REMOVAL OF RESIDUAL CREOSOTE IN OUT OF SERVICE UTILITY POLES USING STEAM TREATMENT [1)]

(*Pengeluaran Sisa Kreosot dalam Tiang Listrik Bekas Pakai menggunakan Perlakuan Uap*) [1)]

By / *Oleh*

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ABSTRAK

Keberadaan sisa-sisa kreosot dalam produk kayu bekas pakai dan tak lagi digunakan, diantaranya tiang listrik bekas, dapat mengakibatkan kesulitan/masalah dalam pemanfaatannya menjadi produk berguna lain seperti: papan blok, papan partikel, papan serat, dan pulp/kertas. Maka, sisa kandungan kreosot tersebut harus dihilangkan atau diturunkan menggunakan perlakuan khusus yang efektif. Sebelum perlakuan uap, tiang listrik tedsebut perlu dibuat menjadi partikel-partikel berukuran kecil, antara lain serbuk gergaji sehingga memudahkan penguapan kreosot oleh uap.

Perlakuan uap terhadap tiang listrik bekas pakai telah dicoba keefektifannya dalam menghilangkan/menurunkan sisa kandungan kreosotnya. Hasil menunjukkan bahwa perlakuan uap dapat menurunkan kandungan kreosot hingga 1,31 persen, untuk kandungan awal kreosotnya yang berbeda-beda. Tiang listrik dengan kandungan kreosot lebih tinggi membutuhkan waktu perlakuan uap lebih lama. Pada kandungan awal kreosot tertentu atau sama, penurunan/pengeluaran kreosot pada batang/tiang listrik bekas yang berumur pakai lebih lama ternyata lebih sulit dari pada tiang listrik berumur lebih muda. Pada berbagai umur Selanjutnya baik pada tiang listrik berumur lebih muda ataupun lebih tua, penurunan/pengeluaran kresosote juga lebih sulit pada bagian dalam batang/tiang dibandingkan dari bagian yang lebih dekat permukaan batang/tiang.

Perlakuan uap merupakan cara yang murah dan efisien menurunkan kandungan kreosot. Penurunan lebih lanjut kreosot yang tersisa dalam batang dapat dilakukan dengan *cara lain, antara lain dengan pelarut organik yang memerlukan biaya mahal dan penggunaan mikororganisme tertentu yang memerlukan waktu lebih lama.*

Keywords: Perlakuan uap, sisa kreosot, tiang listrik bekas pakai, keausan, dan tiang listrik baru/segar diawetkan

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ABSTRACT

The presence of residual creosote in out-of-service weathered creosote-treated wood products, such as used utility poles, can bring about problems/troubles in their reutilization into other useful products (e.g. block board, particleboard, fiberboard, and pulp/paper). Therefore, their residual creosote content should be removed/reduced by particular effective treatment. Prior to the steaming, the poles should be converted to smaller-size particles (i.e. sawdust) to ensure more effective creosote volatilization by steam.

Steam treatment of weathered out-of-service utility poles has been experimented to evaluate its effectiveness in removing their residual creosote content. The results revealed that steaming reduced the creosote to a 1.31-percent level, regardless of different initial creosote contents. Poles with higher initial creosote content required longer steaming duration. At a given initial content, creosote removal from weathered poles and from materials in the inner pole portion was more difficult than that from freshly treated poles and the outer portion. Regardless of pole ages, creosote removal from the inner portion of the poles was also more difficult than the outer portion. Steaming could prove an efficient and cheap way for creosote removal. Further reduction in residual creosote content in the poles below 1.31 percent can be done by other methods (e.g. more costly solvent extraction and time-consuming bioremediation).

Keywords: steaming, residual creosotes, out-of-service utility poles, weathering, and freshly treated poles

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I. INTRODUCTION

Attention has long been placed on removing or reducing creosote preservative in weathered treated wood products which were no longer serviceable, among others utility poles, before being utilized/processed into particular useful products, e.g. block board, particleboard, fiberboard, and pulp/paper. This is because the residual creosote can bring about troubles/problems in that processing. Two methods of creosote removal have been so far experimentally tried, i.e. (1) bioremediation and (2) solvent extraction. Bioremediation is a biological process using organisms that can "consume" the preservative. An experiment done by Eslyn (1976) on creosote-treated marine piles showed that approximately 80 percent of the creosote can be eliminated, but the processing is exhaustively time-consuming. The microorganisms used for his work was *Pseudomonas creosotensis*. Using water-nutrient broth, the incubation took about nine days.

The LSU (Louisiana State University) Institute for Environmental Studies has conducted solvent (methanol) extraction on severely weathered creosote-treated wood. This extraction could remove almost 100 percent of the creosote (Portier *et. al*., 1994). However, the creosote-removal by this method in large-scale implementation can required the use of expensive methanol solvent and costly extraction apparatus. Therefore, "cheaper and not too lengthy" method to remove this creosote should be found out, such as steaming..

Steaming is often used in preservative treatment, especially by the vacuum-pressure method, to increase wood permeability (Eaton and Hale, 1993; and Hickin, 1971).

Steaming is also used to separate the volatile compounds in wood extractives (Browning 1967). Since creosote contains compounds that ranges from low-boiling fractions (i.e. more volatile) to high-boiling fractions (less volatile), steaming can expectedly volatilize the creosote thereby removing or reducing it in the creosote-treated wood.

II. MATERIALS AND METHODS

A. Materials

Samples of sawdust from the sawing on the utility poles of southern yellow pine species as previously used for creosote-content determination (Roliadi, et. al. 2000) were collected from various vertical and horizontal locations in 5- and 25-year weathered out-of-service poles and freshly treated poles (Figure 1). For replication, five poles were taken from each group of pole ages.

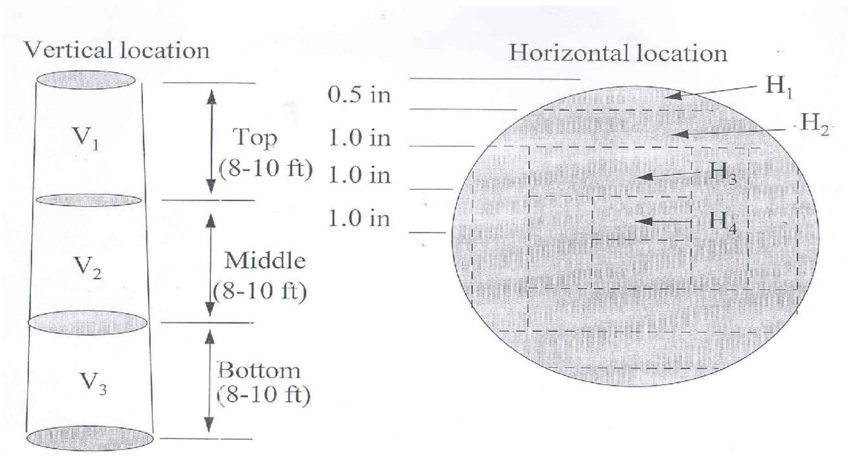


Figure 1. Patterns of cutting/sawing procedures in treated poles
Gambar 1. Pola prosedur pemotongan/penggergajian tiang listrik yang diawetkan

Translation of English words in Figure 1 into Indonesian (*Terjemahan kata-kata bahasa Inggris dalam Gambar 1 ke bahasa Indonesia*): Vertical location = *Lokasi vertikal*; Top = *Bagian atas*; Middle = *Bagian tengah*; Bottom = *Bagian dasar*; and/*dan* Horizontal location = *Lokasi horisontal*.

B. Methods

Each of these samples weighing about 5 grams, with predetermined creosote content using toluene extraction (AWPA Standard, 1984), was placed in fritted glass crucible and then steam-treated in a retort at atmospheric pressure and 100°C for up to 3 hours. At 15-

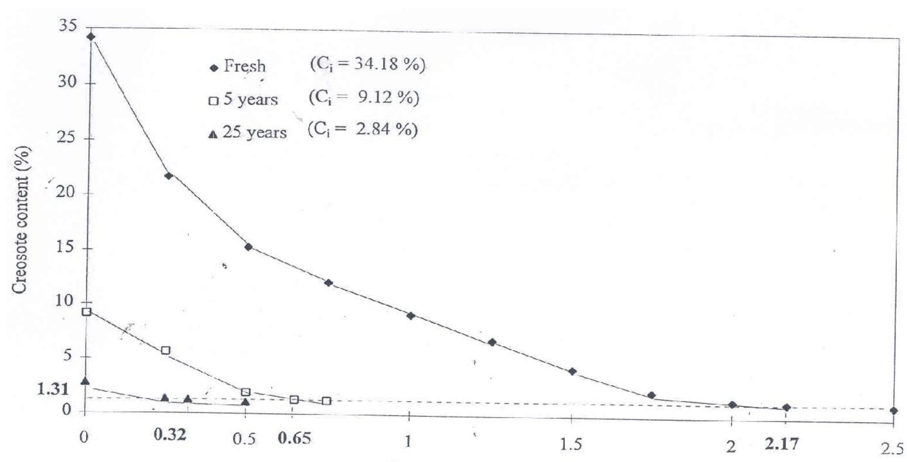
minute interval, the samples in the glass crucibles were removed from the retort and washed with boiling water to facilitate as much creosote removal as possible. The possible remaining creosote contents in the samples were determined again in accordance with the corresponding AWPA Standard (1984). Steam treatment was terminated, when the residual creosote contents became stable and were further considered as the final contents. The criteria used to evaluate the effectiveness of steam treatment were final creosote content and steaming duration.

C. Data Analysis

In order to assist the data evaluation (i.e. final creosote content and steaming duration), statistical analysis that employed repeated-measurement design was used, whereby pole ages (i.e. freshly treated, and 5 and 25 years) acted as the main plot, various vertical and horizontal locations in the poles as the sub plot, initial creosote contents as the covariate, and five poles taken from each age group as replicate.

II. RESULTS AND DISCUSSION

In general, steaming reduced creosote to a final content that ranged about 1.2 – 1.5 percent regardless of different initial contents (Figure 2). Heat from the steam caused the volatilization of compounds in creosote and lowered their viscosity, thereby greatly assisting the movement of creosote, which is not chemically held in wood. However, the capability of steam treatment was limited to about 1.2 – 1.5 percent final creosote content, which is less effective than solvent extraction and bioremediation. This is because creosote is oil-soluble and therefore immiscible in a polar substance (steam). Also, creosote left at that low percentage might contain greater fractions of high-boiling compounds which are difficult to evaporate by steam (Andrew, 1952).



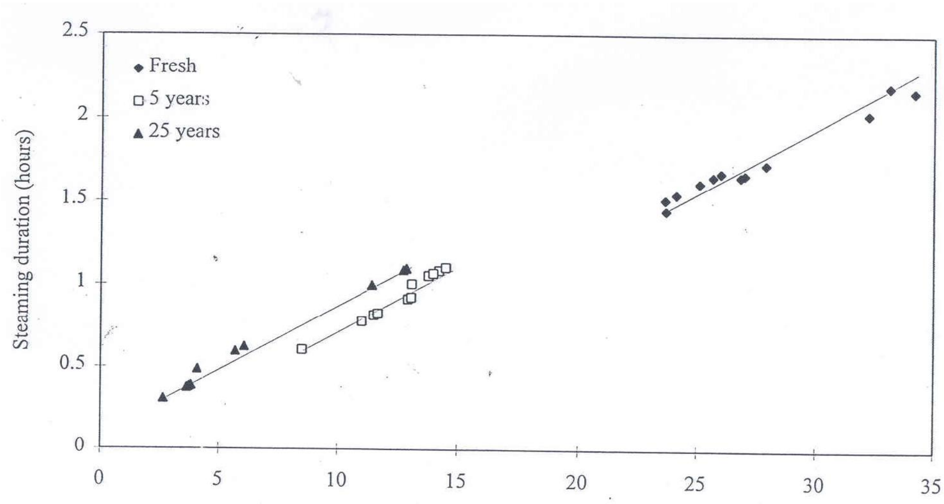
Steaming duration (hours)

Figure 2. Approximate steaming durations required in 3 kinds of creosote-treated poles (i.e. 2.17 hours for freshly treated poles; 0.65 hours for 5-; and 0.32 hours for 25-year weathered poles, respectively) to reach 1.31 % final creosote content (Ci = initial creosote content)

Gambar 2. Perkiraan waktu perlakuan uap yang diperlukan pada 3 macam tiang listrik yang diawetkan dengan kreosot (2,17 jam untuk tiang listrik baru/segar diawetkan; 0,65 jam untuk tiang listrik berumur 5 tahun; dan 0,32 jam untuk tiang listrik berumur 25 tahun) guna mencapai kandungan kreosot akhir 1,31 % (Ci = kandungan kreosot awal)

Translation of English words in Figure 2 into Indonesian (*Terjemahan kata-kata bahasa Inggris dalam Gambar 2 ke bahasa Indonesia*): Steaming duration (hours) = *Waktu perlakuan uap (jam)*; Fresh = *Tiang listrik baru/segar diawetkan*; 5 years = *Tiang listrik diawetkan telah berumur 5 tahun*; 25 years = *Tiang listrik diawetkan telah berumur 25 tahun*; dan/*and* Creosote content (%) = *Kandungan kreosot (%).*

The analysis of variance (Table 1) reveals that that the final creosote contents were not significantly different among all the variable tested (i.e. poles, ages and various vertical and horizontal locations, and hence those final contents could be averaged, i.e. 1.31 percent. The approximate steaming duration for various initial creosote contents could be determined, as shown in Figure 2, by interpolating it to the overall 1.31-percent average, which was regarded as the effective final creosote content. As a result, when the experimental data of initial creosote content were plotted against the steaming duration (Figure 3), the plots revealed that higher initial content required longer steaming duration.



Initial creosote content (%)

Figure 3. Relationship between initial creosote content and steaming duration to reach 1.31 % final creosote content
Gambar 3. Hubungan antara kandungan kreosot awal dan waktu perlakuan uap untuk mencapai kandungan akhir kreosot 1.31 %

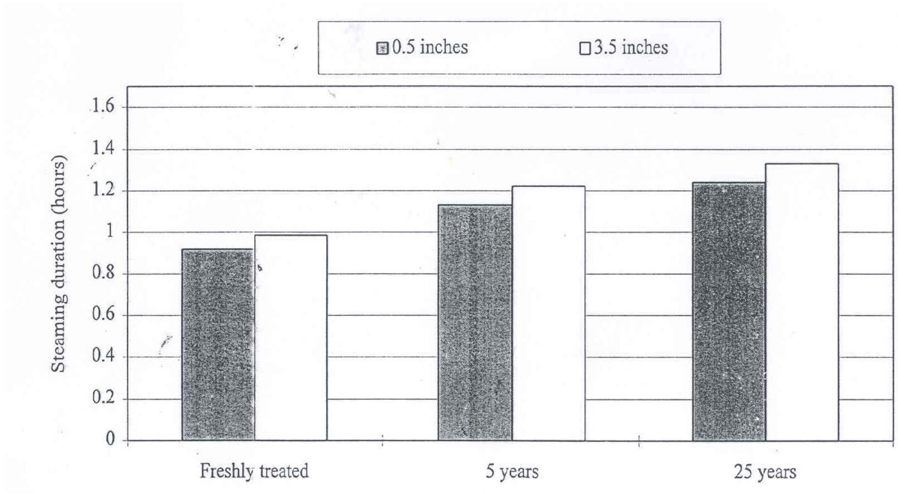
Translation of English words in Figure 3 into Indonesian (*Terjemahan kata-kata bahasa Inggris dalam Gambar 3 ke bahasa Indonesia*): Initial creosote content (%) = *Kandungan kreosot awal (%)*; Fresh = *Tiang listrik baru/segar diawetkan*; 5 years = *Tiang listrik diawetkan telah berumur 5 tahun*; 25 years = *Tiang listrik diawetkan telah berumur 25 tahun*; and/*dan* Steaming duration (hours) = *Waktu perlakuan uap (jam)*.

In addition, the analysis of variance on steaming duration (Table 1), which incorporated the initial creosote contents, explained the effect of various locations in the poles and different service durations (pole ages), whereby the overall initial contents were statistically assumed as constant. At that constant initial creosote, i.e. 6.14 percent (Table 1), steaming duration of samples from pole of older ages and of the outer portions was actually longer than that of freshly treated poles and of the inner portion, respectively (Figure 4). More difficulty in steaming of older poles again confirmed that the residual creosote in 5- and 25-year weathered poles contained greater high-boiling fractions, due to more evaporation of low-boiling compounds, as compared to those in the freshly treated poles. On the other hand, more difficult creosote removal from the inner pole portion could be attributed to greater occurrence of aspirated pits on the cell wall of that portion. The analysis of variance further reveals that different vertical locations in poles did not significantly affect steaming duration.

Table 1. Analysis of variance on final creosote content and steaming duration
Tabel 1. Analisa keragaman terhadap kandungan kreosot akhir dan waktu perlakuan uap

Source of variation (*Sumber keragaman*)	Final creosote content (*Kandungan kreosot akhir*)		Steaming duration (*Waktu perlakuan uap*)	
	df (*db*)	F-values (*F-hitung*)	df (*db*)	F-values (*F-hitung*)
Main plot (Petak utama)				
Service duration / *Umur pakai* (S)	2	2.13	2	14.98**
Error / *Galat* (a)	-		12	
Sub plot (*Petak* sub)				
Vertical location / *Lokasi vertikal* (V)	2	2.08	2	2.47
Horizontal location / *Lokasi horisontal* (H)	1	2.55	1	9.22**
Interaction / *Interaksi*				
S*V	4	1.98	4	1.78
S*H	2	1.77	2	3.67**
V*H	2	1.13	2	1.34
S*V*H	4	0.97	4	0.91
Error / *Galat* (b)	72		59	
Covariates / *Peragam*: Initial creosote content / *Kandungan kreosot awal*	-	-	1	22.31**
X [1)]	-	16.14	-	-
Y [2)]	-	1.31	-	1.14
C.V. (%) [3)]	-	9.42	-	7.23

Remarks (*Keterangan*): [1)]Overall average of initial creosote contents / *Rata-rata keseluruhan kandungan kreosot awal* (%);[2)]Overall average of final creosote contents (%) and steaming duration hours) / *Rata-rata keseluruhan kandungan kreosot akhir (%) dan waktu perlakuan uap (jam)*; and/dan [3)]Coefficient of variation / *Koefisien keragaman*



Service duration

Figure 4. Steaming duration required in sawdust samples from three kinds of treated poles (freshly treated, and 5- and 25-year weathered poles) at 0.5-inch distance (outer portion) and 3.5-inch distance (inner portion) from pole surface, by assuming that their initial creosote contents were the same (i.e. 16.14 %)

Gambar 4. Waktu perlakuan uap yang diperlukan pada contoh serbuk gergaji dari tiga macam tiang listrik yang diawetkan (baru/segar diawetkan, berumur pakai 5 tahun, dan berumur pakai 25 tahun) pada jarak 0,5 inci (bagian lebih luar) dan pada jarak 3,5 inci (bagian lebih dalam) dari permukaan tiang listrik, dengan asumsi bahwa kandungan kreosot awalnya sama (16,14 persen)

Translation of English words in Figure 4 into Indonesian (*Terjemahan kata-kata bahasa Inggris dalam Gambar 4 ke bahasa Indonesia*): Service duration = *Masa pakai tiang listrik*; Freshly treated = *Tiang listrik baru/segar diawetkan*; 5 years = *Tiang listrik diawetkan telah berumur 5 tahun*; 25 years = *Tiang listrik diawetkan telah berumur 25 tahun*; 0.5 inches implies the distance from pole surface (outer portion) toward the pole core = 0,5 inci menunjukkan jarak dari permukaan tiang listrik (bagian lebih luar tiang listrik) menuju ke bagian pusat tiang listrik; 3.5 inches implies the distance from pole surface (outer portion) toward the pole core = 3,5 inci menunjukkan jarak dari permukaan tiang listrik (bagian lebih luar tiang listrik) menuju ke bagian pusat tiang listrik; and/*dan* Steaming duration (hours) = *Waktu perlakuan uap (jam).*

IV. CONCLUSSIONS AND SUGGESTIONS

Trial on removal of out-of service using steam treatment was conducted by at first converting the poles into smaller-size particles, i.e. sawdust. In this way, therefore, it will inflict more effective creosote removal, because sawdust particles has substantially much larger surface area than the corresponding poles. As a result, there would be more intimate contact between creosote stuffs and hot steam, thereby incurring effective volatilization of the creosote.

The initial creosote contents in sawdust samples from the creosote-treated poles correlated positively with steaming duration. Regardless of different initial creosote contents, steaming reduced the creosote to 1.31 percent level. Beyond this level, steaming brought about no significant reduction in creosote content.

At a given initial creosote content, removal of creosote by steam was more difficult for poles with longer service duration (i.e. older ages) than with shorter duration/younger ages, and for pole materials from the inner portion than the portion near the surface.

Steaming, however, can be an efficient and cheap method of reducing the creosote content in weathered poles. Further removal for effective treatment can be done by other methods (e.g. more costly solvent extraction and time-consuming bioremediation).

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