Intra-ring internal checking in radiata pine

Dave Cown

Intra-ring checking, and its effect on value recovery from clearwood products has produced significant industry interest. In recent years Wood Quality Initiative and Solid Wood Innovation have funded a large amount of research in the hope of uncovering specific causes and eventually eliminating it as a serious defect in radiata pine.

Within-ring checking is specific type of internal checking. The checks are contained within single growth rings and not apparent on the surface, as distinct from surface checking which is clearly visible. It is only after the kiln drying process that these checks become visible. Depending on the severity of the defect, it can cause rejects, raw material losses and increased processing costs.

Normal occurrence is at low levels in timber, but it can be highly unpredictable. The checks cannot be covered with filler because they shrink and swell, so affected material is downgraded to firewood. All costs are borne by the wood processor as it is often impossible to identify the source of the logs. A level beyond five per cent in sawmill production is considered unacceptable.

Intra-ring internal checking is a well-known feature in the drying of certain hardwoods, notably the eucalypts. In softwoods, it has been mentioned sporadically in the literature for over 100 years (Reid & Mitchell, 1951), but mostly as a novelty rather than as a recognised defect of timber. Early reports from Europe attempt to relate occurrence of such checking to fast growth or climatic factors such as frost and drought.

Observations since then have been very infrequent until the 1990s. From 1990 onwards, internal checking of sapwood has become sporadically reported for plantation species, particularly radiata pine in the southern hemisphere (Cown & McConchie, 2000; Pang, Orchard, & McConchie, 1999b). It is a serious concern due to the large investment in forest operations producing clearwood, based on the assumption that the final products will be largely defect-free. Losses can be more severe in thicker timber and in edge-glued material. Some assessments have put potential losses across the industry at several hundred million dollars.

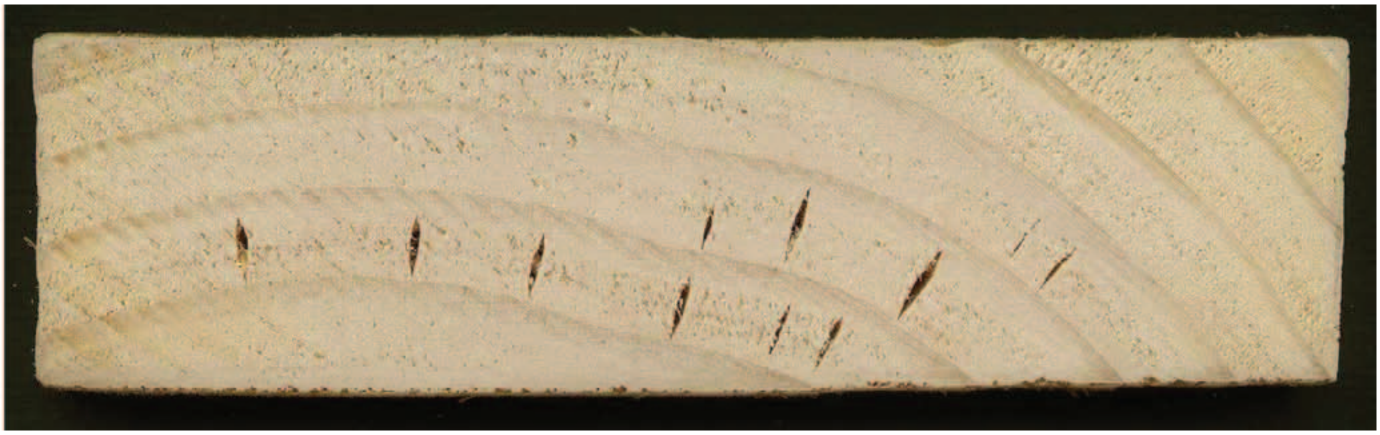
A lot of research has since been completed, mainly by WQI Ltd. Although several contributing factors have been identified, checking still remains a problem for wood processors because it is so unpredictable.

Causes of checking

Within-ring internal checking and collapse are caused by the same mechanism – stress created by differential shrinkage in the saturated sapwood fibres caused by evaporation of water at the surface of a board. In fresh sapwood, with moisture content well above fibre saturation point, such drying stress or tension can promote tissue collapse in low density wood. Some small studies have indicated that reduced lignification at the cell wall middle lamella may contribute to crack initiation at the cell or ray boundaries.

In sapwood with moisture content above fibre saturation point, such drying stress can promote tissue collapse in low density tissues wood, and ultimately initiate fibre separation and check development. Some small studies have indicated that reduced lignification at the cell wall middle lamella connecting individual cells may contribute to crack initiation at the cell or ray boundaries (Nair, Butterfield, & Jackson, 2009).

In contrast to sapwood, fresh heartwood of has a moisture content of only about 40 per cent and very few of its cells are water filled. As a result, radiata heartwood normally shows neither collapse nor internal checking on drying. Very occasionally internal checks are seen in heartwood boards. In this case, the internal checks did not form during wood drying, but in the living tree before the wood converted from sapwood to heartwood. This can be concluded because of the presence of callus tissue, indicating that they formed while the area was still living sapwood.



Effect of site

Studies have revealed the presence of intra-ring checks in radiata pine all over New Zealand. While site differences have been confirmed, no specific site factors have been identified to contribute to this. Several studies have investigated the influence of nutrients, such as boron and aluminium, without conclusive results.

Replicated genetic studies have indicated that it may be slightly more common in southern forests, where it has been suggested that the lower wood density may be a contributing factor. The highest incidence has invariably been gravelly sites in the South Island, where moisture stress is evident from the occurrence of false rings (Cown, 1973). Sites with extreme weather fluctuation have been implicated in European studies of spruce (Grabner, Gierlinger, & Wimmer, 2001).

Effect of growth rate

A common feature of affected wood appears to be wide juvenile growth rings with narrow late wood bands. It is now accepted that within-ring internal checking appears with higher frequency in fast growth softwood species worldwide (Vera, Ananias, & Diaz, 2007). However, growth rate alone is not the only factor – it is growth early on while stems are still producing low density juvenile wood. Studies of the ring structure failed to find a definite link to low density early wood (Ball, McConchie, & Cown, 2005a).

Effect of tree age

Most intra-ring checks occur in sapwood, where frequency decreases with distance from the heartwood boundary. Heartwood generally starts when there are about 10 growth rings from the pith and the deposition of extractives and some drying prevents collapse and check formation(Miller & Simpson, 1992). Older stems are less susceptible to checking because there is more heartwood and the sapwood tends to have a higher late wood content and higher density, and therefore more resistant to collapse. Irrespective of tree age, most intra-ring checks occur within five to ten growth rings of the heartwood boundary.

Occurrence within and between stems

Intra-ring checking has been found to be very variable between stems in all trials, but all studies have confirmed that the incidence decreases dramatically with height in the stem (Kumar, Cown, Ivkovic, & Burdon, 2010). Therefore the most affected logs are always the butt logs. Checks are relatively common up the stem as far as the third log.

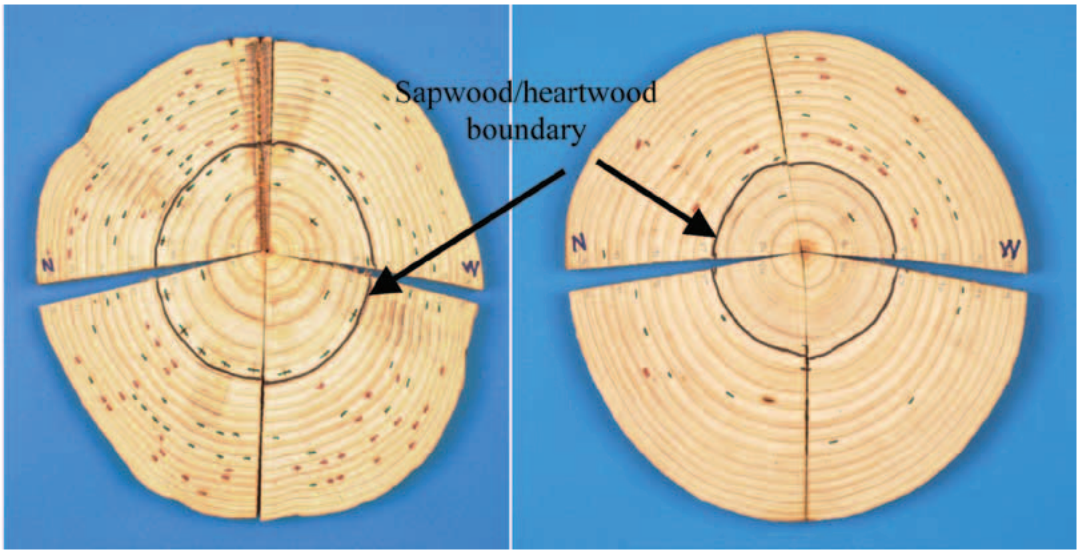
Effect of silviculture and genetics

Despite the inference that fast growth is associated with checking, Scion thinning, pruning and fertiliser trials have consistently failed to uncover strong statistically significant differences between treatments and controls. However, contrary to expectations of a growth rate effect, an analysis of the Tikitere spacing trial at age 26 years revealed that checking was significantly more severe at the higher stocking of 400 stems per hectare, where diameter growth was considerably less than in the 100 stems per hectare treatment.

The incidence of intra-ring checking is generally low, but there is often a high degree of variability between stems, some of it related to differential heartwood development. Genetic trials have confirmed a low to moderate heritability (Ball, et al., 2005a; Kumar, et al., 2010).

Effect of wood drying

Indications are that, although mainly resource based, internal checking is aggravated by increased drying temperature. It is also aggravated by the drying rate. Both are most critical in the early stage of drying when the timber is above 60 per cent moisture content (Booker & Koga, 2003). Compared to standard drying at 90°C, dehumidifier drying offers substantial reduction in within ring internal checking and also surface checking, although at the cost of significantly longer drying time (Haslett & Dakin, 2003).



Prediction of checking

As the effect of intra-ring checking is not apparent until after wood drying, various approaches have been used to try to predict its occurrence in the living stems or fresh logs before processing. These have met with variable success (Ball, McConchie, & Cown, 2005b; Booker, 1995) because the only real non-destructive possibility with disc or increment core samples is to estimate the tendency to collapse.

This has been used in some studies where fresh samples are available, such as from genetics trials (McConchie, 1999). Tests using the collapse tendency of fresh 12 mm diameter increment cores have proved to be most successful. Wood Quality Intiative developed a standard method or assessing collapse severity, with a strong focus on comparing genetic material at early age of seven years.

The future

There are now signs that foresters are moving away from the strong focus on fast individual stem growth and pruning for clearwood (Dean, 2012), and may concentrate more on higher stocking rates and longer rotations for structural timber. However, the harvest will still contain material highly prone to checking for some time to come from the first three sawlogs.

Under this scenario, intra-ring checking will become less frequent because of the smaller area of sapwood in stems and less of an issue overall. Nevertheless, it is frustrating that while there are significant variations between sites, the causes have not yet been firmly established and it will be important to continue research to clearly identify predisposing factors to ensure that the next generation of trees is free from intra-ring checking. Since there is moderate heritability for intra-ring checking, the most likely route of improvement will be tree breeding.

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