Fighting corrosion on rail networks in Asia

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Corrosion has always been the cause of much damage, economically and otherwise, to all steel structures. Its impact on Asia is no different from that seen in other places around the world and especially so when some sections of the regional rail system are more than 30 years old. The main cause of such failures includes a variety of reasons ranging from the failures of welded joints to actual "cracking" taking place due to stress corrosion.

Lately, one reported failure in "cracking" resulted from a rusted piece of steel coming into contact with the rail underside. This caused a 'galvanic cell' to form, where the newer (and more active) steel of the track dissolved to protect the corroded piece of steel. Once the track base had dissolved to a certain point, the strength of the metal was compromised and the rail cracked when it came under load. If the rail has been coated with Zinga, the zinc layer would have selectively depleted as the dissimilar metals came into contact, leaving the other metals totally unaffected.

The region has also seen cracking involving joints welded between old and new rails that were located on a curved section of track. Curved track is always under more stresses than a straight track section. This is why the tracks in metro systems globally are more prone to cracking than those on the national railways, due to the far higher traffic volumes, with far longer periods of cyclic vibration taking place, as well as the increased sheer and tensile loadings on the tracks.

A corroded rail from the West Barnes crossing in East London clearly demonstrates that a rail with a predicted life of six years was written off within three months. It was this incident that triggered the whole rail-coating process and was followed by six years of intensive research and trials.

Coated rail being levered and hammered into position using a 7kg sledge hammer. A perfect response to questions asked about the impact-resistance of the Zinga coating!

Zinganised rail tracks do not suffer from the effect of Stress Corrosion Cracking (SCC), because the zinc layer has a 'throw' of up to 15 millimetres in length, (also known as 'linear polarisation'). The zinc layer can project a voltage of around 850 – 1000 mV inside any surface cracks. This prevents the formation of an SCC cell, which only requires around -220 mV to 230 mV to initiate. The much higher voltage of the Zinga layer will always over-ride the voltage from a corrosion cell.

Another lesser-known stress on rail track is corrosion, especially where the local atmosphere is hot, humid and marine in nature. This exacerbates the daily stresses placed on the track. Where there is humidity, there is condensation and where there is condensation, this forms as liquid on the cold steel surface of the track, forming corrosion cells in those areas. Condensation

A zingarised rail in place.

droplets can also form on the underside of a rail track and hang there all night (due to the surface tension or 'meniscus' of the water) giving plenty of time for a corrosion-cell to form.

Coastal zones with their humid atmospheres help to transport chloride salts from the sea inland carried on a sea breeze. These are then deposited onto steel track surfaces, initiating corrosion cells. The combination of such corrosion cells and physical stress from train traffic on the same track has been proven over again and again as the main cause of stress corrosion cracking.

In Europe, studies have shown a lot of cracking on the joint of the vertical web section/rail foot. In the case of straight track there has been cracking on the underside, induced from the loading and subsequent cyclic vibrations from train traffic that take place in the gap between the sleepers (or base-plates). The sheer stresses are quite high on curved track sections and a shallow surface crack can be permeated with moisture (especially salty moisture in Asia). Stress Corrosion Cracking (SCC) can begin over a short space of time, depending on traffic volumes and frequency.

Likewise, the flexing of the rail-underside can cause surface cracks across the full width of the rail track and where there are water droplets or moisture on the underside of the track, this can penetrate inside the crack, setting up an anodic area at the crack-root. Each time a train passes overhead, this crack starts 'working' and gradually penetrates deeper and deeper into the steel until it reaches the point of failure.

Once again, the 'throw' of the voltage from a rail that has a layer of Zinga applied will prevent this type of corrosion on the rail track undersides. This form of corrosion cannot happen as the strong 'throw' from the very high zinc content within the Zinga layer will be working around the clock, providing a strong cathodic protection. The only other coating that can provide such a 'throw' is the zinc layers applied in hot-dip galvanizing.

The final type of corrosion to be covered in this article is extremely pertinent to countries in Asia. It is caused by the very technology that is now used worldwide to make rail track safer for trains to travel on. This is "welded joint" failures. It is common knowledge that metal expands when it gets hot, and shrinks as it cools down. Hence, where a piece of steel track is several kilometres in length and is locked into position using strong rail-clips, bolted onto heavy cast-iron or concrete sleepers, it cannot move very much. In fact, when it gets hot there is only one direction in which it can expand and that is lengthways.

Using the coefficient of thermal expansion for steel (0.000012 m/m°C), the result is that, for every degree that a rail heats up, a 5km length will elongate by 6.0 cm. If it heats up by 10°C, it expands in length by 60cm. It must be remembered that the rails are constrained by many hundreds of rail clips, so they can only expand lengthways. The problem is that these rails cannot do that because there are other equally-constrained rails at both ends of every section, all the way to the end of the track. This is a common problem with continuously welded rails (CWR) globally.

In the UK, rails can stand this stress for a certain period of time, as the track engineers have enough experience to have already pre-stressed the rails to the length they would naturally be at 27°C. This is known as the Stress Free Temperature (SFT). This means that if the rail temperature is actually under 27°C, it is shorter than it should be so it is stretched. If it is over 27°C it is compressed. Problems therefore only start when the temperature goes above the magic figure of 27°C. Steel is a good material and it can take quite a bit of tension and compression, but like all materials, it has its limit.

It is therefore important to note that the expansion of the rails in hot weather puts a very high compressive strength on the rails and on all welded joints. This can/will cause them to buckle. When the rails cool down and shrink, it places a high tensile stress on the welded joints. This thermal cycling can add to the fatigue already placed on the rails by train traffic and this can lead to cracking within the welds.

In countries in South East Asia, where the temperature of main-line rails (with its tropical weather) baking in the sun all day can easily reach well over 60°C, something has to eventually give. The rails expand, pushing towards each other from either side of the welded joint, forcing it to move either sideways or upwards, placing a heavy strain on the weld-joint. The newer rail can take more of the strain, leaving the older rail with its 'tired' internal matrix to suffer the consequences, and therefore being more prone to developing cracks.

A Zinga layer properly applied on a rail track network can expand up to 17% linearly (as tested by Oilfield Inspection Services in Aberdeen). It can distort sideways to a very high distortional co-efficient, and can contract again every evening as the rails cool down, all with no concerns about the coating ever cracking, peeling or splitting, even under the impact from a vehicle, or other solid steel structure. Furthermore, the coated rails are fully weldable, which makes maintenance much easier as well. Such a system is definitely worth considering for operators of rail networks within Asia.