Full life cycle reliability is the future

With 23-years of maintenance and reliability management experience in the chemical industry, Alex Chen has a unique opinion on reliability. Comparing the reliability of equipment to the lifespan of humans, Alex vividly illustrates the history of equipment reliability engineering, and explores how 'full life-cycle reliability' is the key to operational excellence.

By Laura Wang

Alex Chen (Dow): "The reliability of any equipment should always be decided early in the development and design stage"

From a state-owned enterprise to a foreign company, from an equipment engineer to senior reliability manager, Alex Chen has developed a deep understanding of equipment maintenance and reliability in chemical industry throughout his career. Starting with 'breakdown maintenance' at the first stage, followed by 'preventive maintenance', and then 'reliability-centred maintenance' became popular as well. Each area aims for the perfect balance of minimized resources for maintenance and a suitable level of reliability, to ensure satisfaction of requirements for the equipment. The question is: what is reliability? Well, it is the probability that an item can perform its intended function for a specified interval under stated condition.

"Generally speaking, reliability is all about durable service. No matter if the application is for aviation or a home appliance, reliability is closely linked to industry and our daily lives. Yet, different industries have different viewpoints on reliability management. For example, the process industry is quite different. In general, the process industry focuses on equipment reliability to produce while the discrete manufactured industry focuses on product reliability. However, it is clear that building a 'reliability-centered culture' is essential to the development of companies and industries today."

Roots in the 30s

"The concept of reliability was initiated in the 1930s and 1940s", Alex explains. "It was initially used in the military field in the western world. In 1950s, Americans published the 'Reliability of Military Electronic Equipment' as a guideline document. It was a milestone that defined the direction for the development of reliability engineering. It also signalled that reliability engineering had become a new independent discipline. In the 1960s, reliability engineering evolved to include a full range of applications, extending from the military to civil engineering. In the 1970s, the concept of reliability engineering spread from a limited number of countries to all over the world. Many more countries soon began to research on and adopt practices for reliable engineering. This is a constant, ongoing progress that matures with industries and steadily grows in influence. With the ever-changing complexity of modern industrial processes, and severity of process conditions, industries are more demanding of equipment and its reliability."

From breakdown repair to prevention

Alex analyzed the course of change in the managing principles of equipment reliability. "According to the development history of equipment maintenance concept, the earliest approach was 'breakdown repair'. At that time, equipment was relatively simple and was not expected to deliver an outstanding performance. In the 1940s and 1950s, equipment breakdowns tended to impact production more, mainly due to upscale of process, complexity of equipment, higher production rate et cetera. That gave birth to the concept of 'preventive maintenance'. In

the 1960s and 1970s, 'predictive maintenance' became more and more popular. By analyzing purposely collected, early fault signals maintenance could be performed preventatively with proper planning. That helped to eliminate both excessive maintenance and insufficient maintenance. After that, the concept of 'reliability-centred maintenance' came up. This helps to formulate maintenance strategy based on logical decision making."
Other reliability tools have been developed in recent years as well, such as FMEA (Failure Model and Effect Analysis), DFR (Design for Reliability), RCA (Root Cause Analysis), et cetera.

The full-life cycle reliability concept

Alex has been working to manage the maintenance and reliability of equipment in chemical industry for more than twenty years. In the earlier stages of his career, he focused on routine management, such as scheduled inspection, maintenance, spare part management, overhaul planning and coordinating.
Later on, his focus changed to reliability data analysis, equipment maintenance strategies, and root cause investigation on unplanned failures. Years of work experience with equipment makes him certain about one concept: the inherent reliability of any equipment should always be decided early in the development and design stage.
"In the stage of equipment operation and maintenance, the objective is more about maintaining the reliability of the equipment. Therefore, it is necessary to bear in mind the 'full-life-cycle reliability concept' all the way through the planning, designing, manufacturing, operation, maintenance and write off. In the case of ageing assets, the reliability management focuses on the preventive and predictive inspections based on the nature of identified failure modes, and the replacement and upgrade plan based on the condition assessment)."

The human analogy

According to Alex, the 'trick' behind full life-cycle reliability, is to "link the pools of data from each equipment stage and connect them into a closed loop. That is the most effective way to help improve the reliability of equipment, gathering relevant information into one place. The manufacturer collects the internal test- and quality data and external user data, then they can conduct the analysis through root cause investigation etc, and identify the root causes and address the gaps to improve the product reliability."

Dow's state-of-the art headquarters in Shanghai.

Alex mentions there is specific terminology, such as inherent availability, achieved availability, and actual availability, tied to reliability. Inherent availability is determined by the product design, although sometimes it will be partially compromised during manufacturing for various reasons. A finished product exhibits the achieved availability when the product reaches the end user and is put into service, but its reliability will be compromised during operation and maintenance. What an end user is most experienced with is the actual availability. Alex relates product reliability to a human life span. In simple terms, a human's maximum life span is determined by genes. However, the inherent life span will be compromised during pregnancy. After birth, the life span will be further compromised due to living habits, medical conditions, health management, et cetera. That is why they live within this actual life span.

Data bundling

As mentioned before, the more attention is given to reliability in the planning and design stage, the more potential to improve the product reliability in the long term. In another words, it will be more difficult and expensive to improve reliability in a later stage than in an earlier stage.
"In the specific case of equipment operation and maintenance, taking valves as an example, when a critical valve malfunctions, we will firstly carry out root cause analysis. Common causes include design deficiency, incorrect use, improper maintenance and so on. Then we will feed back the related design information to the manufacturer in question. Then the manufacturer can improve the design

according to our feedback and hence improve the inherent reliability of their product. In fact, series of reliability tests will be done during the design and manufacture stage. When the test data are combined with the end user's application data, better effect on boosting the product reliability can be expected."

Reliability engineering boosts manufacturing industry

Working to improve reliability engineering, Alex naturally feels a sense of responsibility. He is convinced that with the development of modern industrial technology, the role reliability engineering plays is becoming more and more important, mainly due to higher customer expectations and the cost of unreliability. That's why it is necessary to share knowledge and experience about reliability to strengthen the community and build better reliability technology. "Quality and reliability are inseparable. Broadly, reliability is a key part of quality. In a narrow sense, reliability means quality over time. Traditional quality concepts are more about the satisfaction of quality criteria prior to and upon leaving the factory ($t \leq 0$, 't' refers to the timeline of the product life cycle. $t = 0$ refers to the moment when product hits the shelf.). Reliability engineering cares more about the failure that occurs after the product hits the shelf ($t > 0$). End users have only been able to judge product quality using provided technical parameters as a reference for many years. Unfortunately, this only reflects quality from one single perspective. If the product is not reliable, none of the technical advantages can be realized in service. In a sense, reliability is a comprehensive index about product quality. It is necessary to build up a modern understanding of quality, broaden the meaning of quality reliability, improve price efficiency, safety, reliability, maintainability, and support performance. For the same reason, time spent on quality management should be extended, from development and design all the way to the end uses application."

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Quality over price

Alex hopes the manufacturing companies start to build the reliability culture and invest more resources in reliability engineering. He explains: "With the progress of localization, competition between domestic and imported equipment is going more and more fierce. As an end user, we care about the initial price level but we also care about reliability and life cycle cost. Manufacturers should address reliability issues in each stage of a product lifecycle. Customers' needs can be satisfied using a better approach. The importance of quality and reliability surely outweighs that of price advantage, because outstanding quality and reliability is the inevitable path towards core competence and brand promotion."

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Dow's production facility in Zhangjiagang.

Conference chairman

After years of cultivation in the field of reliability in the chemical industry, Alex realized that outside his daily routine, he can contribute more by sharing his understanding and experience about reliability with young generation engineers, specifically promote the culture, thoughts, and knowledge about reliability. This is also why Alex has accepted the role as the 2022 Valve World Asia Conference Chairman, which is scheduled for 10-11 July 2022 at the Shanghai New International Expo Center.