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DEVELOPMENT OF CODE-MARKING EQUIPMENT FOR LOGS — SENSITIVITY OF FLUORESCENT CODE-MARK FOR LOG MARKING ENVIRONMENT

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Abstract: *This paper describes the readability of fluorescent paint marks for the development process concerning code marking of logs using automatic vision systems. The result indicates that using fluorescent paint is a technique with many advantages e.g. offering the possibility to be read under ice. An imprint marking technique was tested in the recently finished European Community LINESET project. One disadvantage of using paint instead of the imprint technique is the cost of paint. Another is its sensitivity to weather conditions during marking, but the paint is much better discernible for a vision system than the imprint code-mark also the mechanical constraints at paint marking are lower than at the imprinting.*

Key words: *Code-marking of logs, marking-reading system, fluorescence paint, environmental conditions in wood processing chain*

1. INTRODUCTION — WHY PAINT?

The first practical study of code-marking logs was carried out in Nordic project “Spårbarhet” (Uusijärvi R., Usenius A. 1997). Next project in the wood traceability field, started in 2000, was EC project LINESET (Uusijärvi R. 2003). In both these projects, log-marking systems using electronic log code labels (RFID transponders) that were injected into the logs near the log ends, were developed and used. A transponder is specially developed for identification but has a big disadvantage when used for log marking, the cost is too high — around 1 Euro each. Also the price (for the read-only transponder type) does not depend on the amount of information that will be used. While the transponders were developed, a common idea prevailing was that they would be much cheaper in the short future. The cost has decreased but very slowly and they are still too expensive. Another log code-marking system for the sawmill log sorting station was created in the LINESET project. The system was based on an imprint marking technique, Circular Code-Mark - CCM from the circular shape of the code elements, where a code mark was compressed onto the log end (Seidla A. 2002). The log marking took place directly after the log sorting operation and the code existed, and could be used, up to the moment when the log was sawn into boards. A default presumption and also the main reason for developing CCM was that the whole marking-reading system had to have as low a price as possible. The simplest and most rational way to reduce the cost was to avoid the cost of additional material for the mark and to create the code mark using only the wood material itself. The second possible advantage of using an imprint was the hope for easier recognition of the code. Toward the end of the LINESET project an idea appeared to create a cheaper code-marking system for harvesters instead of using transponders. The first idea was to build a pendulum device that could imprint the log end using the same or similar code-mark as CCM and the same code-mark recognising system that had already been created in the LINESET project. Nevertheless the pendulum idea was rejected as marking with the pendulum device meant a harvesting process time delay. Also only the root end of the log could be marked instead of the ultimate choice - the top end (Sondell J. 2002). The harvesting environment is also very aggressive so it was doubtful if the pendulum device would endure. Soon it was realised that maybe some kind of paint marking technique could satisfy the needs of harvester code marking. Usual paint was considered impractical according to a brief study performed during the LINESET project because the visual variation of the log ends was too big. Therefore an idea came up to use paints with a “glowing in the dark” feature. It was supposed that with this kind of paint it would be possible to filter out the visual variation of the log ends. The first idea was to test phosphorescent and fluorescent paints, the first of which can glow for a relatively long time after being charged with visible or UV light but the fluorescent paint can be activated only using UV. In this paper some tests using red solvent-based fluorescent paint called “Super Enamel” from Humbrol are described.

2. AN AUTOMATIC MARKING-READING SYSTEM — A COMMUNICATION TOOL

When developing a system for a log marking purpose, the code mark on the log end surface must be considered to be very different for the reading system in comparison with the log end itself. In the ideal case it must be something absolutely anomalous. If comparing an imprint and a fluorescent paint mark it is obvious that the latter is more anomalous on the log end. For example if using a CCD camera and a single light source for shadowing to read the imprints (Ekros E. 2002), it will be possible to find and account for some natural holes on the log end surface as imprint marks. Figure 1 shows a picture of a hole (Ø10 mm) and a ring (Ø10/Ø6 mm) pressed into a log's end surface (Pinus sylvestris). Figure 2 shows the resulting greyscale (0-255) in the cut from the marks in Figure 1 (the lines at the arrows).

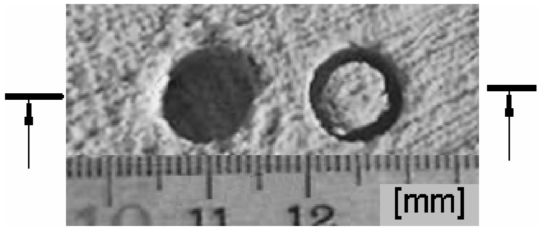

Fig 1. Hole (Ø10mm) and a ring (Ø10/Ø6mm) imprints in wood (Pinus sylvestris).

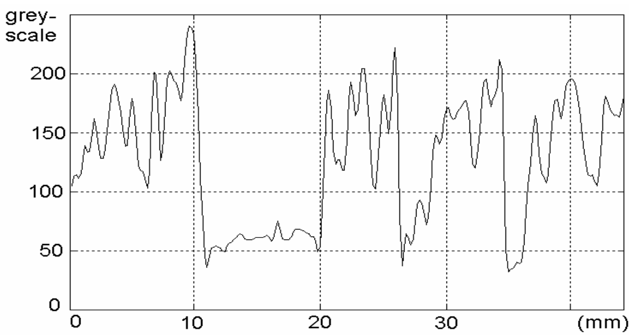

Fig.2. Greyscale (0-255) considering the spatial coordinates in Fig.1 at the lines at the arrows.

Figure 3 shows a picture of a log end (Pinus sylvestris) surface with twelve squares painted with red fluorescent paint. The biggest square has a side of 10 mm and the smallest a side of 0.5 mm. Figure 4 shows the same picture as in Figure 3 having the paint reactivated with an UV lamp (irradiance — 1400 $\mu W/cm^2$) in a dark room (nothing was perceivable to the human eye). The picture was taken with a CCD camera having an automatic adjusting of the brightness sensitivity so in these tests the absolute brightness of the pictures was not measured but the relative difference between the marks and the log end surface.

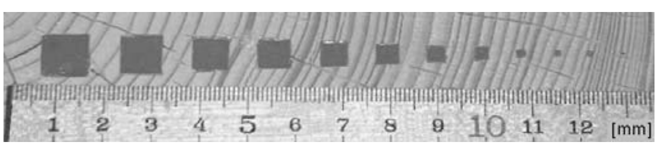

Fig.3. The twelve square (10 — 0.5 mm) marks of fluorescent paint. The log end has a much smoother surface than the log end in Figure 1 because of the rather accurate "filigrain" painting required in this very study, although during the real paint operation the surface roughness does not play such a big role.

Fig.4. Same test sample as in Fig.3. but here the paint was reactivated with UV light in a dark room.

In Figure 5 again is given a curve, which describes the greyscale of the painted squares according to spatial coordinates. When analysing this image it is translated into a greyscale without RGB-separating. Also note that the background between the bigger squares is much brighter, probably the emitted visible light from the paint has started to illuminate the background also the UV lamp probably was not homogenous enough.

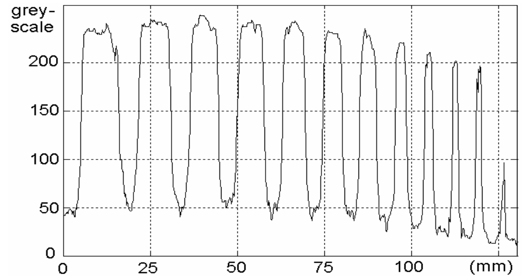

Fig. 5. The curve that describes the greyscale level of the twelve squares in Figure 4.

If comparing the signals in Figure 2 and 5 it is possible to conclude that even the smallest square in Figure 4 is perceivable and the signal in Figure 5 has much less noise than in Figure 2. When developing the imprint marking system it was supposed that the 3D feature of the imprints would somehow be practicable for the reading purpose. And that it would be possible to find some reading technique that measures the surface of the log end and detects the imprints without having to deal with the visual variation of log end surfaces. The problem with this measuring is that it must happen very quickly, mechanical contact is not proper. For example in the LINESET project a vision system including a camera and a laser-line was tested. If the laser line was moved over the surface with imprints it imitated the surface profile and the camera recorded the profile of the laser. But this system was as sensitive to the visual variation of log end as a usual CCD camera and much more expensive (Forslund M. 2001).

The code-marking must be made quickly and cheaply. A low price is of great importance because one can not determine strictly how beneficial the marking-reading system is economically; this system therefore should be recognised as to be highly sensitive to the price. The low price of the imprint mark was its biggest advantage. On other hand if marking with an imprint technique the marker and the log must get into physical contact with each other and this means many mechanical constraints on the system. If marking with paints, the marking gets much easier but the paint needs to be applied on a dry and clean surface.

3. THE MARKING AND THE READING ENVIRONMENT AND ITS VARIATIONS

In this chapter the environmental variations of the marking and reading process and the sensitivity of the fluorescent paint to these variations as well are described. The log material varies and causes changes in the paints; the time between marking and reading varies also so do the conditions at reading, marking and in storing of logs. All these mutations cause changes between the visual image of the code mark and that of the log end surface.

3.1 Variations at the marking process

Here is considered that the paint marking is made by a forest machine in the forest (where the log end surface was just made — fresh cut) but also the conditions for the marking at the log sorting station in the sawmill are taken into account:

- In the sawmill case, the first and the biggest problem is that the log ends can be covered with water, dirt, ice, and snow etc. This is the biggest disadvantage of paint marking. If the log end is covered with something solid and non-fixed to the log end surface, the marking will be unpractical. Also if the log end surface is covered with rainwater, paint marking is questionable.

- The moisture in the log varies. When considering the fact that most of the moisture passes out through the log end, it is still presumed that it will not remove the paint mark, but the paint mark could get small cracks but that would not affect the reading.
- The surface roughness of the log end varies and it varies considerably even on the same log end. The small problem of paint marking is that the same volume of paint would give different mark sizes; some of the paint penetrates into grooves and cracks on the log end. For example if the tree is “dead” (the biological functions are finished) already in the forest, the crosscut will be rougher (on the left side of Fig. 6).
- Cracks and small rifts can be found in the log end surface (they can be up to 5 mm wide). This can be a problem especially in the sawmill case and if the code mark is a small paint dot. Here is presumed (without a test) that if the paint mark is at least 4-5 mm wide then it should be visible despite of cracks.

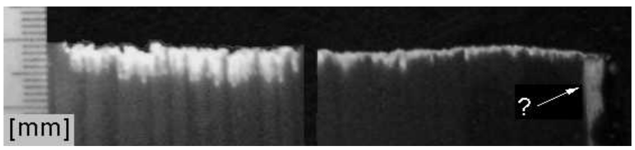

Fig. 6. Two longitudinal-cut log end surfaces with reactivated UV paint. Note that on the left picture the paint has penetrated up to 6-7 mm into the wood. Note also the white area on the right picture at the inner bark which is naturally fluorescent (in blue).

3.2 Variations at the reading process

Reading can take place wherever in the wood production chain after the marking operation where the log end is reachable — before sawing, after or before sorting of the logs or perhaps even on the road. By default it is presumed that for reading a visual reading technique is used. If looking with a camera on a code-marked log end surface there are two phenomena: the code mark and the other area that is not the code mark. When detecting the code mark, the most important parameter is the relation between the code mark and log end surface. In general the visual image of the log end surface depends on the following aspects:

- The reflection of tree material varies considerably but the variation is much smaller under UV illumination than under illumination of visible light (compare Figure 3 and 4). In general the variation depends on the natural reflection and texture of the wood surface, the time between marking and reading and on the storing conditions (sun, rain, and temperature) in the log yard. The visual image depends on the surface roughness of the log end. If using the fluorescent paint and the UV illumination, the roughness is not a problem, only the size of the paint mark varies.
- Unfamiliar objects can appear on the log end. Dirt, snow, ice, water etc. can also appear on the log end surface. The tests show that water is not a problem. The paint mark is also visible even though there is ice (Figure 10) and snow (Figure 8). On the other hand the code mark is not visible through dirt.

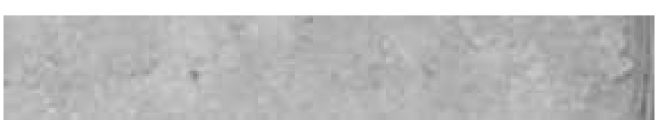

Fig. 7. The twelve squares are covered with snow (5 mm).

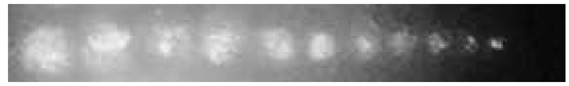

Fig. 8. The squares are reactivated with the UV light through the snow.

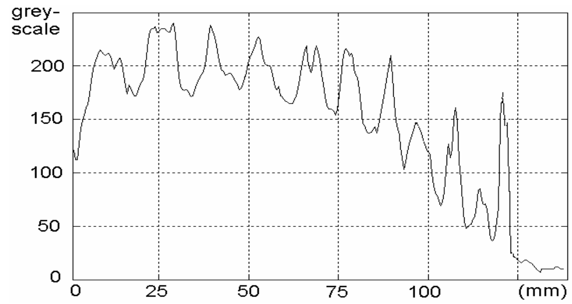

Fig. 9. The curve that describes the greyscale of the twelve squares according to the situation on the figure 8.

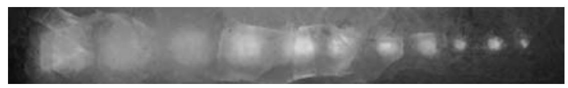

Fig. 10. The squares are reactivated with the UV light through the ice (4 mm). Another test sample (not Figure 3) with 11 squares, the smallest of which was 1x1 mm^2.

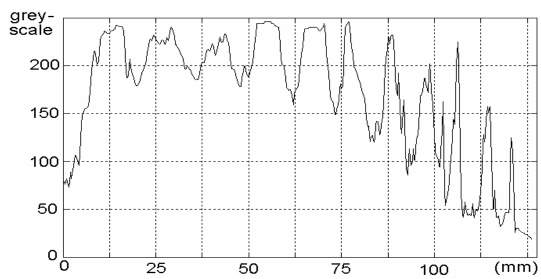

Fig. 11. The curve that describes the greyscale of the twelve squares according to the situation on the figure 10.

- The problem with UV-illumination is that resin, knots and the inner bark also are UV reactive in blue. In Figure 12 tree pictures are shown, the left shows a cross section of a fresh pine (Pinus sylvestris) in visible light and the middle the same test sample but UV illuminated. The knots are clearly discernible, in blue, but the paint mark, in orange, glows stronger.

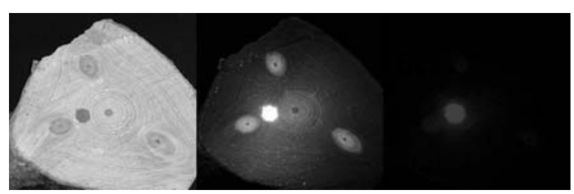

Fig. 12. Knots and a paint mark, the right picture is illuminated with a visible light, the middle with UV-light. In the right the middle picture RGB is separated and only the red colour is shown.

Also the paint changes with time; it is caused by the wood material under the paint mark and by the environmental conditions and of course by the time period. Perhaps caused by the erosion of the paint it loses its ability to glow in the dark. Figure 13 shows a paint mark on the log end surface, which has been outdoors for 1.5 years; the left picture is illuminated with visible light and the right picture is illuminated with UV-light. It is possible to conclude that the glowing ability of the paint remains even after 1.5 years and the paint mark is still discernible from the background.

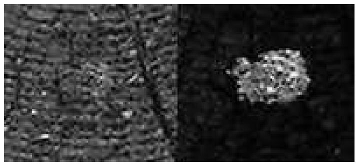

Fig. 13. The paint mark that has been exposed outdoors for 1.5 years, left in visible light right in UV-light. The size of the mark is approximately 8 mm; the erosion of the paint layer was not measured.

4. CONCLUSION

At the beginning of this investigation the most important question was whether the fluorescent paint marks would still be readable after having been exposed outdoors? Yes they did to some extent, but Fig. 13 shows they are still discernible from the background because the log end surface gets darker too and the difference remains. Surprisingly enough shows that this paint was strongly visible even through ice and snow. If comparing the readability of fluorescent paint (Fig. 4) and the imprint mark (Fig. 2) then it is easy to conclude that the glowing paint gives a much more homogenous and better signal than the imprints and the shadowing do. The idea of the anomalous object worked but not absolutely, the resin on the log end surface, knots and the area at under bark is visible under the UV light. As these objects emit blue light then it can possibly be filtered away if using RGB-imaging technique.

The smallest paint dot in the test was a square with the side of 0.5 mm and it was not visible through the snow. The marks that were tested in long time tests under 1.5 years had a diameter of ≈Ø8 mm. In reality the marks should probably be at least Ø 5 mm considering the problem with cracks, dirt, snow and ice. Something could also scratch the log end during the production process, for example the knife of the debarking machine.

This current paint costs 2.4 € per 14 ml can and painting the test sample in Figure 13 0.0004 g/mm^2 were used. As the exact density is not known then roughly assuming that 1g is equal to 1ml, then for painting an area of 25 mm^2 the costs would be ≈ 0.0017 €. This price is not too high but a cheaper paint is under testing, hopefully with same environmental durability.

In conclusion the tested paint is proper for log marking by a forest machine. In the log sorting station of a sawmill problems will appear. If the log end is covered with something solid and non-fixed to the log end surface it must be removed or the paint mark will probably be undetectable. Also the problems for paint marking of wet log ends must be further investigated.

5. REFERENCES

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