RECOVERY OF TURPENTINE FROM THE PRODUCTION OF MEDIUM-DENSITY FIBREBOARD

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ABSTRACT

The rate of production of oil and turpentine in the effluent from the plug screw feeder at the exit from the presteamer of a fibreboard pilot plant was determined after a steady state of operation had been reached. From these data, the recovery of turpentine from the plug screw feeder effluent, as a proportion of that available in the wood chips, was shown to be 27%. Turpentine levels in wood of *Pinus radiata* D. Don were determined and compared with previous data, along with causes of variations in these data. The presteamer plug screw feeder effluent from a medium-density fibreboard production line appears to be a useful source of turpentine.

Keywords: turpentine; medium-density fibreboard; presteamer plug screw feeder effluent; *Pinus radiata.*

INTRODUCTION

Turpentine is the volatile component of the resins of conifers (Drew & Pylant 1966; Zinkel & Russell 1989). It is the most abundant essential oil in nature and the oils of commerce are usually obtained from trees of the genus *Pinus*. Turpentine is described according to its origin as (a) gum turpentine, which is steam distilled from the resinous exudate of wounded pine trees, (b) crude sulphate turpentine (CST), which is condensed from the vapours produced during the alkaline digestion of pine wood chips for paper-making, and (c) wood turpentine which is obtained by the solvent extraction and steam distillation of waste wood (usually branches and stumps). Today, gum turpentine is produced largely in China, and crude sulphate turpentine in north-western Europe and North America. Turpentine consists largely of the monoterpenes, α- and β-pinene, and the inclusion of other mono- and sesquiterpenoids is dependent on the source species. Turpentine is used as a solvent, for the preparation of antiseptic pine oil, and for the synthesis of perfumery materials and plastic resins.

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The current world production of turpentine is not readily determined as economic data usually refer to imports to and exports from a country rather than production of turpentine — *see* Table 1 for the leading exporters of turpentine as listed in a United Nations statistics database (UN Statistics 2006). This database shows that New Zealand exported 2 tonnes of turpentine but it produced 1500 tonnes in 2005 (D. McKenzie, Carter Holt Harvey, pers. comm.). The price for crude sulphate turpentine in December 2004 was US$0.21/litre (Tilton 2004), but the current price for gum turpentine is over five times that value at US$1.08/litre (US$1245/MT — Nicole Zhou, Beijing Boatfly Century Technology and Trading Co. Ltd, pers. comm.). This difference in value reflects the absence of sulphur from gum turpentine which can therefore be used for the manufacture of perfumery materials without the need for extensive purification. The turpentine that can be recovered from a medium-density fibreboard (MDF) production plant will be very similar to gum turpentine in composition and purity and this, along with environmental considerations, was the driving force for the investigation of the economic potential of the recovery of turpentine from such operations in New Zealand.

TABLE 1–Countries which exported more than 2000 tonnes of turpentine in 2003 and 2004.

Country	Turpentine exported to the world (tonnes)	
	2004	2003
Sweden	9575	7130
Brazil	8545	10030
China	8400	16430
USA	8375	10950
Canada	8140	8600
Argentina	3750	3340
Portugal	2985	2275
Singapore	2640	4135
Russia	2375	2150

The volatility, flammability, strong aroma, and solvent properties of turpentine dictate that its recovery (removal) from waste vapour and liquid streams is desirable, and in some areas it is necessary in order to meet occupational health and environmental safety regulations. The recovery of crude sulphate turpentine from paper and paper-pulp manufacturing plants has been practised for decades, but the recovery of turpentine from other forest product operations has not been widely reported. The manufacture of wood products such as paperboard and particleboard is not new but the manufacture of MDF is a relatively new operation and one which is increasing rapidly due to the popularity of the product in the building industry.

While the processes involved in the manufacture of MDF are straightforward in principle, they are complex in practice. The MDF process simplistically involves the passage of washed wood chips to a presteamer, a vessel in which the chips are softened with steam at atmospheric pressure, and then to a preheater, a closed vessel in which the chips are again subjected to steam but at a pressure of 8 atmospheres. From there the chips are forced into a mechanical refiner, which consists of counter-rotating plates containing channels which decrease in diameter from the centre to the circumference and in which the chips are shredded to fibre. The fibre is mixed with a urea-formaldehyde resin and a wax, and water is removed from the mixed product in a cyclone drier. A homogeneous bed of the fibre-resin mixture is formed on a conveyor and led to presses which gradually remove air from the bed and hot-press the fibre to a density of between 500 and 800 kg/m^3. The board is then cooled, sanded, and cut to panels of a predetermined size.

The engineering of each plant is unique and is designed to make optimum use of water and energy. Consequently, if a turpentine recovery unit is to be established at one single position in a MDF plant, the question arises to which part of the plant that unit might be attached. Turpentine is most likely to be recovered from gaseous and aqueous streams emerging from operations prior to the refiner (Sueiro & Gill 1995), whereas hazardous air pollutants are most likely to arise from operations after the refiner (NCASI 1999). Sueiro & Gill (1995) demonstrated that “30% of the available turpentine can be extracted from the chips during the washing and conditioning operation. This fraction also includes the amount of turpentine removed in the pressate liquid from the plug screw feeders” and a NCASI (1999) study showed that 95% of hazardous air pollutants were due to formaldehyde and methanol. Much of the methanol is discharged from the presteamer (Suckling *et al.* 2005) and the remainder, together with the formaldehyde, is emitted from the resin (binder) during the pressing process. Over 20 years ago Rockhill & Hostetter (1982) described a process for recovering heat, steam, and turpentine from vapours which are released from the mechanical refiners employed in the production of thermo-mechanical pulp (TMP) from southern pines. They reported that 3% of the refiner steam consisted of volatile organics that were mostly turpentine and some 5.0–5.4 litres turpentine/tonne wood pulped were recovered. A method for recovering turpentine from vapours from the preheater of a thermo-mechanical pulp plant was described by Ryham (1990), whereas Tubolkin *et al.* (1996) utilised a two-stage condensation and adsorption system for recovering volatile compounds from waste vapour streams, but it is not clear to which part of the fibreboard process this system was applied. More recently, Rauscher (2002) developed a method which was similar to but improved on that of Ryham (1990), and was used to recover turpentine from the refiners. Reynolds (1990) patented a similar method which separated turpentine from the liquid effluent emerging from the plug screw that feeds chips from a pressurised preheater to the refiner in a thermo-mechanical pulp plant. About 11% of the condensate was oil and 98% of this oil was turpentine that was produced at a rate of 1200–1300 litres/day. In none of these studies was the yield of turpentine in the wood determined and so the percentage of turpentine recovered compared with the amount in the wood could not be determined.

Two studies carried out in New Zealand suggested that the plug screw feeder effluent that emerges from a MDF presteamer, rather than the preheater, is an appropriate site for a single turpentine recovery unit. In a study of the mass balance of turpentine resulting from the production of wood fibre in a large pilot plant, Suckling *et al*. (2005) found that some 62% of the turpentine recovered was in the liquid effluent which flowed from the plug screw feeder at the exit from the presteamer. A number of different methods were used to analyse the turpentine in the various vapour and liquid streams, and this lack of uniformity of analytical methods has cast some doubt on the results of that research. Similar work by McDonald *et al*. (1998) provided yields of turpentine from the screw press effluent in the same pilot plant and also included data from two industrial plants, but did not include the yield of turpentine from the wood used in the experiment, and so recoveries of available turpentine could not be determined. The study by McDonald *et al*. (1998), however, supported that of Suckling *et al*. (2005) by showing that the plug screw feeder effluent from the presteamer afforded more oil and turpentine than the effluent from the preheater. The present study was carried out to determine the recovery of turpentine from the presteamer plug screw feeder effluent of a fibreboard plant as a proportion of the turpentine in the wood, in order to support the view that this effluent was an appropriate stream from which to recover turpentine in a MDF-manufacturing plant.

MATERIALS AND METHODS

Wood Supply

Approximately 6.0 m^3 chips were prepared from residues of logs of *P. radiata* that were sawn the day before the experiment from trees that had been felled within the previous week.

Oven-dried Wood Content of Chips

The oven-dried wood content of chips was determined by drying fresh wood chips in a fan-oven for 48 hours at 110°C.

Pilot Plant Operation

Two chip presteaming experiments were performed under the conditions recorded in Table 2. For each experiment, approximately 3 m^3 fresh chips were weighed and loaded into the chip presteaming bin. Atmospheric steam was then applied to the

TABLE 2–Pilot plant operating conditions

	Run 1	Run 2
Wet weight of fresh chips (kg)	1030.5	1126.0
Oven-dry (OD) weight of fresh chips (kg)	450.1	484.3
OD wood content of fresh chips (%)	43.68	43.01
Plug screw feeder (PSF) run time (min)	40.13	43.50
PSF effluent run time (min)	45.98	47.75
Total PSF effluent (kg)	369.30	399.05
PSF effluent flow-rate (kg/min)	8.03	8.36
Fresh chip feed rate (kg/min)	25.68	25.89
Time to steam chips to 90°C (min)	16	14
Mean temperature in chip pre-steaming bin during run (°C)	90.3	90.5
Plug screw ram pressure (kPa)	500	500
Plug screw speed (rpm)	19	19

bin and the temperature increased to 90°C over a period of approximately 15 min. The fresh chips were then fed through the plug screw feeder (3:1 compression ratio) located directly under the presteaming bin at a rate of 25.8 kg/min. A cone-shaped ram pushed against the chips being discharged from the plug screw to assist in the formation of the chip plug. This ram was operated at its maximum pressure of 500 kPa. After the plug screw feeder, the chips were fed through the impregnator to the preheater and then discharged out of the rear flange on the preheater discharge screw. The impregnator and preheater were operated at atmospheric pressure and temperature. The weight of the chips discharged from the preheater was measured.

Sample Preparation

The plug screw feeder effluent began to flow 10 min after steam was introduced to the presteaming bin, and the chips began to flow after 15 min. A sample of the plug screw feeder effluent (4.5 litres) was taken when the effluent began to flow and another sample was taken after the chips began to flow. Further samples, each of 4.5 litres, were taken subsequently at 10-min intervals until the effluent ceased to flow. The samples were kept at 4°C until analysed.

Sample Extraction

Turpentine was extracted from each of the 4.5-litre plug screw feeder effluent samples by simultaneous steam distillation and liquid-liquid extraction in a Likens-Nickerson apparatus with 10 ml of dichloromethane for 4.0 hours. The solution was dried over magnesium sulphate and was partially concentrated. Octane (0.4 ml, (0.28 g)) was added to the extracted material and the solution was concentrated on a rotary evaporator at 40°C and atmospheric pressure.

Steam Distillation of Fresh Wood Chips

Fresh wood chips (22 kg) used in the pilot plant operation were placed in a 50–litre stainless steel cylinder and steam distilled for 4.3 hours. The temperature at the cylinder inlet was 119°C and the pressure was 600 kPa. The condensate was cooled to 50°C, passed through a water-filled oil-water separator, decanted, and its volume was recorded.

Steam Distillation of Spent Wood Chips

The wood chips, discharged from the pilot plant after 45 min operation (6.1 kg) were placed in a 50-litre stainless steel cylinder and steam distilled for 6.0 hours. The temperature at the cylinder inlet was 116°C and the pressure was 475 kPa. No oil was obtained from this sample.

Turpentine Analysis

The turpentine sample was analysed by gas chromatography, on a Hewlett-Packard 5890 series II gas chromatograph, fitted with a Hewlett-Packard Ultra 2 column, 50 m × 0.2 mm, which was coated with a 0.33-μm thick film of 5% phenylmethylsilicone. The column was programmed from 60°C (held for 1 min) to 250°C at 5°C/min. The injector was at 250°C and the FID was at 320°C. The carrier gas (helium) flow rate through the column was 0.6 ml/min. Analyses were performed using octane as an internal standard according to ASTM (2002) method D6387.

RESULTS

Oil and Terpene Content of Wood Chips

The fresh wood chips used in the pilot plant experiments had an average oven-dried wood content of 43.3% and an oil content of 3.55 g (4.0 ml) yield, 0.161 g/kg fresh wood (374 mg/kg oven-dried wood), and a terpene content of 2.82 g yield, 128 mg/kg fresh wood (298 mg/kg oven-dried wood).

Oil and Terpene Content of the Plug Screw Feeder Effluent Samples

The only components detected in the extracted oils by gas chromatography were the monoterpenes α- and β-pinene, camphene, limonene, and α-terpineol. The mass of each component was calculated from the gas chromatogram using the internal standard, and the total mass of all the terpenes was then obtained by summation of these results. The mass of the extracted oils and the total mass of the monoterpenes in these oils is given in Table 3 and the rate of production of oil and terpenes from the plug screw feeder effluent, averaged over two runs, is shown in graphical form in Fig. 1.

TABLE 3–Oil and terpene content of plug screw feeder (PSF) effluent samples

	Time (min)					
	5	10	20	30	40	45
Run 1						
Mass of PSF effluent (kg)	4.25	4.75	4.95	4.70	4.65	
Mass of oil (mg)	109	810	1084	844	1318	
Mass of terpenes (mg)	13	416	658	512	587	
Oil (mg)/PSF effluent (kg)	25.6	170.5	219.0	179.6	283.4	
Terpenes (mg)/PSF effluent (kg)	3	88	133	109	126	
Run 2						
Mass of PSF effluent (kg)	4.35	3.75	4.60	4.65	4.65	4.55
Mass of oil (mg)	479	294	784	968	605	862
Mass of terpenes (mg)	268	152	454	517	386	394
Oil (mg)/PSF effluent (kg)	110.1	78.4	170.4	208.2	130.1	189.5
Terpenes (mg)/PSF effluent (kg)	62	41	99	111	83	87

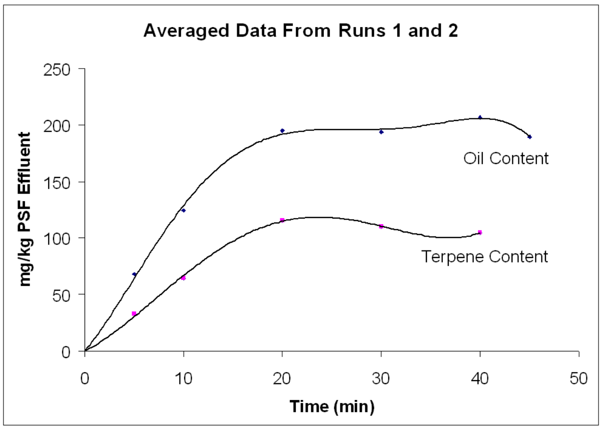

FIG. 1–Rate of recovery of oil and terpenes from plug screw feeder effluent, averaged over two runs.

DISCUSSION

Recovery of Turpentine from Plug Screw Feeder Effluent

Analysis of the chips, which emerged from the presteamer at the end of the experimental operation, demonstrated that the conditions used, viz, 90°C at atmospheric pressure for 45 min, were sufficient to remove all the (steam-distillable) oil from the chips. However, it is also clear, that under these same conditions, a uniform rate of oil extraction was not reached until approximately 17 min after the effluent had begun to flow from the presteamer (Fig. 1). Therefore, for this batch operation any samples taken before 17 min had elapsed could not be regarded as representative for analytical purposes. Conversely, data recorded after

17 min could be translated to a continuous operation, with one proviso. For a continuous operation, the residency time for the chips in the presteamer is the same for all the chips, whereas in this batch operation all the chips were loaded into the presteamer at the beginning of the experiment so that the first chips to emerge from the presteamer were heated for only 15 min while the last chips to emerge were heated for up to 60 min.

The "steady-state" rate of production of steam-distillable oil from the presteamer plug screw feeder effluent was 196 mg/kg while the corresponding rate of terpene production was 110 mg/kg, indicating that the oil had a turpentine content of 56%. The other 44% of the oil will have included furfural and non-volatile wax esters, diterpenes, fatty acids, sterols, and other lipid materials, as only monoterpenoids were detected in the oil by gas chromatography. These data agree with those obtained by McDonald & Clare (2000) who found levels of 45% of these materials in the chloroform-soluble portion of the presteamer plug screw feeder effluent from this pilot plant and 34% and 44% from two industrial plants. The oil yield of 196 mg/kg plug screw feeder effluent (0.02%) likewise is similar to that obtained by McDonald *et al.* (1998) for two commercial plants (208 and 236 mg/kg plug screw feeder effluent) (Table 4), even though the chip feed and effluent flow rates for the commercial plants were much greater than for the present study.

TABLE 4–Yields of oil and terpenes from pre-steamer plug screw feeder effluent

Sample	Source	Oil (g/*l*)	Terpenes (g/*l*)
1	Present work	0.20	0.11
2	Comm-1*	0.21	0.16
3	Comm-2 *	0.24	0.21
4	FRI *	1.02	0.91

* McDonald *et al.* (1998).

From Table 2, the average flow-rate of the plug screw feeder effluent for the two runs can be calculated as 8.20 kg/min, and the steady-state (period from 17 to 45 min) production of monoterpenes (turpentine) in this effluent was 110 mg/kg; therefore the rate of production of turpentine from the plug screw feeder effluent was 0.90 g/min. Likewise, the average flow-rate of the fresh chips through the plant for the two runs was 25.78 kg/min, and the fresh chips had a turpentine content of 128 mg/kg, and so the steady-state rate of turpentine production for the pilot plant operation was 3.30 g/min. Comparison of these two sets of data showed that the recovery of turpentine from the plug screw feeder effluent, as a proportion of the potential yield (by steam distillation), was 27%. The results of the present work therefore are consistent with those of Sueiro & Gill (1995) who recorded a recovery of 30% for their process, but our data are somewhat lower than those estimated in the study reported by Suckling *et al.* (2005). This work therefore suggests that a recovery of turpentine from the presteamer plug screw feeder effluent in a MDF production plant will be around one-quarter to one-third of the turpentine level in the wood chip furnish. Since the spent chips contained no residual turpentine, then the 70–75% of the available turpentine that was not recovered must have been discharged to the atmosphere from the presteamer; one might argue that to enclose the top of the presteamer and condense the steam and volatile emissions from that vessel would be a fruitful means of recovering turpentine. Such a study has not been carried out on a large scale.

Turpentine Content of *Pinus radiata* Wood

A small number of publications list the terpenoid content or composition of *P. radiata* wood, but few of these have employed an internal standard to calculate the absolute values. Using steam distillation to isolate turpentine, Suckling *et al.* (2005) found 447 mg/kg oven-dried wood and McDonald *et al.* (1999) found that 25 samples of 13-year-old *P. radiata* sapwood provided mean terpenoid yields of 167–518 mg/kg oven-dried wood with an average yield of 232 mg/kg.

The fresh chips used in the present study, yielded oil at 160 mg/kg which had a turpentine level of 79.5%. These data afford a turpentine yield of 128 mg/kg fresh wood and, since the oven-dried wood content of these chips was 43%, then the turpentine level of the chips was 298 mg/kg oven-dried wood. The chips used in this example were collected in September, but the terpene yield of freshly chipped wood collected in February was 2.15 g/kg oven-dried wood, while the terpene yield of weathered chips that were collected in the same month was 1.43 g/kg oven-dried wood. Clearly, seasonal and other factors (*see below*) make a generalisation of wood turpentine yields difficult.

Steam distillation was chosen as the method for determination of the level of turpentine in wood as it closely resembles the processes involved in the production of MDF board. The Kraft process used to produce pulp and paper from wood affords higher yields of turpentine as the wood structure is dissociated to produce a mixture of fibrous material, largely lignin and cellulose, suspended in an alkaline solution of extraneous chemical products such as fatty and resin acids, sterols, and terpenes. The annual production of crude sulphate turpentine (CST) in New Zealand in 2005 amounted to 1500 tonnes (D. McKenzie, Carter Holt Harvey, pers. comm.), which was derived from 3.5 million m^3 wood and represents a yield of 0.43 kg CST/m^3 fresh wood. If *P. radiata* wood has a basic density of 425 kg/m^3, then this yield converts to 1.21 g CST/kg oven-dried wood. This crude sulphate turpentine has a turpentine content of 85% and because the Kraft mills in New Zealand use both batch and continuous digesters, from which crude sulphate turpentine is recovered in yields of approximately 50% (McSweeney 1989), then these yields convert to levels of 0.73 kg turpentine/m^3 fresh wood and 1.70 g turpentine/kg oven-dried wood. These yields are derived from mature trees that were felled over a 12-month period and therefore are devoid of variation due to age and season and to differences that may occur between sapwood and heartwood. These data are the only yields available for the production of turpentine in New Zealand and can be compared with the yields mentioned next for turpentine from American pine species which were determined from annual production and with the digestion method of analysis.

Variation of Yield of Turpentine in Wood

The wide variation in terpenoid content of a wood sample is due to factors including the method of analysis, the proportion of sapwood to heartwood, sample height, tree age, geography, and season. Data for comparison with *P. radiata* were obtained by Drew & Pylant (1966), who used a digestion method to extract turpentine from a range of conifers and did not use an internal standard. Their work demonstrated that turpentine yields from 14 species of pine averaged 3.4 g/kg oven-dried wood. Drew (1987) showed that the turpentine content of *P. taeda* L. (loblolly pine) could vary by over 90% (1.6–3.1 g/kg), merely by virtue of different geography. Foran (1984) stated that a juvenile tree yielded 4.2 g/kg oven-dried wood, and mature trees of the same species yielded 5.1 g/kg. Seasonal variation of turpentine content has been studied extensively. Pearl (1975) found that loblolly pine would produce 2.1 g/kg in June/July but this would increase to 5.6 g/kg in December, while *P. elliottii* Engelm (slash pine) produced 2.2 g/kg in July but 6.1 g/kg in November. In addition to these factors, wood chips prepared for MDF production are stored for varying periods in large piles which are exposed to the elements. Springer (1978) and more recently NCASI (1995) reviewed the extensive work which had been published on evaporation of turpentine from chip piles and showed that losses of turpentine up to 90% of the potential yield could occur, the extent depending on factors such as those already mentioned.

Methods for Recovery of Turpentine

Compliance with environmental regulations might be the primary reason for recovering turpentine from a MDF plant, but other reasons include for use as a furnace fuel and for the manufacture of perfumery materials. Unlike crude sulphate turpentine, turpentine recovered from MDF manufacture will be free of sulphur and therefore can be described as wood turpentine, which is commercially more desirable. Sale of this turpentine could offset the cost of compliance with environmental regulations, which might include the installation of equipment for the recovery of turpentine and other volatile materials, e.g., methanol, acetic acid, furfural, and formaldehyde. Sueiro & Gill (1995) noted that the low concentration of turpentine in the pressate water from the plug screw feeders made removal by decantation unfeasible, and so they investigated a steam stripping method for recovery of turpentine. The method of Reynolds (1990) involved passing the plug screw pressate, which emerges under pressure from the preheater, to a separator where the pressure is released; the water and vapours are then condensed and separated, and the turpentine is decanted as for crude sulphate turpentine in a Kraft pulp mill.

The plug screw pressate from the atmospheric presteamer of a MDF plant is proposed as a good source of turpentine as the temperature of the presteamer pressate is much lower than that from the preheater and there is therefore no need to use a condenser which is capable of cooling large volumes of near-boiling water. However, some MDF plants recycle liquid from the preheater in order to maintain a constant pressure in that vessel. In such plants the choice of using the plug screw pressate from the presteamer or liquid withdrawn from the preheater to recover turpentine, as suggested above, would depend on the engineering of the plant (each one differs in the way that steam and water are recycled), whether scrubbers are present, and therefore where turpentine might accumulate. Of course, for optimum recovery of turpentine, liquids and vapours from both vessels should be utilised and, if the turpentine is to be sold rather than used as a fuel, then a steam stripping method is required to isolate the turpentine from the oil. Ultimately, benefit *versus* cost will determine these choices.

Potential Recovery of Turpentine from MDF Operations

New Zealand has one of the world's largest MDF plants, which annually uses some 700 000 tonnes of wood from virtually a single source (*Pinus radiata*). If these logs had a turpentine level of 128 mg/kg fresh wood, as determined for the chips used in the work reported here, and if 30% of the potential yield of (steam-distillable) turpentine was recovered from the presteamer effluent, then using a turpentine density of 0.87 g/ml this plant could produce a minimum of 31 000 litres turpentine per year. With a value of US$1.08/litre, the recovered turpentine would be worth US$33,500 annually. On the other hand, if the wood (700 000 tonnes) had a dry wood content of 43% (*see above*) and a turpentine level of 1.70 g/kg oven-dried wood, as was determined from New Zealand crude sulphate turpentine production, and if 30% of the potential yield of turpentine was recovered from the presteamer effluent, then using a turpentine density of 0.87 g/ml this plant could produce some 176 000 litres turpentine per year. With a value of US$1.08/litre, the recovered turpentine would be worth US$190,000 annually. Whether the annual yield of turpentine is 30 000 litres or closer to 175 000 litres will be determined by the efficiency of the presteaming operation at releasing turpentine from the wood chips. Furthermore, if the volatile material which is discharged from the presteamer were to be condensed, then these turpentine production estimates could double. In those regions where stringent environmental protection regulations necessitate the recovery of turpentine, such an operation, particularly at the upper level of these estimates, would provide an additional commodity or a valuable furnace fuel.

At a national level, some 1.7 million m^3 wood was estimated to have been used for the manufacture of fibreboard and particleboard in the year to March 2005, and 78.5% of the total production of fibreboard and particleboard was fibreboard (MAF Statistics 2006). Therefore, if the turpentine level in this wood was 90 g/m^3 (McDonald *et al.* 1999) and 30% of the turpentine from this wood was recovered, then 41 500 litres turpentine could be produced in New Zealand from the manufacture of fibreboard. On the other hand, if the turpentine level in this wood was 730 g/m^3 fresh wood, as was determined from New Zealand crude sulphate turpentine production, and 30% of the turpentine from this wood was recovered, then some 335 000 litres turpentine could be produced from the manufacture of MDF board. The MDF plant referred to above would be capable of producing more than half of this volume of turpentine. If the current national production of (crude sulphate) turpentine is 1500 tonnes (= 1 725 000 litres), then fibreboard manufacture could increase New Zealand's national production of turpentine by 19.5%.

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