XVIII IMEKO WORLD CONGRESS
Metrology for a Sustainable Development
September, 17 – 22, 2006, Rio de Janeiro, Brazil

INVESTIGATION FOR TIMBER BARKING ROBOTIZED SYSTEM PERFORMANCE

Jaromír Volf [1], *Josef Vlček* [1]

[1] Fac.of Mechanical Engng. – CTU - Prague, Czech Rep., jaromir.volf@fs.cvut.cz
[1] Fac.of Mechanical Engng. – CTU - Prague, Czech Rep., vlcek@fsid.cvut.cz

Abstract: The original Timber Barking Principle – Using Electrical Current Effects has been tested for an industry timber barking purposes. This untraditional timber barking - no wood loss - method demands the special measuring Stand By Post to be done – for the parameters identification and setting; to be realized the voltage control for the Timber Barking Model with Operational Dimensions. The other control way – acceptable for the logs with the low quality subcortical layers has been tested. The speed control tests of the feeding device has been done – to be improved the robotized system intelligent behaviour. The tests results and problems are given. To the successful Timber Barking - the specific energy range w [Ws/m^2] has been caught.

Keywords: timber barking, adaptive control, robot, subcortical layers, speed control.

1. INTRODUCTION – PURPOSE

The wood being more and more valuable raw material, the demand is to reduce the wood-loss by the industry timber barking. Mainly used, the mechanical way creates about (3 – 5)% wood-loss, at present. Therefore the others methods are tested, too (e.g.: chemical, biological etc.). Our attention is concentrated on the no wood-loss method, for what is the timber barking robotized system intended.

The new one, unique principle: - Being attacked, the Subcortical Layers of the log, the Electrical Current Effects, with – the evaporation can be expected, so that the coherence between wood and bark is destroyed. To be reach the successful timber barking, the measurement number and the sensors have to be used. To be verified, the successful Timber Barking (TB), for what - the model with operational dimensions has been realized – the right values, especially the voltage and the time-stay in the high voltage zone have to be set and controlled.

2. PURPOSE

To this method – the first approach was rather sceptic. Unless, we consider the main advantage (practically no wood–losses), the great number of the technical difficulties can be expected, as e.g.: the right voltage range setting for the overall subcortical layers (SL) qualities, and for the overall electrodes parameters (as: the electrode spacing, length) too; the right time determination for the successful timber barking; the effective way for the el. energy transport into the SL; the right control and supervisory tools; the vapours and gases concentration in the inter-electrodes spaces (the oversparks- and the breakdowns- generation possibilities). Beside that, the others obstacles – given by the natural character of the timber can be expected, too as e.g.: the quality changing of the SL- moisture / dryness; the winter (summer) season; temperature; the log's local damaging etc. These changing influences can be only heavy or complicate expressed, but these ones have to be taken in consideration for the used control way – to be reached the Successful TB – see Fig. 1. These outdoor influences, we try to be respected with the one – overall factor – í [A/s] – the Quality SL factor. Having been combined this one with the others parameters, we receive the limits for the areas of the Successful TB. The success scale level is evaluated as the Success Percentage of the Timber Barking Area. Then, the clusters analysis generates the logs groups with the similar properties. Each group is characterized with the typical parameters for the input data setting - for the power AC/AC controller, (up to 1730V); and the voltage/speed control during the log's passing throw the el High Voltage head. The controller ´s intelligent behaviour is expected, due to the great conditions variance.

For the logs of the high or middle subcortical layers quality, the Voltage Control has been relatively successfully tested. However, for any logs with the low subcortical layers quality, only – this control way seems to be limited. To

Fig. 1. Timber Barking – Released Vapours

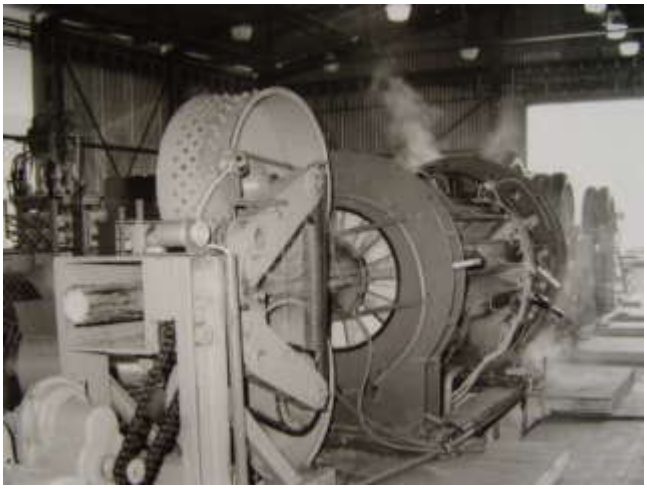

Fig. 2. El. Head in Activity

improve the situation – to be extended TB Area on these logs, too – the other principle control way has been tested. The attention has been focused on the Speed Control of the feeding device – especially the low speed – to be prolonged the stay in the active zone; what in practise means to slow down (respectively) to control the log's passing through the high voltage el. head (1730 V) – see Fig. 2. The others experiments purposes – to be verified, either the TB possibilities for an industry wood–processing; and either to be caught the parameters for an Economy Calculations, and the TB device setting and control; to be gained experiences – which enable to be prevented the harmful effects.

3. METHODS - EXPERIMENTS

No experiences and results could be used from any similar device – for the project dynamic timber barking model with the operational dimensions; neither the data for the adaptive control way. These ones have been mostly derived and transformed from the great number labs experiments on the static strongly scale down model (electrode length from 0,1 m; voltage up to 700 V, 50 Hz; applied for spruce logs).

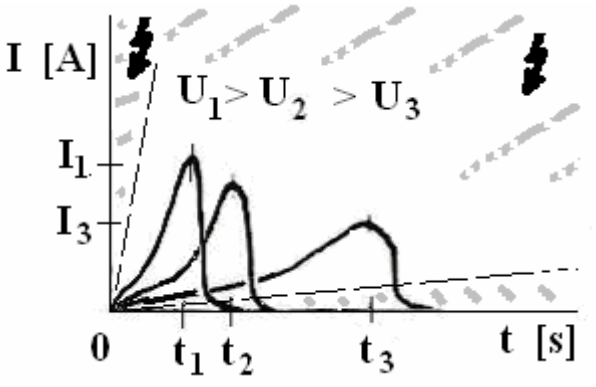

Fig.. 3. The Supply Voltage influence U = const., by the Timber Barking Area Determination as Current vs. Time dependence I = f (t) - for Electrodes Spacing a = const. by the same quality Spruce log – í = const. ; for the electrodes couple length 0,1 m ; - an ideal case.

From the control view-point - to reach the successful TB it means to solve the system with the adaptable time delay. To express the time delay T_D in reality means – to find the speed for the feeding device; and to let the time T_D – to be realized the vapours development, from the same Voltage Start to the Current – Excess, what can be seen in Fig. 3 – then the bark-wood coherence is being destroyed. The other T_D- prolonging means only the total energy consumption increasing; a longer one causes the risks and hazards generation of an electrical sparksovers and breakdowns (shadows area; except – the bottom – being used the low voltage the SL are dried only, and NO – TB effect can be expected). In this contribution, the attention would be concentrated on the experiments only, which are leading to the acceptable timber barking area determination, as the background – for the speed – control range setting. An ideal case – see Fig. 3 – the parameter's influence (the supply voltage U = const) on the I-t waveforms: the Current passage throw the subcortical layers vs. the Time, if we suppose the same quality (í = const.) what means to realise measurement in the same conditions (on the same spruce log); by the electrodes spacing a = const.).

Having been set: the supposed reliable timber barking areas; parameters for the AC/AC controller setting from the view-point of the subcortical layers quality, and the log's geometrical dimensions; the control ways mode – the first results have been gained on the timber barking model with the operational dimensions. The success percentage timber barking area was about 90 – 98 % for the high or middle subcortical layers quality logs by the Voltage Control way. Being reached the voltage limit 1730 V - NO well results - for any Low subcortical layers quality logs. To be improved the situation, we tested to control the Speed of the feeding device from 0 to 0,5 m/s, too. Any more experiences; the experiments results – oriented for the Specific Energy determination w [Ws/m^2] – as an important economy parameter; the identification system problems for this adaptive speed control way – will be briefly given; for what, the other important result can be derived from Fig. 3. The very rough equality of the specific energy: $w_1 = w_2$ [Ws/m^2] – approx. in the same quality conditions (ref. [1]), what is used usually as criteria by mathematic processing e.g.: to be converted the results gained on the scale down static model for the real timber device with the operational dimensions; to gain missing values; for the rough data transformation from one electrode spacing to the other one.

To be caught the Acceptable Areas for the TB, it means, to collect the I-t waveforms for the others parameters - e.g.: a = const. – electrode spacing (in steps 2; 3; 4 cm - for the SL log's low quality L2); as example I = f (t) - see Fig.4. The great conditions variance, we try to respect with the others Qualitative groups (H-high, M-medium ....), and for these ones – to derive the Areas – similar as AAs in Fig 4 (which don ´t be given here). Then, the Control strategy is quite clear – either to start the Voltage Control mode, only; - or either to start the Speed Control mode. So that, for the first case – it can be theoretically found (so called) the Common Time – T_c, which allows the successful TBarking – either for the overall Qualities ranges, and either for the overall electrodes Spacing. What means, that we have the

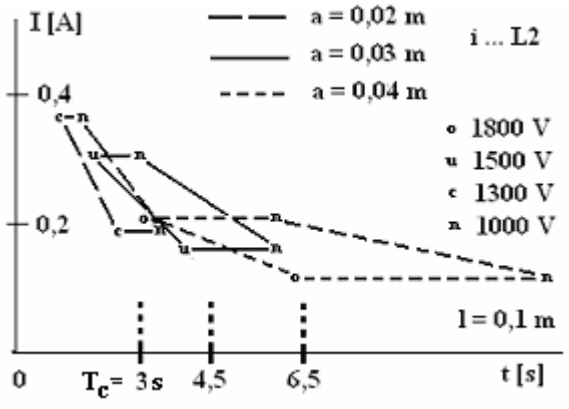

Fig. 4. The supposed Timber Barking Areas as dependence Current vs. Time I = f (t) for Electrode Spacing a = const. ; by the Low quality Spruce logs – L2 ; for the electrodes couple length 0,1 m ; with the signed common time values - t_c .

T_c = *const*., so that the Speed of feeding devices v = *const*., too; and "all" is realised as the Voltage Control Way, only (what is the great simplification).

Unfortunately e.g.: – for the $T_c = 4,5s$ (by the electrode length 1,5m, and by the const. speed $v = 0,33m/s$); we received only the poor TB Quality (in agreement with Fig. 5 - for any "low logs quality" í = L.. , and partly the medium quality M.. , too – being on the upper voltage limit 1730 V, by the higher electrodes spacing).

Then the second control way - Speed of the feeding device – has to be used – to be reach the successful Timber Bark.. However, the risk of the sparksovers and breakdowns seems to be rather higher. The signals for these ones – see Fig. 6 - The real measured current by the log's passage throw the el. head - no calm dependence.

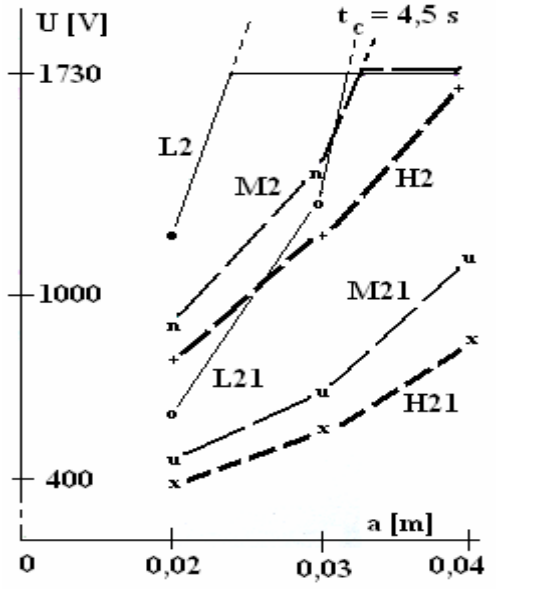

Fig. 5. The supposed Voltage limit for the Low qualities L.. (partly M2 - Medium) for Timber Barking Voltage vs. Electrodes Spacing dependence U = f (a) by the common t_c = 4,5 s (i.e. 0,33m/s)

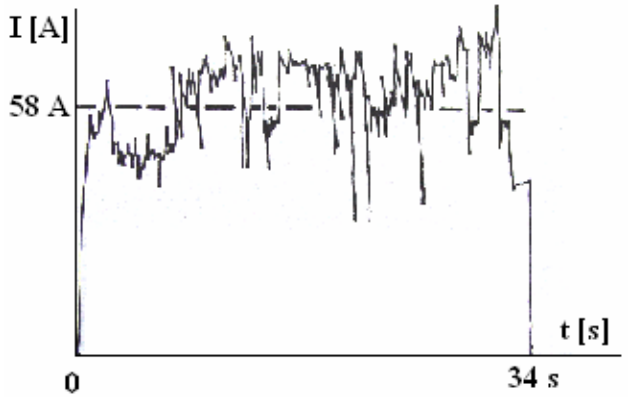

Fig. 6. The real line current

To prevent these situations, to predict the time delay of the vapours development, to preset and to adapt the controller's parameters, to be caught and transformed the great conditions variety, what is given by the natural material variance, the special measuring Stand By Post has to be realized for the system identification (diagrammatically – see Fig. 7.) - to enable the intelligent behaviour.

4. RESULTS

Main features – Timber Barking Model with the Operational Dimensions:
The spruce log (length up to 16 m, diameter about 6 - 24 cm) can be driven through the "electric head" with the speed 0,23 m/s (or adapted up to 0,5 m/s). The chain electrodes (in two sets 2x9 pcs – length 1,5 m each) are step by step cut to the log's surface, being automatically adapted the distance between two electrodes from 2 cm to 4 cm – with respect the log's cone. The high voltage can be controlled - up to 1730 V, 50 Hz - IT – 3 line system.

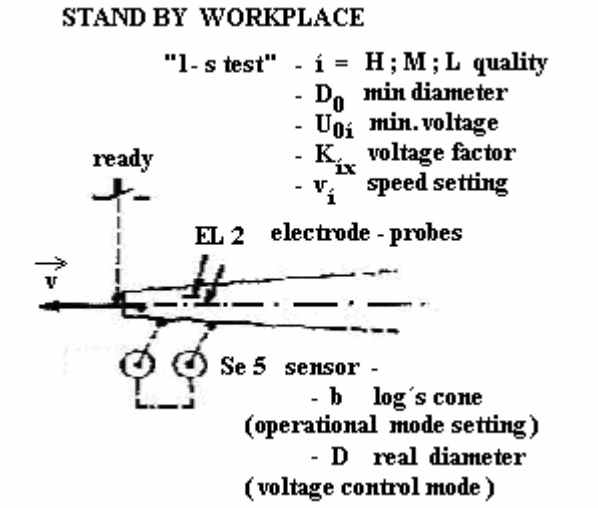

Fig. 7. Stand By Workplace - the Log's Identification - for Parameters and Operational Mode presetting.

Fig. 8. The breaking chain electrode

The control speed tests – have had only the rough frame character; in spite this fact – it has been proved, the Control Speed of the feeding device – to be the other effective way – to be realize the successful Timber Barking. However, the measurement couldn't be systematically realized, due to the frequent breaking of the chain electrodes – see Fig. 8 – especially by the Continuous Control Way, for what these electrodes haven ´t been projected. So that the others tests have been done by the speed $v_i = const$ (in steps $v_1 > v_2 >$ ...); being followed the Success Percentage *SP [%]* - of the whole Timber Barking Area – e.g.:

~ 60 m/min ..... practically NO – Timber Barking Effect;
30 m/min .... ~ 30 ÷ 45 % - very bad;
17 m/min .... ~ 90 – 98 % - very well;
23 m/min .... ~ practically almost same.

The others step–down speed was usually accompanied with the electrodes breaking, – and the vapours concentrations in the space of El. head (followed with the oversparks and breakdowns) – so that one electrodes set (9 pcs) was taken out; and the vapours blowing out has been realized – as any others improvements.

The others experiments have been done with const. speed *v = 0,23 m/s*; to be tested the voltage control way; and to be caught The specific energy range – $w\ [Ws/m^2]$, as the important "indoor" parameter for the robotized system setting; and as the main economy parameter, too – for the typical selected logs – the results review – see Tab. 1.

5. DISCUSSION

Why we stay by this problematic "special low" group of the subcortical layers quality logs – to be known the total consumption range for the other optimisation, being attacked the low border from the range $w = 45.10^4 – 215.10^4$ Ws/m^2 , to this time.

To be enlarge the adaptive control way possibilities – it has been proved, that the Control Speed of the feeding devices (for the Timber barking model with the Operational dimensions) is the other effective – control way; beside the Control Voltage way, which has been used to this time – to be reach the Successful Timber Barking. However, this speed control way cannot be recommended for this mentioned model – due to the frequent mechanical defects – the chain electrodes breaking (active length 1,5 m).

Any others restrictions have been verified, too – as by the high speed – only poor or no timber barking effect can be expected. The subcortical layers are only merely heated and dried – so that no el. current is passing through these ones. Of course, the slow–down speed by the industry timber processing means – to put down the productivity and effectivity; beside that, the level's increasing probability of the harmful effects – as the sparksovers and breakdowns can be expected, too - due to the high vapours concentration in space of el. head.

As the integrated component of the Stand By Post (common with the others sensors) the thermocamera using is believed to help so much, by the í – Quality Subcortical Layers Determination (as the key parameter); and by the

Tab. 1. Successful Timber Barking

log no.	quality í	timber barking voltage [V] input output Umin Umax	current 1 electrode	total line current	input power P	el. power consumption -	- for a log length L	Specific energy	log transit time through el. head	log length L	log diameter [m] input output Dmin Dmax	electrode distance input output a_{min} a_{max}	success % barked area	timber barking quality scale
-	A/s	[V] [V]	[A]	[A]	[kW]	[MWs]	[kWh]	$MWs.m^{-2}$	[s]	[m]	[m] [m]	[m] [m]	%	
2	M	1100 1630	21	62	185	6,1	1,7	2,16	35	8	0,085 0,014	0,03 0,039	95	well
4	L	1300 1630	20	61	181	6	1,66	1,98	35	8	0,09 0,015	0,031 0,042	95	quite well
5	H	1000 1630	15	46	130	4,5	1,26	1,51	35	8	0,09 0,015	0,031 0,042	98	very well
9	H	950 950	7	21	33	1,2	0,33	0,45	35	8	0,095 0,0115	0,033 0,037	95	well
11	H	800 1300	17	51	114	4,5	1,24	1,54	39	9	0,07 0,0135	0,024 0,036	90	enough well

monitoring of the temperature processes, too – but this way hasn't been tested to this time.

6. CONCLUSION

As measuring results have been gained:
- the Specific energy range $w = (45 \div 215) \cdot 10^6$ $[Ws/m^2]$ –for the successful timber barking in the followed logs range, can be used as an important economy parameter, and the indoor parameter too;
- the Speed control range $v = 0 \div 0{,}23$ m/s;
(effective $v = 0{,}17 – 0{,}23$ m/s) , for the feeding device of the mentioned TB model with the Operational Dimensions.

Being verified the importance of the special measuring stand for the other control way, what is the Control Speed of the feeding device - for the timber barking model with the operational dimensions; the mechanical problem was appeared – the electrodes breaking. In spite this fact, the control speed way seems to be effective – especially for the Low subcortical layers quality logs, however with any other electrode type. To be used for Industry Timber Processing – the precautions number has to be projected – to be respect the restrictions mentioned above.

Probably seems, to be very early – to want – to compete this developing, fine (rather complicated – to this time) Robotized System vs. The traditional, simply, rough, mechanical TB way, which is usually manned with one person only, who is no special expert. It's worth seeing, that not only technical and economical aspects are followed, by this no-wood loss timber barking method, but the ecological aspect, too – to help to conserve the natural resources – being prevented the potential negative consequences for the environment and human life, what is – the green woods loss.

ACKNOWLEDGEMENTS

This research has been supported by Grant Agency of Czech Republic – GAČR, and by Research Programme of Czech Technical University in Prague MSM 6840770015.

REFERENCES

[1] M. Bumerl, "New Principle Timber Barking, AO 130 192; AO 148 475," habilit. work VSZ – Agricultural University Prague, Czech R. - Kostelec n C.L. 1975.

[2] F. Fetter, J. Hladik, "Barking Timber by Electric Current Effects," technical report of the state research project C-08-333-015, CTU-FME Prague, 1977.

[3] V. Tuma, "Design of Mechanical Part of Barking Device," drawings, CTU-FME Prague, 1980.

[4] J. Vlček, "Timber Barking by Using of Electric Current Effects," theses, CTU-FEE Prague, 1989.