Looking at creosote

Creosote is a highly effective preservative chemical for protection of timber in heavy duty industrial applications such as railway sleepers, agricultural and fencing poles, utility poles, and marine piles where surface appearance is not important.

With the current shortage of creosote in the South African industry, finding a solution is vitally important. This was seen through the attendance of Moldrup at the inaugural WoodEx for Africa show as well as the decision by Arcelor Mittal to find ways of increasing its creosote production.

The latter follows on a meeting between Arcelor Mittal the South African Wood Preservers Association in April where they indicated that they will be increasing their creosote production by adding an extender similar to what was done by FFS Refiners in October 2011.

It is foreseen that the extender will increase AMCC’s production by 40% to 50%. AMCC has done most of their in-house analysis on the product and final independent third party analysis has also been started at the SABS. Most important is the fact that the final product should comply with the requirements of the SANS 616 Type 3 Creosote, which is acceptable for use in accordance with the SANS standards.

In order to highlight the importance in the use of creosote in the South African industry we will take an in-depth look at creosote and its relevance and application in modern timber treatment.

Background

Creosote was the first wood preservative to gain industrial importance more than 150 years ago and it is still widely used today for protection of industrial timber components where long service life is essential.

Creosote is supplied as a ready-to-use solution. No dilution is necessary or mixing with other components is required before use and it is usually supplied to timber at elevated temperature by vacuum-pressure impregnation in specialised industrial treatment plants.

Being oil-borne, creosote will migrate slowly in the treated timber and may leave an oily surface finish which prevents creosote treated timber from being painted. The oily surface may also stain and damage plastic, clothing and painted surfaces in contact with treated timber.

Due to its toxicity and strong odour, creosote treated timber should never be used where it will be in frequent or prolonged contact with the human skin or in residential interiors or where the timber is likely to be in contact with or in the vicinity of foodstuffs and drinking water.

The chemical composition of creosote is typically a thick oily liquid which is amber to black in colour. It is a complex mixture of hundreds or even thousands of different aromatic hydrocarbons anthracene, naphthalene and phenanthrene derivatives, and at least 75% of the coal tar creosote mixture is polycyclic aromatic hydrocarbons (PAH’s).

Creosote is normally produced by distillation of coal-tar and refers to the portion of the coal-tar which boils between 200 degrees Celsius and 400 degrees Celsius. Most of the components in coal-tar creosote oil are heavier than water (specific density of 1.04 to 1.5 kg per litre). While normal oil floats on water, coal-tar creosote sinks. However, it tends to leave an oil slick on the water surface.
Key benefits of creosote

Highly efficient against biological degradation
Creosote oil offers excellent protection of wood against a broad range of decay, insect and marine borers. While an untreated pole may only provide a service life of 1 to 3 years, a properly creosote treated pole would give a service life of more than 40 to 50 years.

Natural water repellent
In addition to provide protection against a broad range of fungi, insects and marine borers, creosote also serves as a natural water repellent which adds to the service life of the timber by forming a long lasting physical and chemical barrier against leaching and weathering.

Enhanced fire properties
Creosote will minimise destruction of poles during bush fires by forming a char layer around the post/pole during fire – creosote does also not cause any after-glow effect which is a characteristic of CCA preservative. This is an important advantage compared with metal based preservatives in fire prone regions such as Africa.

Does not swell the timber
Since creosote is oil borne, it does not swell the timber during treatment. This makes creosote very suitable for treatment of glulam products for outdoor use.

Approval by EU
In July 2011, the European Commission has announced that creosote will be included under Annex 1 of the European Biocidal Products Directive 98/8/EC with effect from 1 May 2013 for an initial period of five years. Creosote is hereby approved by EU for vacuum pressure treatment by professional users of certain industrial products such as electricity/telephone poles and railway sleepers.

The stakeholder consultation which was part of the decision making process by the European Commission indicated that there are considerable socio-economic benefits of using creosote for applications such as railway sleepers and electricity and telephone poles. There is furthermore no other alternative at the moment for these applications that would be better for a human health of environment point of view.

Drawbacks of creosote oil
Although creosote oil is a very effective preservative, it does have some drawbacks

Use restrictions
Due to its toxicity and strong odour, creosote treated timber should never be used where it will be in frequent of prolonged contact with human skin or in residential interiors. It should also never be used where it may come into direct or indirect contact with drinking water and food for domestic animals or humans.

Bleeding
Creosote is mobile in the treated wood and might bleed out of the treated wood as an oily dark brown to black stain. This makes creosote unsuitable where a clean surface appearance and paint ability are important.

The amount of bleeding depends on many factors such as grade of creosote oil, application method, wood species, retention of creosote in the treated timber etc. Since bleeding makes the treated timber very dirty, it is important to minimise bleeding. This is best done by treating the timber using well formulated creosote oil in a well designed treatment plant.

Sophisticated treatment equipment
Treatment with creosote oil is carried out at elevated temperature in specialised industrial treatment plants that are more complicated and expensive to build compared to treatment plants used for treatment with water based preservative chemicals.

EU restrictions
Due to the suspected carcinogenic character of creosote, the European Union has restricted the sale of creosote oil to professional industrial users only, and creosote treated timber must not be used inside buildings, in toys, playgrounds, parks, gardens and outdoor recreational and leisure facilities where there is a risk of frequent skin contact. Nor is use allowed in the manufacture of garden furniture such as picnic tables, in containers for growing purposes, packaging that may come in contact with raw materials, intermediates or finished products for human and or animal consumption.

To improve the safety of creosote, UE has limited the content of benzoapyrene = BaP in creosote to maximum 50 pp and the content of water extractable phenols should not exceed 3% by mass.
International specifications

Creosote is a complex mixture of hundred of different chemical components from the distillation of coal tar at temperature ranging from 200 to 400 degrees Celsius and there is no single chemical in creosote that specifically makes it a good wood preservative. All chemicals combined together are much more effective than just one alone and a broad range of high- and low boiling components are important to make creosote oil and effective preservative.

The low boiling compounds are the more toxic preservative and their low viscosity allow for easy penetration. But the low boiling fractions are exposed to loss by evaporation and migration. The higher boiling fractions are less effective preservatives, but research has shown that the effectiveness of creosote as a wood preservative is predominantly related to the quantity of preservative at that is retained in the wood over its lifespan. To achieve long-term retention of the creosote in the timber, the creosote formulation has been shown to require sufficient of the high boiling, heavy fractions to reduce the amount of creosote that evaporates out of the wood over time. Oils with the heavier fractions are also less smelly and tend to protect the timber better against cracks and weathering, but to penetrate the wood with greater difficulty and have a greater tendency to bleed.

Selection and preparation for timber

As with all other preservatives, the effectiveness of creosote depends not on its own intrinsic preservative power alone, but to a very great extent on how it is applied, the species of the timber, and where the timber is used.

Long service life, (40 years or more) can be expected for permeable timbers correctly treated by vacuum pressure imprecation at elevated temperature with creosotes conforming to international standards.

The timber to be preserved shall be clean, dry and not decayed by fungi or attacked by insects, and all inner and outer bark has to be removed. The moisture content of the wood must be
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oak, eucalyptus and other heavy tropical hardwoods for the treatment of piles and timbers subjected to marine environments where a high absorption of creosote is required.

Empty cell process
There are two empty cell processes, the Lowry and Rueping processes. Both processes were introduced for treatment with creosote more than 100 years ago and involve compressing the air inside the wood to drive out a portion of the preservative that is absorbed in the wood during the pressure phase, so that the preservative can only coat the inner cell walls rather than saturating the interior cell voids.

In the Rueping process, compressed air is forced into the wood cells at the beginning of the treatment process. The initial pressure typically ranges between 1 and 5 bar depending on the net preservative desired and the resistance of the wood. After filling the wood with compressed air, the treating cylinder is flooded with preservative while maintaining the compressed air in the wood cells. The pressure is then raised above the initial air pressure and maintained until the timber has absorbed the desired level of creosote. After the pressure period, the preservative is removed from the cylinder and surplus solution is removed from the wood with a final vacuum. The final vacuum may recover 20 to 60% of the gross amount of preservative injected.

The Lowry process is an empty cell process without the initial air pressure. Preservative is pumped into the treating cylinder without either an initial air pressure or initial vacuum trapping the air that is already in the wood. After the cylinder is filled with preservative, pressure is applied and the remainder of the process is similar to the Rueping process.

In the empty cell processes, the preservative penetrates as deeply as with the full cell process, but less preservative is allowed to remain in the wood. This prevents excessive amount of creosote from being absorbed in timber. The empty cell processes are therefore widely used for treatment of timber with a high content of sapwood such as pine and beech and for treatment of poles, posts, railway sleepers where a low to medium high absorption of creosote is required.

Additional information by Moldrup.