Building Better Paper

Thad Fisher
Undergraduate Student, Packaging

Introduction

Paper is the oldest and most widely used form of packaging in existence today. Through the years, paper has continued to be the focus of many projects and has undergone numerous improvements. As engineers search for new ways to protect and contain products, paper continues to evolve and serve new purposes in the expanding world market. The issue is the lack of demand for ordinary paper results in the overproduction of paper. This has left many large paper mills wondering what went wrong. The global approach to paper production has shifted from high volume to high quality.

A study conducted by PricewaterhouseCoopers LLP shows the net earnings of the top 100 global forest and paper companies has dropped over 20 percent in 2002, while companies that focus on specialty grade papers have managed to improve their bottom line by 22 percent (Nelson 2003). Many paper producers and market analysts share PricewaterhouseCoopers'view of the paper industry. Simply stated, the market is flooded with standard paper. "The only way for some paper mills to stay competitive is to be innovative, produce new products, and break into new markets," (Harris, 2002). An article titled, "Packaging and Containers Industry" provided evidence that the market for craft and traditional papers is rapidly moving out of the U.S. and into other countries like China, Mexico, and India. This is happening for numerous reasons, including the fact that labor and supplies are cheaper and environmental laws are less restrictive in these countries (Harris, 2002).

Overview of Papermaking

The focus of this paper is to explore the production of higher grades of specialty paper through the use of pulp additives. In order to understand the advantages of pulp additives, one must first understand a little bit about the papermaking process. The main ingredient in paper is wood pulp. This is what provides the stability and volume needed to produce a sheet of paper. After this pulp is finely ground and mixed with water, it is beaten in pulping vats where other chemicals and materials are added in order to produce a sheet of paper with specific qualities. This is the stage when common additives such as starch (to improve tear strength) and polymers (to improve overall strength and decrease porosity) are added. Once the pulp and additives are beaten, they are carried to a head box. Next, a thin layer of liquid pulp is spread onto a moving screen. The screen then moves past stations where coatings can be applied to it. The coatings range from clay (to improve surface smoothness) to polyurethane (to decrease porosity). The screen then works with drying mechanisms, such as rollers and blowers, to remove excess water from the pulp, pro-

ducing a dry sheet of paper. Every process up to this point is referred to as the wet end of papermaking.

After the paper has become a dry sheet, the properties of the paper itself cannot be changed. However, it can be coated or laminated with other materials, such as plastic or foil, in order to produce specific qualities that are often needed for packaging products. One example could include food packaging. Any lamination or addition of other materials to a finished sheet of paper is known as a dry end application.

Breaking into New Markets

Currently, packaging is exploding with new, innovative plastics and package manufacturing techniques. This allows for faster and easier packaging, shipping, storing and selling of products. However, through it all, paper has remained the most commonly used material for packaging and shipping. Why is this? It is because paper remains inexpensive and easy to produce in mass quantities. However, paper is being viewed as little more than a structural component in a package, serving only to contain the product and keep the package from collapsing. This means that in order to add barrier properties, greater tearing/bending strength, or enhanced printability to a paper package, it must be laminated with materials such as plastic or metal foil.

Imagine the never-ending uses that paper that could be considered for if the tear strength and barrier properties could be incorporated directly into the sheet. A number of companies are currently working to develop specialty papers with packaging in mind. These companies range from specialty chemical producers, to food packaging companies, to material engineering firms. Their main goal is to develop materials and chemicals that can be added to the wet end of the papermaking process to produce an enhanced sheet of paper with little additional investment of time.

In an article from BASF, the author discussed two new advances that this company has made toward increasing the tear strength of paper. The focus of the article was making a stronger paper bag, but the author admitted that he could imagine this technology being used in all types of paper production. They have succeeded in producing additives that can enhance the tear strength comparable to that of a plastic bag. The two advances were molecularly modified starch and a substance known as polyvinyl amine. As stated by the author, this technology can have great impacts in areas of packaging in which products must be contained by packages having high tear strength.

In this time of economic uncertainty, it has become increasingly important to capitalize on new and different areas of the market. As shown in Figure 1 below, consumption of certain types of paper has been unpredictable, showing a downward trend over the past few years. However, demand for specialty papers has continued to gain market share and outperform the rest of the industry.

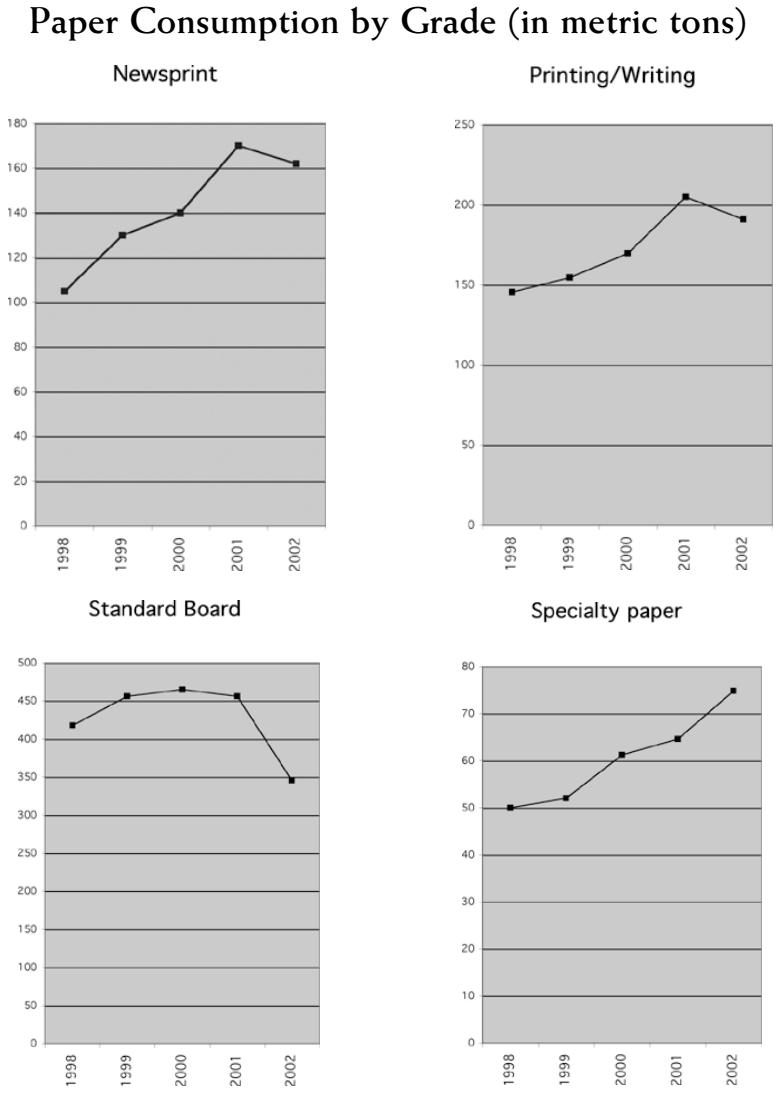

Figure 1: Paper Consumption by Grade (in metric tons)

Specialty / other grades refer to chemically or materially enhanced papers
Source PULPAPEL (1998-2002) Pulp and Paper Industry Report 2002

Material Savings

Material savings are an important part of improving any product line, in order to stay competitive. It is especially important in the paper industry because there are so few ways that paper can be improved. Basically, for the past few decades, paper has just been paper; nothing could be added or taken away from it. Now, additives have been developed that can drastically decrease the materials

needed to produce a high performance sheet of paper. There are four main types of material savings related to the manufacturing of packaging paper.

1. Less Lamination

First, less lamination material is necessary when additives are added directly to the pulp (applied on the wet end of the papermaking process). In the past, 3M® used a technology called Scotch ban, a treatment added to the paper during sizing. This added treatment included the addition of a substance known as perfluorooctanyl sulfonate (PFOS). It has been shown to resist permeation by water vapor and grease, making it ideal for packaging foods and other products where permeation must be kept low. The paperboard produced with PFOS sizing has been used for various applications including fast food, ground coffee, chocolate, pet food, and hardware. It has even been used as an E-flute corrugated, for things such as pizza boxes. The benefit of this sizing agent is its virtual elimination of the need for laminates or dry end treatments (Keeping up Appearances, 1997). Although 3M no longer manufactures Scotch ban, other companies continue to produce PFOS and similar sizing agents.

2. Decreased Thickness

The second way to save materials is by simply decreasing the thickness of paperboard itself. When additives are used to create a stronger sheet of paper, this new blend of paper can withstand greater force per unit area. This makes a thinner sheet of paper just as effective as a thicker, untreated sheet. The same is true when examining the issue of porosity in paper. In the past, sheets of paper had to be made very thick because of paper's high porosity. Currently, additives and sizing treatments can be used to produce a sheet of paper that is much thinner, but capable of preventing the transmission of water vapor, even in extreme conditions. This effect is outlined in an article about polyurethane dispersion (PUD) (Osby, 2002). The article explains how the addition of polyurethane can turn ordinary paper into a high performance package by increasing its strength and decreasing its permeability at extreme temperatures (hot and cold). This is especially important for packages containing such things as hot coffee or ice cream because they are subjected to extreme conditions. PUD also maintains other important properties of packaging paper, such as printability.

3. Paper as a Barrier

The third way materials are saved is when paper acts as a barrier. Even if the paper still needs to be laminated, the barrier layers can be taken out. An example of the potential for material savings is a specialty paper called intergral. Intergral, developed by Elf Atochem, is a water and greaseproof type of paper designed for food packaging that is produced by mixing virgin wood fibers with Foraperle, a specialty chemical (Anon, 2002).

4. Printability

The final benefit of using additives to increase strength and decrease porosity is that the finished product is often better equipped for high clarity printing. It makes a lot of sense, enhancing the strength of paper allows it to run better in printing presses. Decreasing porosity allows it to receive and hold

ink in a higher quality fashion. This is very important in the packaging industry because marketing is a huge part of selling any package. This technology could make it possible to print right on the package without having to add any additional surface treatment or lamination.

Process Improvements / Time Savings

The best part of using additives on the wet end of production is that it often leads to great advancements on production lines. There are two reasons how the process can be greatly improved.

1. **Ease of Use**

First, increasing additives directly in your pulp requires little additional time. Even the machinery needed for sizing treatments can be added right into your existing packaging line. There are a number of companies that specialize in the production of chemicals and pulp additives. Additives are developed with specific uses in mind and the companies that produce them have a great technical understanding of their effects.

2. **Less Machinery and Lowered Operating Cost**

The second way to make improvements involves a big time saver in the packaging industry. Wet end additives can eliminate the need for lamination or dry end treatments. Currently, a sheet of paper that has already been produced and stored must be reloaded onto a second machinery line, where it is laminated with many additional materials. In the future it is conceivable that the need for lamination may be totally eliminated. At the very least we can expect that some of these laminating steps can be cut out of the process. This will undoubtedly lead to the simplification of the laminating process, less need for additional workers, the elimination of some machinery, and an overall process improvement. This results in lowered operating costs.

Environmental Issues

When making changes to the structure of paper, environmental and recycling issues must also be explored. There are a number of factors to be considered, depending on circumstances surrounding the production, application, and end use of the paper.

1. **Increased Recycling Due to Less Lamination**

In the case of packaging paper, there appears to be potential for more environmentally friendly materials. Although the paper itself may be impregnated with certain additives, this does not necessarily mean that it will be less recyclable. In fact, the use of additives may make paper more recyclable. It will replace paper that had previously been laminated or coated with some other material through the use of an adhesive. In recent times, it has been adhesives and laminates that have been the primary barriers that prevent effective recycling. In Europe, legislation passed in order to avoid making paper recycling and recovery of cellulose fibers more difficult. It is necessary that all substances and procedures that contact paper during its service life not interfere with recycling (Onusseit, 2000). This is important because most laminates and adhesives are considered to be detrimental to the recycling process. Most pulp

additives and wet end treatments do not significantly affect paper's recyclability. In the near future it is likely that similar legislation will take place in the United States, and much like laws in Europe, there will be certain exceptions and percentages that paper manufacturers must not exceed.

2. Using Less Landfill Space

The type of paper used to package foods and other materials may make it more difficult to recycle, reducing the probability that the end user will bother recycling it. This means that these food packages often end up in landfills. In this case, it is advantageous to decrease the volume of the packaging material as much as possible. This can often be accomplished by using a thinner, but higher quality paper produced by using wet end additives. Basically, thinner material and less laminates means that paper produced with additives will contribute less to landfills. It may also be recycled more easily because it is not laminated with other materials.

3. Point Source Pollution Reduction

One final advantage that may be overlooked is quite simple. Paper mills may reduce the amount of waste produced while manufacturing the paper. It is well known that paper mills are a major contributor to air and water pollution. Although legislation and environmentally concerned paper producers have greatly decreased pollution levels, there is still a substantial amount of pollution still being produced. If paper mills were to change their product lines to include the production of higher quality papers, they would be able to sustain their profits by producing less paper. Paper mills could focus more on quality and less on volume, thus reducing pollution.

Conclusion

It is important for today's companies, small and large, to remain innovative and competitive in the market. In the case of paper mills, soon there will be a wide spread revolution brought about by the poor economy, stiff foreign industry competition, and the rapid growth of technology.

Paper mills need to look into using wet end additives for a number of reasons. Simply stated, the most important reason is that stronger, higher quality paper is more valuable. A paper mill can expect to increase profits while shipping and producing the same amount of paper. This also means an increase in demand. Package producers will realize that it's more economical to use specialty paper than to laminate and treat paper in-house.

The transition itself is not a complicated procedure. In fact, paper mills can use their existing machinery to produce paper with additives, and the companies who produce these additives can provide their expertise.

Packaging engineers can have a great impact on the production and profitability of their companies simply by understanding the benefits of wet end additives. Furthermore, knowledge of this ever-changing technology could realistically justify the position of any packaging engineer within company ranks.

References

Anon. (2000). Integral, a new specialty paper from Arjo Wiggins. *Papeterie, no. 232, February/March*, 18.

Harris InfoSource International. (2002). Packaging and Containers Industry Report.

Keeping up appearances with less material. (1997). *Packaging Digest*, November, 56.

Krooss, C. (2002). A strong stuff, a chemical additive. BASF Corp. Retrieved May 10, 2003, from http://www.basf.de/basf/img/corporate/innovationen/pdf/papier_e.pdf.

Nelson, J. (2003). Global forest and paper industry plagued by continued price volatility and fragmentation. Retrieved May 2003, from http://www.pwcglobal.com.

Onusseit, H. (2000). Adhesives for the paper and packaging industry - What influence do they have on paper recycling?

Osby, D. and Razzini, B. (2002). PUD broadens sizing potential. *Paperloop Magazines, August/September*, np.