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BRIEF ORIGINALS · KURZORIGINALIA

Minimizing dust emission during routing operation of rubberwood

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Subject The study evaluated airborne dust emission (0.1–10 μm) during the routing operation of Rubberwood (*Hevea brasiliensis*) in the furniture industry in South East Asia. It was found that the average chip thickness of 0.1 mm and wood moisture content of 12–14% minimized dust emission, while the cutting tool rake angle had little influence on dust emission. The study shows that adverse economic implications due to health hazards posed by airborne dust emissions during wood machining can be reduced by manipulating the average chip thickness and work-piece moisture content.

Introduction

The emission of airborne dust during the machining of Rubberwood (*Hevea brasiliensis*) results in increased incidence of respiratory problems and nasal cancer among workers in the South East Asian furniture industry (Anon 2008). Being the most important raw material for the wooden furniture industry in the South East Asian region, the machining properties of Rubberwood have been extensively studied (Hong and Sim 1999, Ratnasingam and Scholz 2007, 2008), yet reports on minimizing the dust emission during its machining are sparse (Ratnasingam 2008). Therefore, this study aimed at evaluating the factors that could minimize dust emission during the routing operation of Rubberwood, which is one of the most important machining operations in the furniture factory, so as to establish an industrial health guideline for the Rubberwood processing industry in the region.

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Materials and methods

The study was carried out in two parts. The first part involved a survey of 100 large Rubberwood furniture manufacturers in Malaysia, Indonesia and Thailand to evaluate the extent of health problems related to Rubberwood dust emission. The questionnaire based survey was carried out according to the method reported in Nylander and Dement (1993). In the second part of the study, a series of experiments were undertaken in the laboratory to evaluate the airborne dust (0.1–10 μm) emission during the routing operation using a MINIRAM (Model PDM-3) personal air quality monitor, as reported in Palmqvist and Gustafsson (1999). The routing operation was carried out under different conditions by varying the levels of the experimental parameters, moisture content (8, 12, 16%), rake angle (5, 15, 25°), and average chip thickness (0.05, 0.1, 0.15 mm). The choice of experimental variables used was based on previous researches by Koch (1964) and Palmqvist and Gustafsson (1999), while the levels of the experimental variables used were based on existing industrial practices. The experiments were implemented as a Factorial Design, with three replicates for each variable level as described in Box et al. (1978). The technique allowed the variables to be as-

Table 1 Average dust emission at different variable levels
Tabelle 1 Durchschnittliche Staubemission bei unterschiedlicher Spandicke, Holzfeuchte und Spanwinkel

Variables	Dust emission (dust units)	Impact factor analysis (average value)
Average chip thickness (mm)		−5.3
0.05	8	
0.10	5	
0.15	5	
Wood moisture content (%)		−2.2
8%	9	
12%	7	
16%	6	
Rake Angle (°)		0.28
5	8	
15	9	
25	11	

Note: Dust emission is expressed in dust units, i.e. higher number reflects higher airborne dust concentration and vice-versa.
Impact Factor value reflects the influence of the variable on dust emission, higher number indicates greater influence, and the −/+ signs reflect inverse relationship between the variable and dust emission.

sessed in terms of their importance in contributing to dust emission during the routing operation.

Results

The survey results showed that Rubberwood airborne dust in the range of 0.1–10 μm had the most severe effect on the health of the workers. 68% of the workers were confirmed as suffering from some respiratory-related problems after five years of prolonged exposure, while 3% reported the possible incidence of some form of nasal cancer after ten years of prolonged exposure. This finding coincides with the previous report by Nylander and Dement (1993), who showed a high susceptibility to nasal cancer among woodworkers exposed to airborne wood dust. It has also been suggested that the wood preservatives in the Rubberwood could also result in potential health hazard (Hong and Sim 1999, Ratnasingam 2004).

The experiments showed that the average chip thickness has the greatest influence on dust generation during the routing operation followed by wood moisture content and the tool rake angle (Table 1). The impact factor analysis suggests that lower average chip thickness and higher moisture content, reduced airborne dust emission significantly. Further, the tool rake angle had very little effect on dust emission from the evaluation of its confidence interval, as described by Box et al. (1978).

Industrial Implications

Although lower chip thickness will increase cutting tool wear and machined surface defects, it is much easier to control than the wood moisture content in industrial settings. This could be achieved by manipulating the rotational speed (RPM) of the cutting tool, while keeping the feed speed constant. This study shows that airborne dust emission during the routing process of Rubberwood could be minimized by targeting an average chip thickness of 0.1 mm, while keeping the moisture content in the 12–14% range. These recommendations could serve as possible industrial guidelines to minimize airborne dust emission during the routing of Rubberwood, which in turn will reduce the health hazard posed by airborne dust to workers in Rubberwood furniture factories in South East Asia.

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