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The Effect of Final Moisture Content of Mat on the Physical and Mechanical Properties of UF-bonded MDF[*1]

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매트의 최종함수율이 요소수지 제조 MDF의 물리 · 기계적 성질에 미치는 영향[*1]

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要 約

목질보드 제조에 있어 매트의 최종함수율은 에너지가 필요한 목질 엘리먼트의 초기 건조공정이나 열압싸이클공정, 목질보드의 균질정합성, 목질재료의 물리 · 기계적 성질 및 치수안정에 지대한 영향을 주기 때문에 대단히 중요하다. 지금까지 PB에 대한 최종매트의 함수율에 대한 연구는 많이 보고되어 있으나 요소수지로 제조되는 MDF에 대한 연구보고는 없으며 미국과 한국을 위시한 각국이 MDF의 최종함수율을 PB에 준하여 8~11%로 조정하여 MDF를 제조하고 있다.

따라서 본 연구는 미국산 침엽수 혼합수종으로부터 제조된 가압 해섬섬유와 요소수지로 제조된 MDF의 물리 · 기계적 성질에 관련된 적정 최종매트 함수율을 규명하고자 실시하여 다음과 같은 결론을 얻었다.

1. 혼합 침엽수 원료로부터 제조된 요소수지제조 MDF의 적정 최종 매트 함수율은 13% 부근으로서 현재 MDF공장에서 적용되고 있는 8~11%보다 높았다.
2. 평판이 시작되는 최종매트 함수율은 15.4%였다.

Keywords: UF-bonded MDF, final mat moisture content

1. INTRODUCTION

Moisture is a critical component in manufacturing wood composites due to its effect on the initial drying operation of wood substrate, press cycle manipulation, wood conformability and composite properties. Especially, in pressing composition board, the moisture content of a mat entering the hot press is of great importance. Mat moisture level and its distribution is probably the most significant factor governing not only the manufacture of board but also the physical and mechanical properties of a given board. Most particleboard can be bonded at moisture contents ranging from 2~18%(Maloney, 1977). But practically boards are pressed

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at moisture contents ranging between 7 and 16%, depending on the particular plant's operating parameters and species. Moisture content of the mats, can be used advantageously and can also cause problems. At the high moisture content level, it may require an excessively long press time. At the low moisture content level, closing problems and poor quality can be encountered. Many studies have been conducted for the mat moisture content of the particleboard, but none for urea-formaldehyde-resin (UF)-bonded Medium density fiberboard (MDF). MDF plants used to apply mat moisture content in accordance with those of particleboard. In the United States and the Republic of Korea, moisture contents ranging between 8 and 11% are usually used for the manufacture of UF-bonded medium density fiberboard from mixed conifers.

The objective of this study was to investigate the optimum mat moisture content of dry-process UF-bonded medium density fiberboard made from mixed conifers in connection with physical and mechanical properties.

2. MATERIALS & METHODS

2.1 Design of Experiment

Experimental design intends to cover the full range of moisture contents from 5% to blowing point. It was very difficult to adjust the final mat moisture contents on a laboratory scale for the statistical design, because moisture in the mat came from three sources and was changed at every step of the procedure.

Therefore, after attrition milling for the uniform spreading of adhesive, the forming procedure was conducted in a large humidity and temperature controlled room. But every real moisture content was different from the target moisture content. So we had to make 18 medium density fiberboards from 5% to blow point, 14 boards successfuly, 4 boards for conforming blows. For the statistical analysis, multiple regression was used in cooperation with ANOVA.

2.2 Material

Fiber material for the study was obtained from Medite MDF plant, and species of material were unknown because of mixed conifers. Moisture content of raw material at experimental time was at the range of about 7% to 8%.

2.3 Fiber blending

A treatment of 10% UF resin solids(Casco UF C261T) and 0.5% wax solids (Casco wax EW403) was accomplished in a rotating drum with an air automizing sprayer.

Fibers were tumbled through spray from a center-mounted sprayer. Nozzle size was Medium(Fluid Cap ID 0.028 in. Liquid Cap 0.073 in.) for wax emulsion and Coarse(Fluid Cap ID 0.058 in. Liquid Cap ID 0.128 in.) for UF resin. The coarse nozzle produced a fairly oblong, oval-shaped pattern. Air pressure used to spray was 35 psi.

2.4 Attrition mill

For the laboratory experiment, as found by Maloney, coarse attrition of 0.050″ plate clearance of Baver mill was needed to distribute adhesive uniformly in the fiber.

2.5 Mat forming and adjusting the final MC

The final mat was 20 in. by 28 in. for a 1/2-in. board and a specific gravity of 0.75 gr/cm3. Mat forming for adjusting final mat moisture content before entering the hot press was carried out in a large humidity temperature controlled room.

2.6 Pre-pressing and hot-pressing

Mats were pre-pressed at 50psi, then, within 1 minute hot-pressed. Preliminary tests showed that the following presstimes were adequate for the corresponding platen temperature and board thickness. A Siempel Kamp Hot

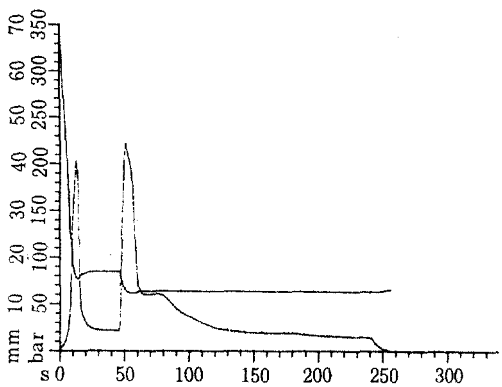

Fig. 1. Hot pressing condition(165, 4min, 10-50sec).

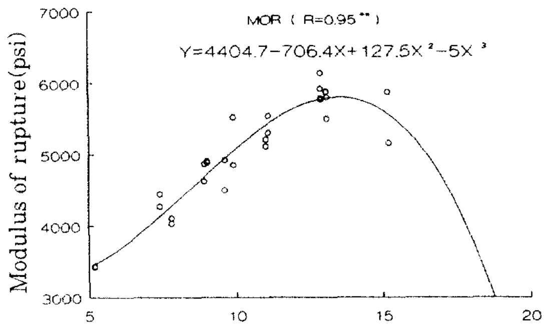

Fig. 2. Relationship between final mat moisture content and modulus of rupture.

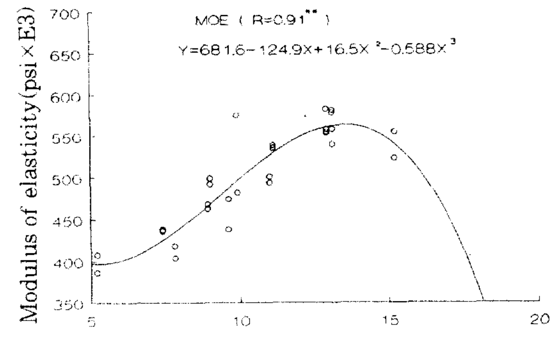

Fig. 3. Relationship between final mat moisture content and modulus of elasticity.

Press with an automatic computer system was used for the hot-pressing with the press temperature 165 C, total press time 4 miniutes, closing time 10 seconds and 50 seconds(Fig. 1).

2.7 Physical and mechanical properties test

Modulus of Rupture(MOR), Modulus of Elasticity(MOE), Internal Bond(IB), Water Absorption(WA), Thickness Swell(TS), and Linear Expansion(LE) were tested by the methods of ASTM D 1037.

3. RESULTS & DISCUSSION

3.1 MOR, MOE

The optimum moisture content depends on many factors such as the nature of the process, particle geometry, and wood density among others. Making generalization is difficult.

Previous work in mat moisture content of particleboard has shown that maximum board strength occurs at the moisture content ranged between 8 to 12 percent by Marion (1958) and maximum bending strength, at 11 percent by Kehr and Schoelzel (1968) who experimented with a three layer particleboards made from spruce furnish with a range of moisture contents between 8.5 to 18.5 percent using a press pressure of 13.5 kg/cm2 and a press time of seven minutes. The more the furnish moisture content increse the more bending strength decrese.

Hawke *et al*(1992) reported that changes in mat moisture content from 8 to 22% had no significant effect on IB, MOE, and MOR of polyisocyanate-bonded hardboard. Chow *et al* (1992) noted that mat moisture content (three levels: 6%, 9%, 12%) influenced all of the properties of the phenolic resin-bonded MDF. The average SG, MOR, IB, WA, and TS values of MDF made from mixed hardwoods and softwoods species fibers consisting of a mat moisture content of 12 percent were better than those of the MDF made from fibers consisting of either 6 or 8 percent mat MC prior to the press.

Results of MOR and MOE vs final mat moisture content are shown in Fig. 2 and 3. It may be noted that higher moisture content increases the MOR and MOE with a high significance (MOR R=0.95, F=110.56**; MOE R=0.91, F=76.37**). In Fig. 2 and 3 of cubic equation. The peak is shown around 13% and beginning point of blows was 15.4% of final mat moisture content.

3.2 IB

Kehr and coworker(1968) showed that internal bonding strength of particleboard was obtained at the furnish moisture content of 13.5 percent and the more furnish moisture content the less internal bond.

Maku and coworkers(1959) indicated same trends and the more furnish moisture content the longer press time.

Fig. 4 is polynominal and shows that 13% was the highest peak for IB(R=0.81, F=48.79**).

In genaral, for particleboard manufacture, higher mat moisture contents will result in lower-density board cores, lower internal bond strengths, and the possibility of blows or delaminations and caul-to-board sticking problems. Among the advantages of lower mat moisture content, higher general strength properties in particular internal bond can be cited (Maloney, 1977). But the results of MDF are different from those of PB.

The reason for higher internal bonding strength at higher mat moisture content of this experiment can be estimated in making the fiber more pliable (Kehr & Schoelzel, 1968 ; Steadman & Luner, 1985) by possible fiber contact bonding formation within resonable bounds so that the board does not blow.

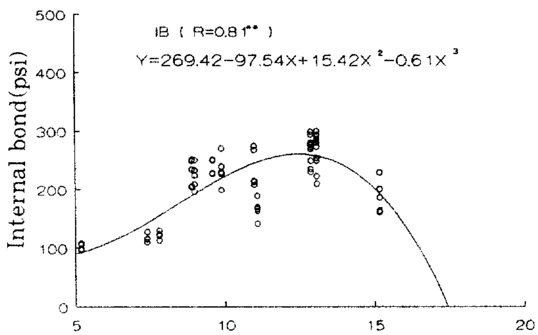

Fig. 4. Relationship between final mat moisture content and Internal bond.

3.3 Dimensional stability

Results of water absorption, thickness swelling, and linear expansion of MDF vs final mat moisture content are shown in Fig. 5, 6, and 7 (WA R=-0.52, F=9.62**; TS R=-0.80, F=44.78**). This indicates MDF has same results of higher water absorption from low mat moisture content as those of PB (Maloney, 1977).

In quadratic equation, the lowest point is about 13% of final mat moisture content. Near the point of blows water absorption and thickness swelling increase again but linear expan-

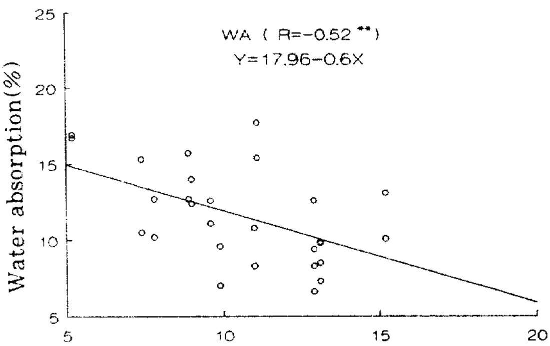

Fig. 5. Relationship between final mat moisture content and water absorption.

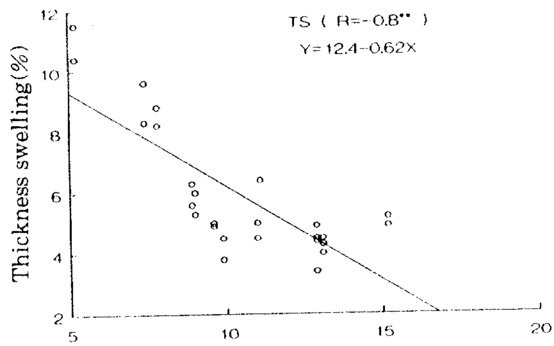

Fig. 6. Relationship between final mat moisture content and thickness swelling.

sion.

Fig. 5, 6, and 7 indicate that higher mat moisture contents will result in higher dimensional stability.

3.4 Density profile

Results of board density profile vs final mat moisture content are shown in Fig. 8. The best result was shown at the mat moisture content of 13.1 percent where the highest density of both surface and core were. High moisture content of 15.2% shows lower density than that of 13.1% and close to those of 9% and 8.9%. This means that high moisture content just before blowing point gives the lower conformability and mechanical properties than that of 13.1%.

The lowest moisture content of 4.8% indicates the lowest density.

In summary, Fig. 8 shows the moisture content around 13% is the best mat moisture content for the manufacture of MDF and supports the previous results.

4. CONCLUSION

1. The best final mat moisture content for the manufacture of UF-bonded MDF from

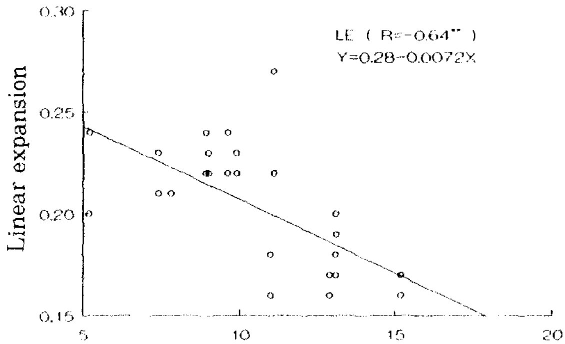

Fig. 7. Relationship between final mat moisture content and linear expansion.

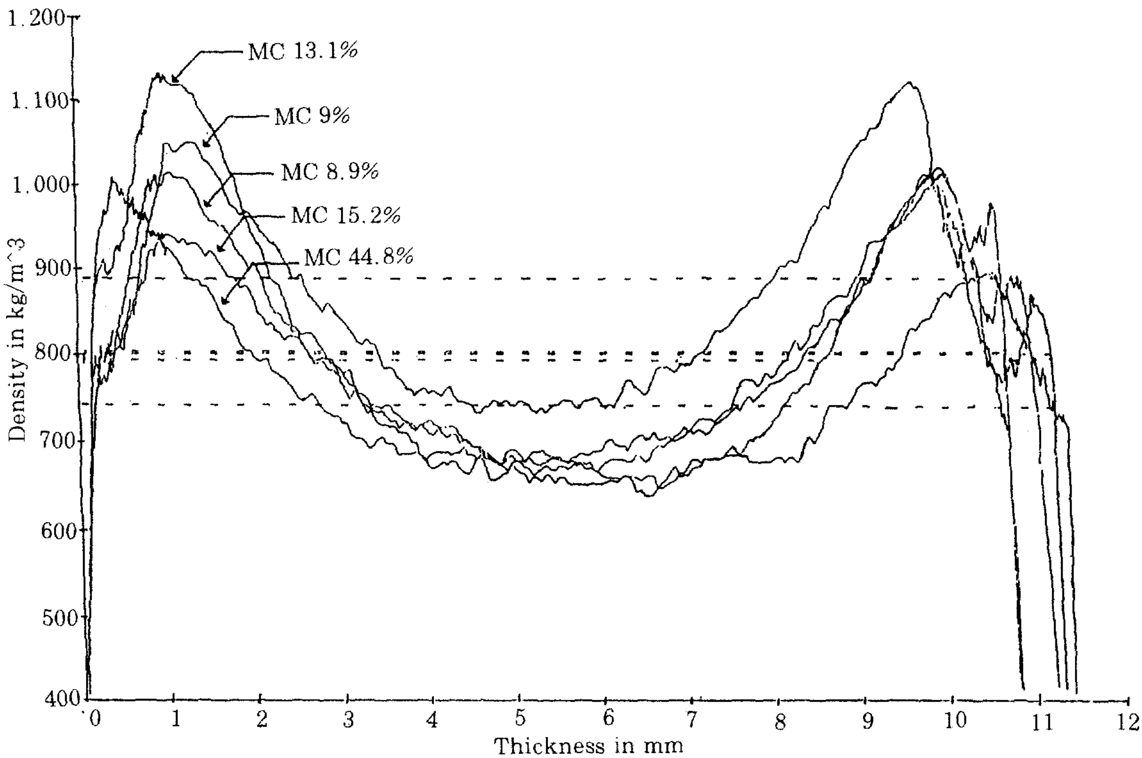

Fig. 8. Relationship between final mat moisture content and density profile.

mixed conifers was around 13% and higher than the range of 8% to 11%which is now applied in MDF plants.

2. The starting point of blows was 15.4 %.

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