Modelling air-drying of wooden poles

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Subject of investigation:

Preserved wooden poles used for power and tele-communication lines, etc.

Before the creosote preservation these poles have to be dried to a MC below the FSP every-where in the pole.

Air-drying

In the present case air-drying outdoors is used. This method has both benefits and drawbacks.

One drawback is the long drying time and a good way to determine the drying end point is thus important.

End point determination

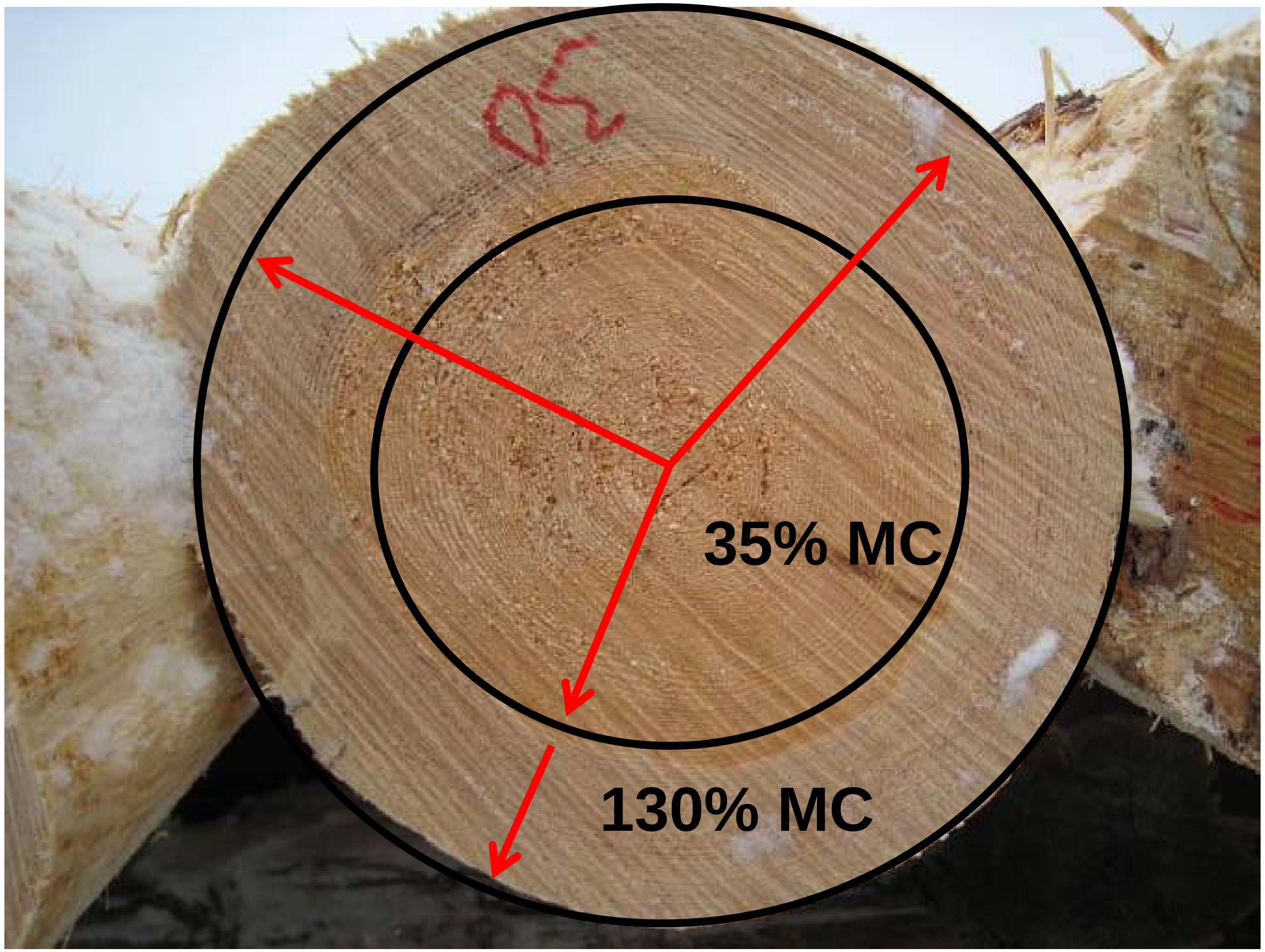
- Sampling possible only from the pole ends, but these are not reliable and a sample shortens the pole.
- Resistance meters are difficult to use as the sapwood/heartwood borderline depth is not accurately known.
- Advanced methods like X-ray, CT-scanning etc. are too expensive in this small scale operation.
- One possibility is to use simulation models and this alternative has now been investigated.

Simulation model

The model consists of two parts:

1. A model for moisture migration in a cylindrical solid. Sapwood and heartwood have to be considered as two different materials.
2. A model for the interaction with the surround-ing climate. The climate is defined by data from a nearby weather station (temperature, RH, wind speed, rain).

Internal moisture migration



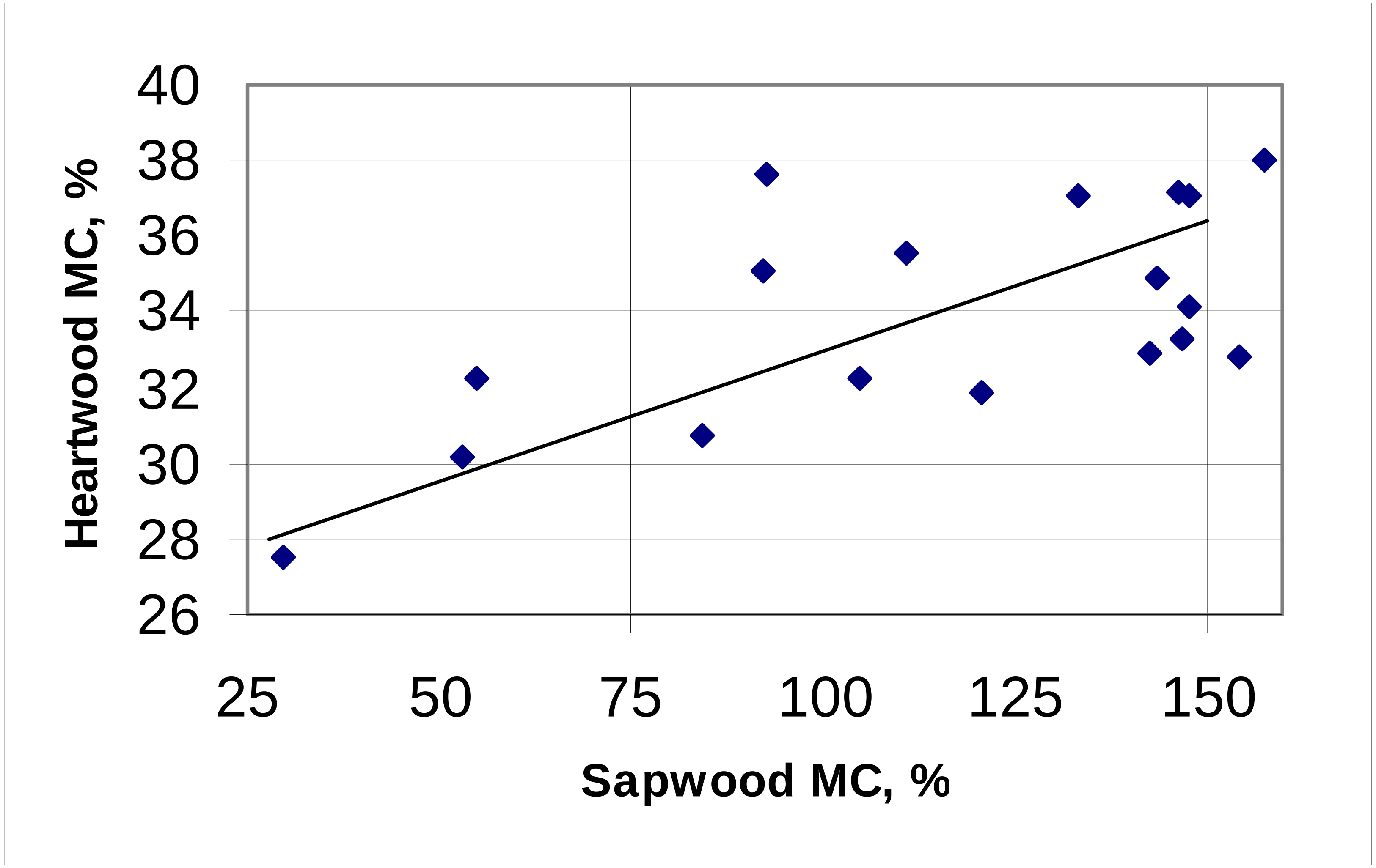
Internal moisture migration

$$\frac{\partial u}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}\left(Dr \frac{\partial u}{\partial r} \right)$$

Fick’s equation in cylindrical coordinates

MC is not an adequate potential for describing flow across the heartwood/sapwood border. The equilibrium MC-pairs in these two materials have to be determined in order to define a replacing potential.

Heartwood and sapwood mutual equilibrium MC values.



Internal model part

Moisture migration potential used in the model:

1. In sapwood: MC (as normally)
2. In heartwood: The MC in sapwood that is in equilibrium with the actual MC in heartwood (linear relationship assumed).

The final internal model is an updated version of an old model for kiln drying of logs and contains thus no further adjustable parameters.

External model part

- Daily average climate data are obtained from a nearby weather station (temperature, RH, wind speed and rain).
- The main problem is to determine the relation between the meteorological wind speed and the external heat (and mass) transfer coefficient, *h*, in the stack of poles.

Attempt:

$$h = a \cdot w^{0,67}$$

a = adjustable parameter, w = wind speed

Tuning of the model

- The model contains only one adjustable para-meter, i.e. the factor *a* in the wind speed equation
- The factor was determined by weighing 31 poles in a test stack during one summer period. In this way the MC development could be followed and compared to model predictions for different *a*-values

Test stack

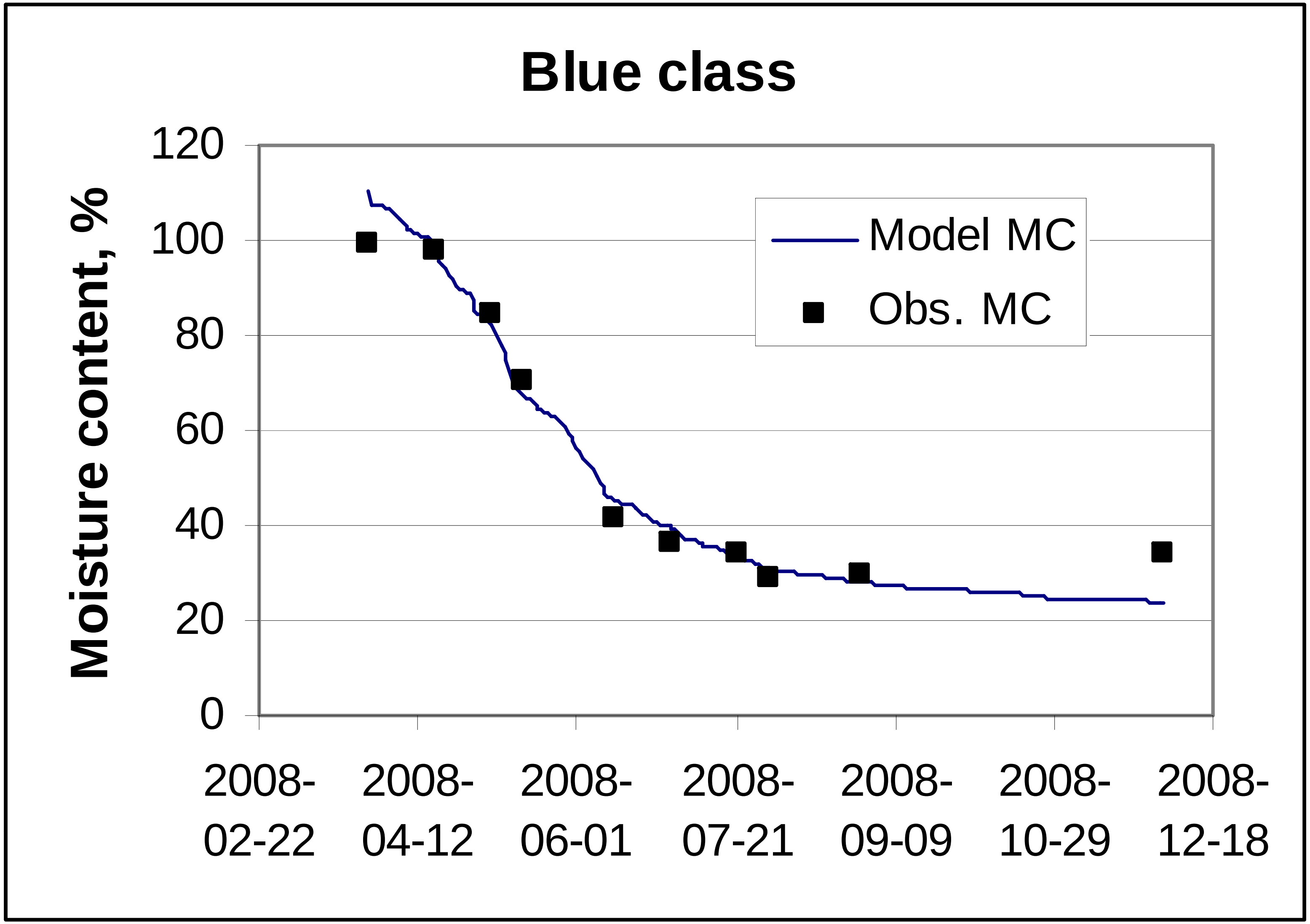
Test poles

Pole length, m	Diameter class	Butt diameter, mm	Colour code	Stack layer
12	Medium	261	Yellow	Top
12	Stout	366	Green	Under
11	Medium	305	Red	Under
9	Light	239	Blue	Under

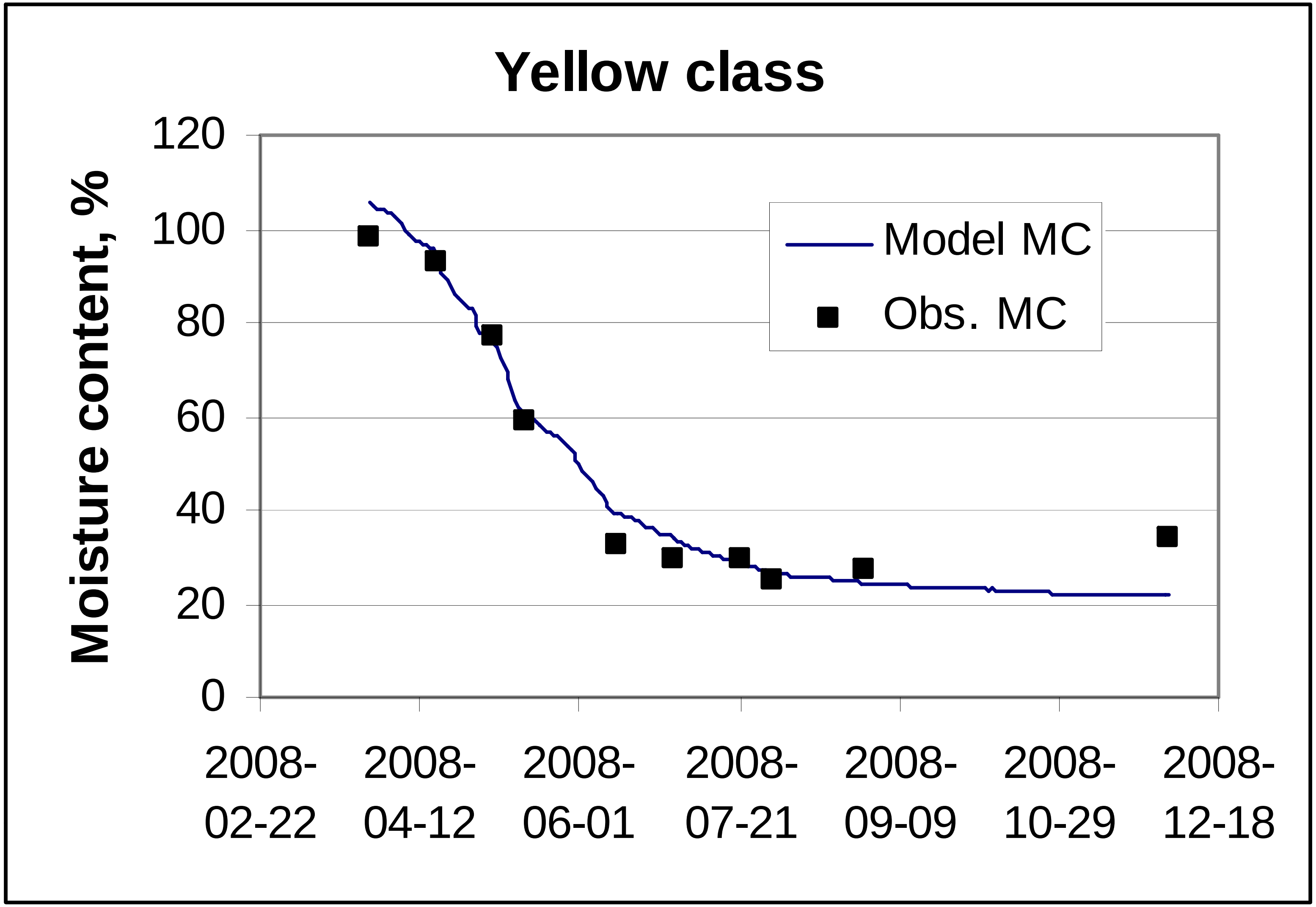
Results

- In the first analysis the influence of rain was neglected. The rain is assumed to flow off the poles without absorption.
- It turned out that the uppermost pole layer has a ~27% higher *a*-value than lower layers. This is probably due to the influence of sunshine and a higher air velocity above the top layer. Thus the top layer and the lower layers are simulated separately.
- The results are presented for the different classes:

Simulation results – best fit



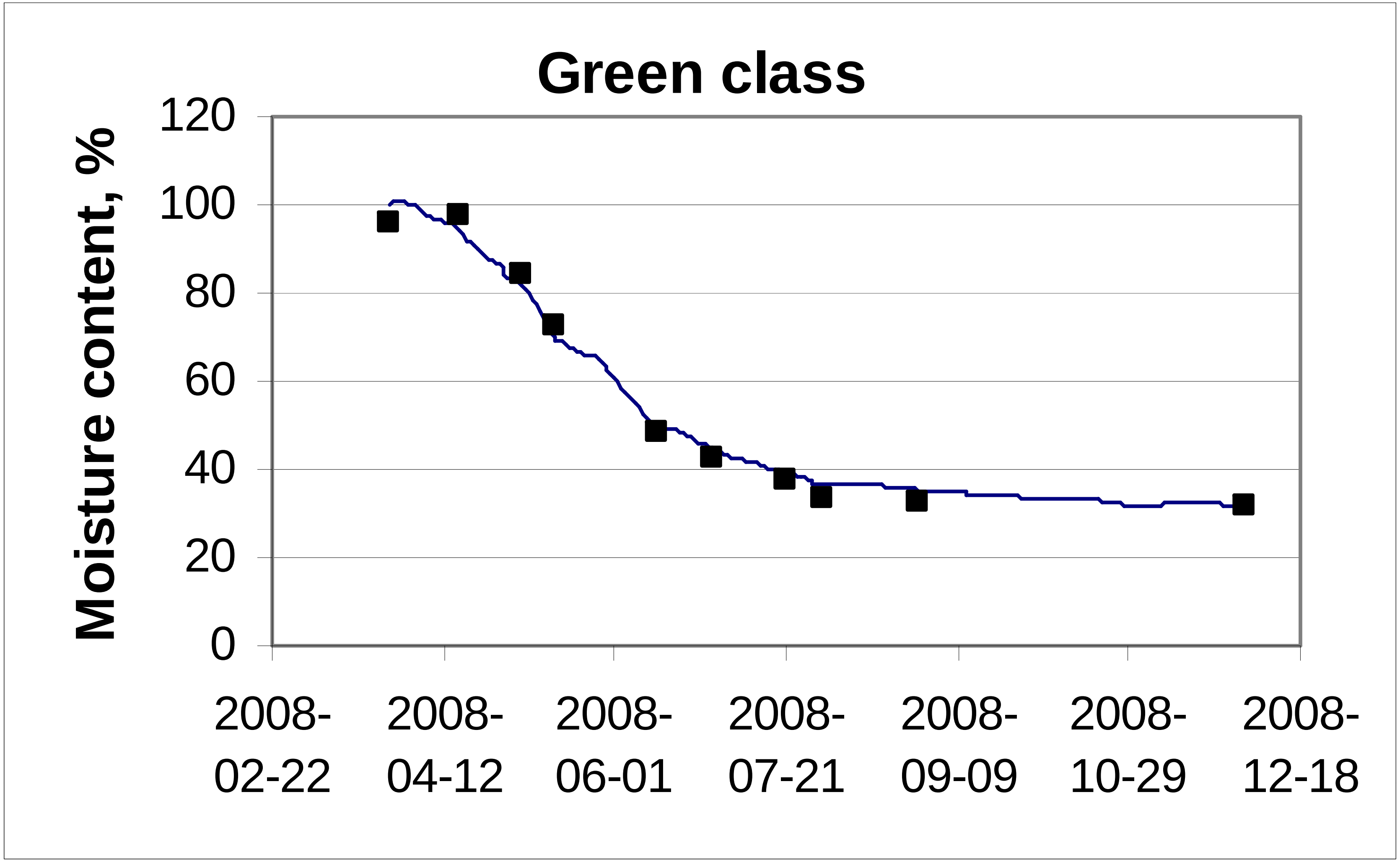
Simulation results – worst fit



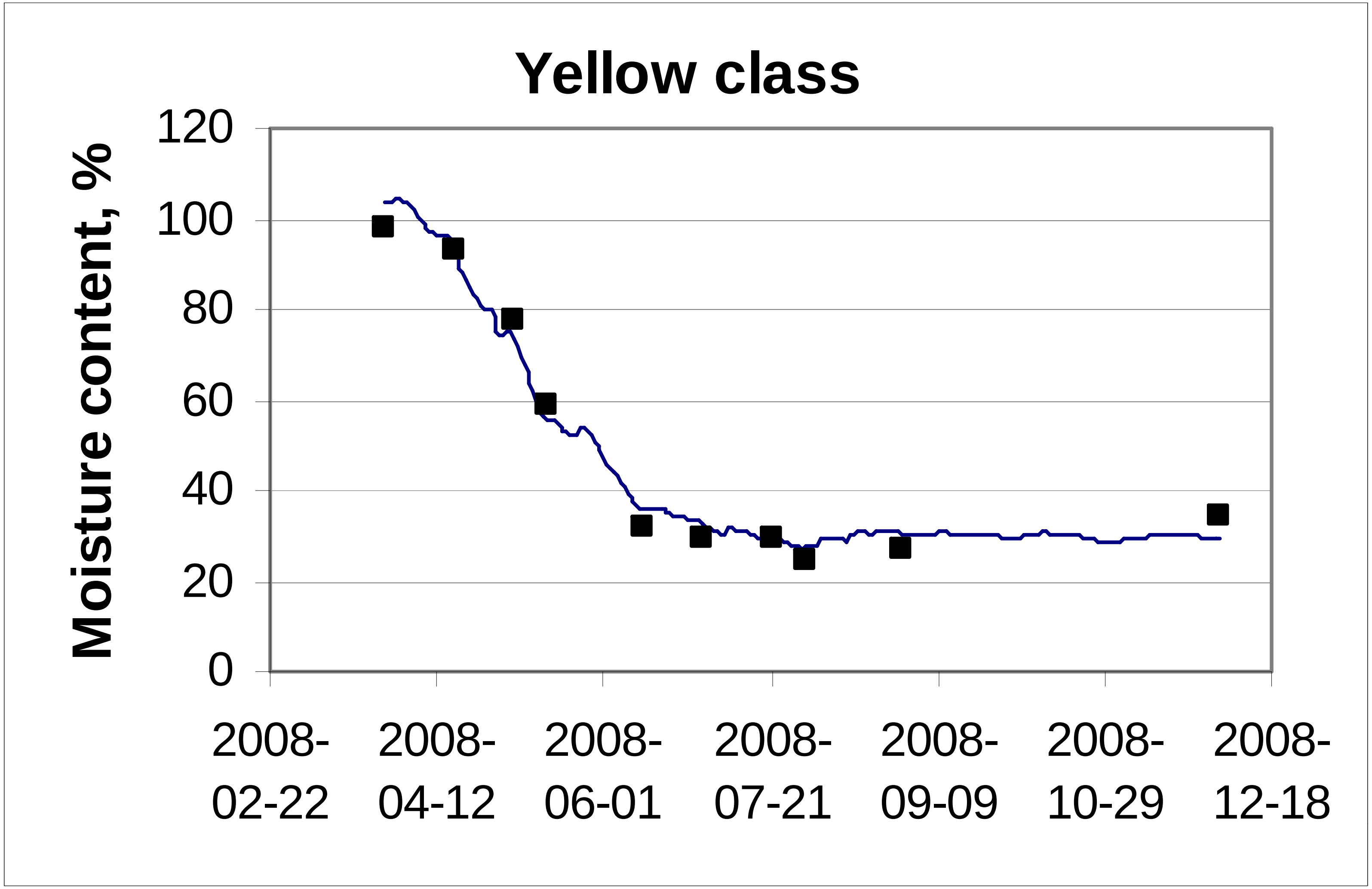
Further analysis

- In the next step it was assumed that a certain amount of the rain hitting a pole is absorbed and has to be evaporated in the drying process. This model has thus two adjustable parameters. Further a 24 hour sine-variation was super-imposed on the daily average temperature.
- Again it turned out that the top layer differs from the rest as a higher amount of rain is absorbed.
- In the model tuning process the last weighing in December with already frozen poles was now included.

New simulation – best fit



New simulation – worst fit



Conclusions

- The model seems to capture the main features of the pole drying process, despite only one (or two) adjustable parameters. It is thus believed that the model can be used as an additional valuable tool in the determination of the drying end point.
- The factory is interested in the MC development in the innermost part of the sapwood, i.e. the point when all free water has been removed.

Example of model use