Different approaches to press consolidation and drying

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Increases in strength of over 50% have been achieved with low-grade furnishes using multiple-nip press consolidation.

Major efforts have been directed at reducing the energy required to produce paper. This emphasis has led to research into pressing and drying and in some cases to the development of new processes. Of particular importance has been the widespread introduction of the extended nip and long press (*1*). A parallel development has been the use of steam showers to raise web temperatures before pressing. This technique reduces water viscosity, leads to a lower moisture after the press section, and can also be used to correct moisture profile problems that originate in the flow box.

Other developments have included impulse drying and press consolidation. Development work on impulse drying has been concentrated on the range of currently achievable pressing parameters. Pressures typically range from 1.0 mPa to 5.0 mPa, surface temperatures are from 150°C to 500°C, and nip residence times are 15–100 ms. A current review of impulse drying was recently presented (*2*).

Press consolidation and drying is a process in which a web is simultaneously consolidated (by pressing) and dried. Press drying is defined as a process in which "paper is dried under restraint due to the application of pressure in the *z*-direction during part or all of the drying process, while at the same time the paper is in contact with a hot drying surface, so that the temperature of the wet web is considerably in excess of 100°C" (*3*).

This process may result in considerable increases in strength properties and drying rate. The concept of press drying is not new, and its potential has been examined by many organizations worldwide. Much of this work has been conducted using static platen presses. Some of Pira's earlier work on such presses has been reported elsewhere (*4*). It is only in the last 5-10 years that work has been concentrated on developing a dynamic press.

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The benefits of press consolidation and drying

The conditions exerted on the web depend on the type of press drying used. Some of the advantages that can be gained by press consolidation and drying are:

- Increased web strength
- Improved product quality
- Reduced furnish costs while maintaining product specifications
- Increased drying rates, allowing production to be increased on dryer-limited machines
- Cost savings through lower refining requirements.

Because the web conditions are affected by the type of press drying used, there are a number of possibilities for altering the sheet structure and product properties. Press consolidation will result in a different relationship of strength to density than either extended nip pressing or hot pressing (*3*). The promising results relating to product quality have been reported primarily for various linerboard grades and newsprint; nevertheless, a smooth and dense sheet surface, good wet strength, and good dimensional stability have all been observed (*3*). Furthermore, delamination can result from the release of pressure built up in the web.

The mechanism responsible for the improvements in strength is the softening of lignin and crystalline hemicellulose when the web is subjected to high temperature and pressure. The glass transition temperature of sulfonated lignin drops from above 300°C to 115°C in the presence of water (*5*). Similarly, crystalline hemicellulose can reach its glass transition at temperatures as low as 90°C in the presence of water.

To raise the temperature of a wet web above 100°C, it is necessary to pressurize steam in the web. This pressurization requires heat and *z*-directional pressure to be applied to the sheet long enough to allow the energy to transfer to the sheet. This requirement causes engineering difficulties that are only now being overcome.

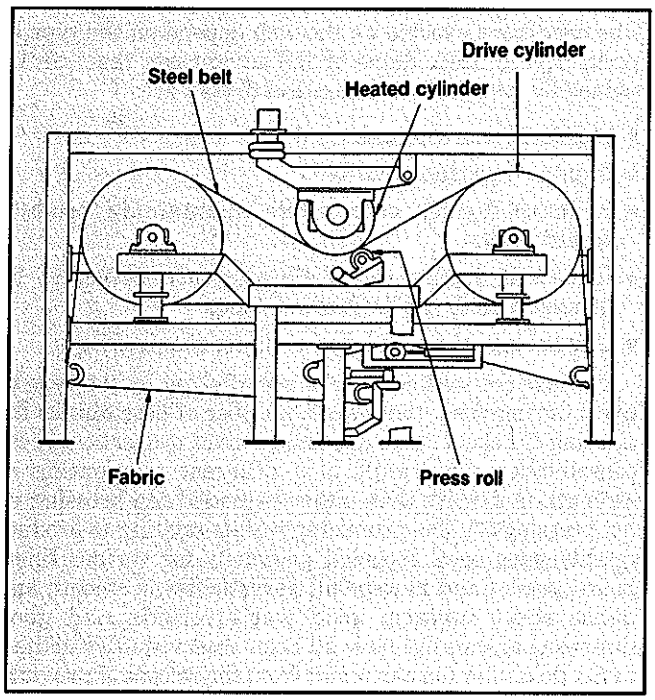
Types of dynamic press dryers

Pira has an on-going research program (*6*) for examining

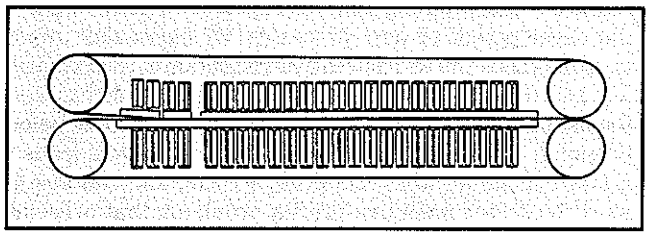
I. Specifications for press drying units

	Pira unit	Twin-belt particleboard		Conde-belt Press	Multiple nip system
		Pilot	Commercial		
Speed, m/min	0–400	0.2	up to 30	0–100	0–600
Nips, no.	2	1	1	1	1–6
Nip length, m	0.2 and 0.3	2	up to 50	1	0.025
Pressures					
Short nips, kN/m	150	...	...	...	0–70
Long nips, kPa	400	2800	up to 4000	0–500	...
Max. temp., °C	350	180	180	145	145

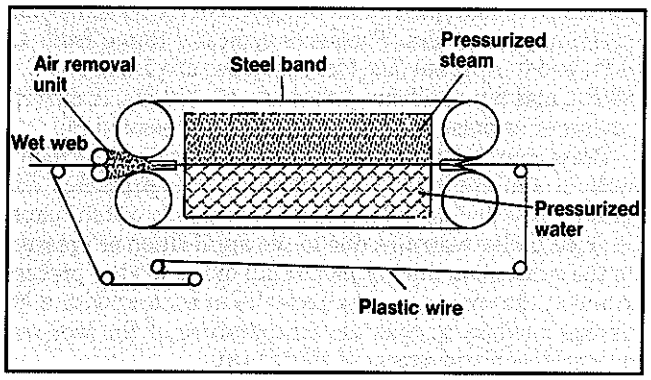
1. Pira press drying unit



2. Twin-belt particleboard press



3. The Tampella Condebelt Press



process and product development through press consolidation and drying. As part of this program, we have studied four different types of dynamic press dryers. These are:

1. The heated extended nip
2. The twin-belt particleboard press
3. Tampella's "Condebelt"
4. The multiple nip system.

Specifications for each of these are given in **Table I.**

Heated extended nip press—the Pira press drying unit

Illustrated in **Fig. 1**, this unit is designed to simulate a long nip press operating at high temperatures (up to 35°C) and at speeds of up to 400 m/min.

The machine relies on a tensioned steel belt to provide a maximum nip pressure of 400 kPa over a length of 0.3 m. A press roll mounted underneath the belt can apply additional pressure over a short nip length (2.5 mm).

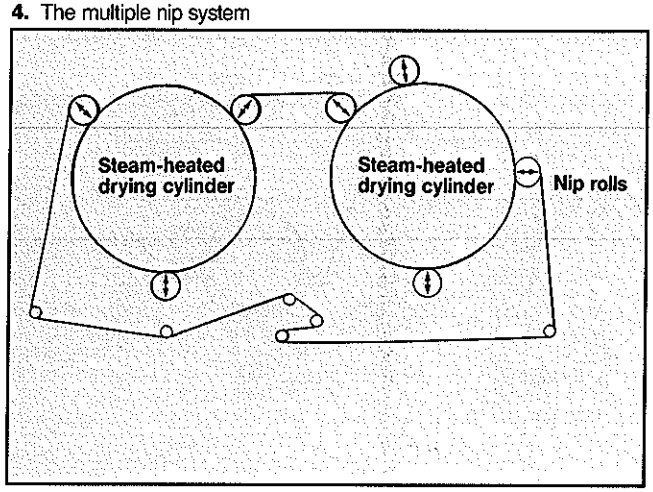
The rig is being used to assess the relative importance of the process variables in press drying. It has already contributed toward isolating optimum conditions.

Twin-belt particleboard press

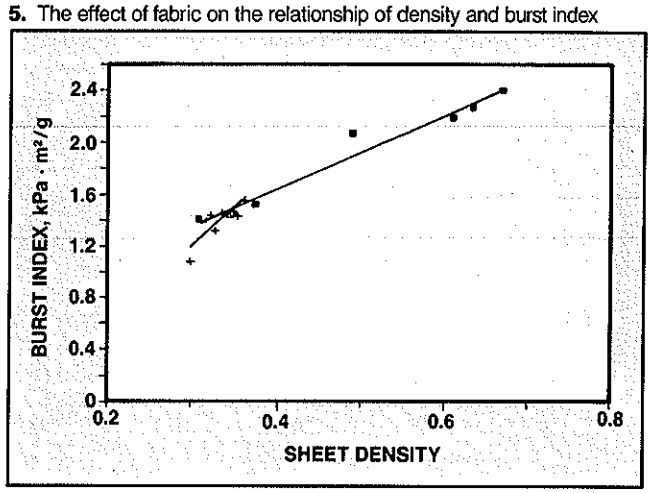
A typical machine system is shown in **Fig. 2.** These machines are of particular interest because they are an available commercial version of press drying. Although they operate at slow speeds by paper industry standards, they can produce severe press drying conditions. This press could have immediate application in the production of grades such as electrical board, where high density is important.

The results from a series of experiments conducted on

4. The multiple nip system



5. The effect of fabric on the relationship of density and burst index



a pilot twin belt press, owned by Bison Werke, showed that large increases in strength were possible through press drying.

Tampella "Condebelt" press

This machine is shown in **Fig. 3**. The press consists of two steel belts, one heated to 150°C and the other to 100°C. The wet web is placed against the hot belt. Water evaporates from the sheet, passes through the fabric, and condenses on the cooler of the two belts.

This novel process is being developed primarily for high drying rates, which are up to ten times those of conventional presses. A review of the development of this method was recently published (*7*).

The effect of dwell time in the nip on strength properties and an examination as to which variables are important in governing the process have been examined on this pilot machine.

Multiple-nip system

The multiple-nip system has been examined in the greatest depth. The system, as shown in **Fig. 4**, has the advantage of being relatively easy to build and could be fitted to existing machines.

Initial work showed an average increase in strength of 13% over a range of speeds up to 400 m/min. This strength increase was less pronounced at higher speeds. Nip pressure was not as significant as speed, with an optimum between 200 and 300 pli. Sheet damage occurred at higher loads.

This early work showed that the fabric (a forming fabric) was not ideal for two reasons. First, the fabric imparted a bad mark to the sheet. Second, it did not prevent steam from escaping the web within the nip.

Static trials were conducted to establish the suitability of different fabrics for press drying. Eight fabrics were evaluated and were found to greatly influence the properties of the press-dried sheet. **Figure 5** shows burst index against apparent density for sheets press dried under the same process conditions with the different fabrics. The fabric makes the difference between a 50% strength increase and no significant increase.

Experimental trials were conducted with the best of these new fabrics, using webs taken from three commercial machines. The web samples were collected after the press section, passed once through the multiple nip rig, dried on a steam cylinder if necessary, and calendered to the same smoothness as the machine product. The results from these experiments were compared with samples of the finished product taken from the reel of the paper machine.

Increases in strength of as much as 50% were achieved with the press consolidation unit running at the same speed as the commercial machine. Significant strength increases were demonstrated at the fastest operating speed of the machine (400 m/min) as **Fig. 6** shows.

Subsequent trials with commercial furnishes, increasing the number of nips, have shown strength increases of up to 70% at production-rate machine speeds of 150 m/min. Burst index, breaking length, ring crush, ply bond, stiffness, and density are all increased.

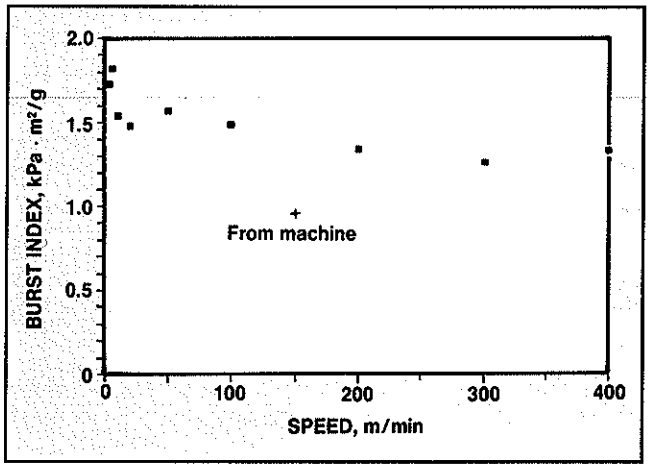
Significant increases in strength can be achieved from adding nips to a heated cylinder on a linerboard machine. Webs of low strength and high basis weight have given the best results. Furnishes with high recycled fiber content and a low degree of refining are particularly responsive.

Press consolidation units with multiple nips are now a commercial reality (*8*). As **Fig. 7** shows, these presses consist of a single hot cylinder with two rolls pressing onto the cylinder. These Tem-Sec presses, built by DG International, do not exert severe enough conditions to give many of the strength improvements we have discussed. However, they do achieve high drying rates, leading to increases in production and energy savings. The press section shown was developed for test liner and fluting; reportedly, it will give an average dryness after the press section of 52%.

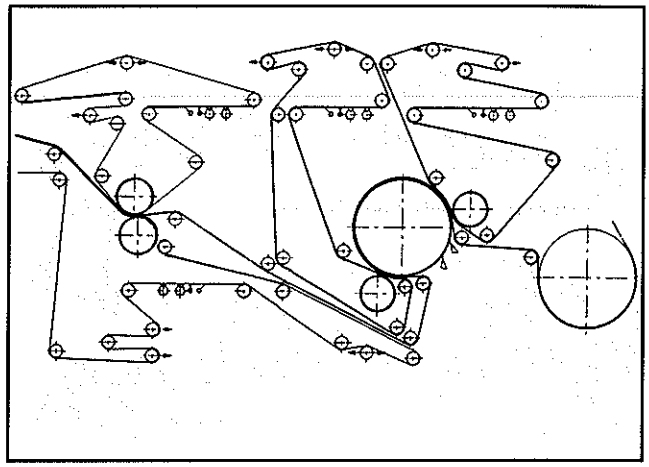
Conclusions

Press drying can improve strength at production machine speeds. Increases in strength of over 50% have been achieved with low-grade furnishes using multiple-nip press consolidation. Numerous product improvements are revealed in comparing the properties of commercially formed samples press dried in the pilot plant with commercially formed samples that have been commercially dried.

6. The effect of speed on burst index



7. Press consolidation unit with multiple nips



Optimization of process variables is important in achieving improvements in product quality. Fabric design is a crucial variable. Temperature, dwell time, and basis weight are the next most important variables, while nip pressure and initial moisture are less important within the specified limits.

Commercial machinery that utilizes this process to enhance drying rate is already available. Development of machinery for strength improvements is continuing. Ultimately, the design and use of the process will depend on the combination of properties required, such as the need for a smooth surface on one or both sides.

Many aspects for press drying need to be explored, including the possibilities for varying the furnish to meet product requirements and the potential use of the product in printing and writing grades. There is also the possibility of combining chemicals or synthetic fibers with various furnishes.

The Pira dynamic test rig is a versatile development on which a wide range of parameters that affect press drying can be examined. Research and development will continue, and the rig will be further developed in consideration of such factors as nip position, the number of nips, and the availability of a hot press *in situ*.

Press consolidation and drying now offers the paper and combined board industry an exciting opportunity. Commercial realization is just beginning. Press consolidation and drying is an important technological step toward developing and improving paper and combined board products.

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