apparatus.

3.4 Filmless Radiography

X-ray film has formed one severe source of pollution to the environment because of the film itself and its processing. Imaging Plates (Computed Radiography) allow a fast detection of radiographic images in a shorter time (a reduction of exposure time down to 5 – 25% in comparison to NDT film exposures) and with higher dynamic than film applications.

Digital X-ray image plate is definitely to replace traditional X-ray film because of less pollution, less consumption of resources, and more important, it allows remote transmission of data and the plate can be used repeatedly[10,11].

It is needless to say that there is possibly a long way to go before domestic manufacturers can catch up with those advanced countries, such as Japan, German and USA in this important area.

3.5 Automatic inspection system

Automation is a big step towards the development of high tech NDT because it involves integrated and comprehensive technologies. Chinese companies have done a lot in manufacturing automatic UT system for large steel enterprises, for example, the HSD type multi-purpose, multi-channel ultrasonic automatic flaw detecting system manufactured by Wuhan Zhongke Innovation Company, which has been used in steel pipeline factory for sometime. The Φ377mm pipeline magnetic leakage inspection system and 80 km/h in-service rail track flaw detector are all good examples of automation. NDT robot is of a big step forward of the current commonly used manipulators and crawlers. Technology in NDT robots is developing very rapidly and this area is possible the largest gap between western partners and us. However, this is an area susceptible to very high price and even to technical blockade. The extraordinarily high price of most automatic NDT inspection systems and possible technical barrier put forward in front of us compel domestic NDT manufacturers and producers to develop own automation inspection system by self-reliance.

3.6 other new areas

Attentions should also be paid to the following areas in order to catch up with the international NDT level. They are:

(1) guided wave techniques, which is mainly used for pipeline inspection at long distances. It is especially suitable for underground pipe corrosion condition inspection and is related with the safety of a city.
(2) Multi-sensor (multi coil) eddy current imaging flaw detector.
(3) Non contact ultrasonic inspection, such as air-coupled UT probes, EMAT transducers and laser generated ultrasonic wave.
(4) New transducer technology, such as smart transducer, probe-on-chips.
(5) Health and condition monitoring of complicated structures.

4 Concluding Remark

The NDT technical level in China has been raised very rapidly in the last 30 years since the foundation of ChSNDT. Now, the Chinese engineers and technicians in NDT field can rely on their own efforts to tackle major and difficult problems in state key projects and programs. Although there is need for some high end NDT products and technology to be imported from the advanced countries, the NDT equipments manufactured by domestic manufacturers and companies are basically in good satisfaction for internal market demand. Presently, the economy in China is well on the road towards market-oriented economy. Those enterprises with high consumption of energy and high pollution will be driven out the market, whereas those with high tech, green type and sustainable development shall be enforced. All these need NDT and NDT related technologies. The development of Chinese industry needs

NDT more than ever, and in return, the Chinese NDT will gain ever greater achievement than before and has a bright future in the forthcoming years. It is certainly believed that the Chinese NDT workers shall achieve ever greater and more glorious success in the near future and that they shall present a satisfactory answer to the world NDT community in the platform of 17th WCNDT.

References:

[1] Geng R S, NDT Technology in New Millenium [J], Non-Destructive Testing (in Chinese), 2001, 23(1): 1-5

[2] Xu Y C, Thirty year review: Chinese Society for Non-destructive Testing[J], Non-Destructive Testing (in Chinese), 2008, 30(1): 2-5

[3] Cheng G, Song J H, Tao X R, The Strategy for the development of safety science and technology of special equipments in 21st century[M], National Defense Publisher, 2007, Beijing

[4] Bai S W, Nondestructive Testing Technology Development in China Oil and Gas Pipeline Industry and in Exchange and Cooperation with Foreign Countries [J], Non-destructive Testing (in Chinese), 2007, 29(12): 685-689, 693

[5] Geng R S, Zheng Y, A prospective view on the application of non-destructive testing in air industry and possible challenges[J], Non-destructive Testing (in Chinese), 2002, 24(1): 1-5

[6] Geng R S, Wu K Q, Jing P, et al, AE Monitoring of Damages of Central Wing and Outer Panel Jointing Areas during Full-scale Aircraft Body Fatigue Test[J], Non-Destructive Testing (in Chinese), 2008, 30(1): 37-41

[7] Nie Y, Zhang J J, The situation of in-service inspection for nuclear power plant in China[J], Non-destructive Testing (in Chinese), 2007, 29(10): 557-559

[8] Huang Y W, Communication and Co-operation on NDT Technology between Chinese and Foreign Railway Departmaent [J], Non-Destructive Testing (in Chinese), 2007, 29(11): 621-626

[9] Monchalin , J P, Optical and Laser NDT: A Rising Star[C], Proc. of 16th WCNDT, Aug. 30-Sept.3, 2004,Montreal, Canada

[10] Morro. A, Computed Radiography: The Future of Radiographic Inspection, Proc. Of 15th WCNDT, idn:56.

[11] Casagrande.J M, Koch.A, High Resolution Digital Flat-Panel X-Ray Detector- Performance and NDT Applications, Proc. Of 15th WCNDT, idn:615.