The challenges of recycled furnish
in the manufacture of premium tissue products

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This paper discusses the challenges a tissue manufacturer faces when using recycled furnish in the production of a premium tissue product. The challenges are many; among them are brightness, bulk, softness and dirt count. Never to be forgotten are the various issues that are caused by stickies. The issues are reviewed and possible solutions are presented. The discussion starts in the deinking plant: Is it part of the operation or is market deink pulp being used? Depending on the issue the solution may be better applied in the deinking plant rather than in the tissue mill. The paper offers a broad review of the subject, but there is an emphasis on the use of enzyme based products for the control of stickies and also for quality enhancement.

Introduction

Recovered or recycled fibre has been used in the manufacture of tissue products for many years. It is an important part of a company's sustainable practices. Looking at the websites of major North American tissue producers shows the importance of sustainability. The Cascades website has the following quote "Long before sustainable development became fashionable, Cascades was putting it into practice instinctively. The Corporation has always believed that remaining true to its principles is the only way forward. It was, in fact, born out of a form of sustainable development: the recovery of waste paper."[1]

Replacing virgin kraft pulp with deinked recycled fibre is also a way to reduce the overall cost of production. The authors would be remiss if no mention was made of the article that was published in Tissue World Magazine, April/May 2013 titled ""Virginising" Tissue Fibre Furnish".[2] The author of this article discussed how a tightening waste paper supply and therefore a rising cost of deinked recycled pulp might lead to a move back to virgin pulps in tissue manufacture. While it is possible that the cost advantage of using recycled pulp may decrease, it is still a "green" practice.

What are the challenges when replacing virgin kraft pulp with recycled? They fall into two main areas: sheet qualities and runnability issues. First let's look at sheet qualities; what are the main qualities that consumers look for in a "premium" tissue product? An August 2013 article in Consumer Reports starts with the following quote: "The differences among facial tissues are nothing to sneeze at. Overall scores in our tests, based on strength (tested by a machine) and softness (judged by human hands), ranged from fair to excellent."[3]. Looking at the same source comparing bathroom tissue we see the same two factors: "was the best of the 25 toilet papers in our tests, with superb softness and superior strength and disintegration" [4]. Consumer Reports lists four criteria that they use for bathroom tissue -- strength, softness, disintegration and tearing ease, and for facial they list strength and softness. Of interest is that Consumer Reports does not have any rating for appearance, i.e., brightness and dirt. Replacing virgin bleach kraft pulp with deinked recycled, the producer will be looking to maintain these sheet appearance parameters.

Possible runnability issues with the use of recycled pulp can be summed up with one word "stickies". Stickies can cause production losses because of breaks and downtime for clean-up and can also lead to sheet issues.

The sheet quality and runnability issues will be discussed as we move through the process from deink plant to reel. Depending on the issue it may be better to try to address this in one part of the process as opposed to another.

Deinking Plant

The main type of recovered paper used in the production of deinked pulp for tissue is mixed office waste (MOW). There are many grades of waste paper so a mill might be using sorted office waste (SOW) rather than MOW. Another common waste paper type used is coated book. All in all the waste paper used will contain mainly wood- free paper. One aspect of these types of waste paper that is a concern in tissue is ash content. All deinked pulp that is going to be used in the manufacture of tissue will have an ash content that has to be at the target or below. The quality parameters of the deinked pulp will be brightness, dirt count, ash and in many cases a macro-stickie content or number.

All of the parameters above are best dealt with in the deink plant. The deink process is designed to remove ink, stickies and ash to produce a bright clean pulp. The first step is to ensure that all of the process equipment in the plant is running at design pressures and flows. CTP studied the deinking process that would be used in tissue production and came up with the following conclusions.

To reduce the size of stickies in the pulper you want soft pulping conditions. What this entails is to reduce pulping time, use the highest pulping consistency possible and avoid too high a pulping temperature. While this would help keep stickies larger and easier for the fine screens to remove, it can also reduce ink detachment. The importance of looking at the total deinking line was highlighted. The reduction in ink detachment can be mitigated if there is a high-speed dispersing step in the process that would detach and break down the ink particles.[5]

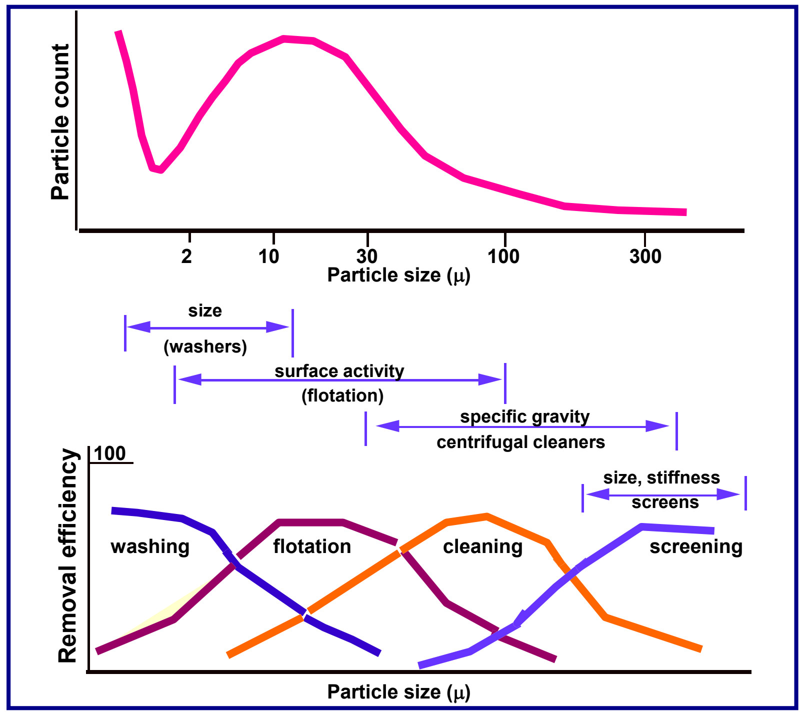

Chart I – Deink Plant Processes and Particle Removal Efficiency

A complete audit of the system will show how efficient each process is running. A complete audit will include brightness, ERIC (effective residual ink concentration) or TAPPI dirt count, consistency, ash and stickies.

If possible, macro- and micro-stickies should be measured. What can be done will depend on the equipment available on site. For example, is there a lab screen that can be used to measure macro-stickies? It is important to measure as much as can be done. You want to measure samples before and after all of the unit operations. You can't control what you can't measure.

Hyperwash and/or hyperfloat are useful tools to measure ink detachment and ink removal in the deinking process. Comparing the ERIC or TAPPI dirt of a pulp sample pad and the same sample hyperwashed will show ink detachment and removal. This information will indicate where improvements are required. You have to first detach the ink from the fibre before you can remove it. If testing shows that ink detachment is an area that needs improvement then you start in the pulper. Many North American MOW deinked plants use little or no deinking chemistry; the nature of MOW usually means that ink detachment is easier as compared to ONP (old newsprint). This is because with MOW the ink is attached to a coating or a surface sized surface while with ONP the ink is attached directly to the fibre.

That being said, the nature of waste paper today means that you usually get a mix of paper grades in the pulper. If it is found that ink detachment needs to be improved a deinking product can be added to the pulper. In MOW the two main types are synthetic surfactants and enzyme based products. Both types have proven successful. Buckman has both types of products available.

One aspect in MOW deink plants is that you will lose ash in the hyperwash or hyperfloat. In a deink plant making pulp for tissue production the removal of ash is important. You can use the hyperwash test to give an indication of what the pulp brightness will be once the ash is removed.

When comparing virgin kraft pulp to recycled pulp a major factor is variability. There is much variability in the deink plant; the waste paper on the conveyer can change from hour to hour. All deink plants try as best as they can to reduce this variability but there is always some that comes from the nature of waste paper collection. Single stream recycling being used in North America is a factor in this. The variability is where regular lab testing becomes a crucial practice. In some cases, mills that are getting swings in ash content find that the problem is on the conveyer. Regular testing of the pulp coming out of the pulper will show if the ash content swings are being caused by variation in the paper being loaded into the pulper. If this is not the case then testing can be done after unit operations to determine where the variation is occurring. Once the problem area is identified then steps can be taken to reduce the variability.

Anyone making any grade of paper with recycled pulp knows about stickies. They come along part and parcel with the waste paper. As with all process improvement, measurement is the key. The measurement of macro-stickies is well established and most methods involve the use of a lab fine screen, a transfer step and then an enumeration. A comparison of four of the available methods can be found in Progress in Paper Recycling [6]. The method used will be determined by the lab equipment available. If no lab fine screen is on site then handsheets and a physical count with a stereoscope or magnifier will give good information. The one aspect of the physical count is that you can probe the stickies and other debris to determine what actually is a stickie. Micro-stickie measurement is less established, but a large number of methods have been developed. The various methods are not discussed in this paper but the following references from Progress in Paper Recycling give a good overview of the micro-stickies methods [7, 8]. There have been some recently presented micro-stickies test methods that show some promise.[9]

The first step in addressing a stickies issue is to make sure your unit operations are removing as much as they can. The coarse and fine screens, flotation, washing stages and any cleaning equipment will remove stickies. What is removed in each is determined by size. The chart below from the NCSU's Recycling Course[10] gives size ranges for the various types of equipment.

In some cases an "outbreak" of stickies can be caused by a specific source of waste paper and the elimination of this source from the mill may be the easiest way to solve the problem. In most cases stickies issues will require the addition of control programmes or additives. These take many forms and include:

- Inorganics such as talc and clays
- Cationic coagulants
- Organic dispersants
- Enzyme based products
- Point of problem programmes
  - Forming fabric coating or treatment
  - Press felt or roll programmes

As keeping pulp ash level low is always a target for tissue production, the use of the inorganics is not widespread. The choice of programme depends a lot on where the problem is; if the only problem is stickies buildup on the forming fabric, then an effective solution could be a simple forming fabric coating programme. Points of problem treatments are well known and can be a cost-effective solution.

Sometimes the stickie issue requires an in-stock programme. One of the most effective has been the use of enzyme based products. Buckman has patented products in the Optimyze® Plus (OPP) family. This is the second generation of this technology. The first generation products had only enzymes as the active agent. The OPP products are combinations of enzymes and other stickies control additives such as dispersants and detackifiers. There are products with combinations of enzymes, enzymes and dispersant type chemistry, and enzymes and detackifier chemistry. [11] The second generation product line of enzyme based stickies control additives gives a greater range of control.

Stickies are never or very rarely one type of compound, so a multi-pronged approach gives superior performance. The versatility of the OPP products is that a number of them can be applied to tissue machine clothing as well as an in-stock treatment. By having a family of products the best product can be chosen for a given application.

The best area to start the attack on stickies is in the deink plant. By maximising the stickies removal of all of the unit operations, then less will make their way forward to the machine. A tissue mill with a deink plant on site has more control over the process than if market deinked pulp is being used. Generally, a market deinked pulp will have fewer issues as the final washing to lap pulp or further drying will remove many of the "bad actors".

Sheet Qualities

When producing a "premium" product we see that the consumer wants strength and softness. These qualities do not necessarily go hand in hand. A soft facial tissue that breaks when pulled from the box will not gain customer loyalty; the same with a soft bathroom tissue that falls apart in the hand. In addition a certain level of sheet strength is required for the tissue to be converted. If the strength is too low there may be problems in the converting plant with breaks and snap-offs. The above challenge leads makers of 100% virgin pulp tissue to use a mix of softwood and hardwood. The softwood gives strength while the hardwoods give a softer product. One aspect of recycled pulp is that it will be a mix of softwood and hardwood fibre and will also be a mix of species. This mix will not be consistent and will change from load to load.

The main sheet quality parameter that we will discuss in this paper will be strength. Other qualities such as brightness can be addressed in the deink plant and with various bleaching programmes. Ensuring that ink removal in the deink plant is effective has already been discussed earlier in this paper. How do we improve the strength of pulp? Mechanical refining is the first tool. In tissue production the power of mechanical refining tends to be on the low side as too much refining can lead to loss of bulk and softness. Adding more virgin softwood kraft pulp will increase strength but once again can hurt bulk and softness.

How do we replace a stronger virgin kraft pulp with recycled without losing bulk to basis weight ratio and handfeel? One answer is the use of fibre development enzyme based products. These products are now well established in tissue production. These products contain enzymes that work on the cellulose chain in the fibre to break the bonds in the chain and weaken the fibre surface. This is the same thing that is being done by mechanical refining but on a molecular level rather than a macro level. In mechanical refining you are beating the fibre to cause delamination and fibre collapse. This along with fibrillation of the fibre gives more sites for fibre-to-fibre hydrogen bonding and gives greater strength. The enzymatic fibre development products have the same final result on the fibre. By breaking bonds you get delamination, fibre collapse and fibrillation.

Mechanical refining will cause some fibre cutting and an overall reduction in average fibre length. The low levels of mechanical refining seen in most tissue mills will reduce the amount of fibre cutting but it will not be totally eliminated. One aspect of the enzymatic fibre development is that the fibre cutting will be lower than with mechanical refining. Working at the molecular level you need to break millions of bonds before you will break or cut the fibre. As compared to mechanical refining, enzymatic fibre development can be seen as a gentler treatment.

Buckman has the Maximyze® (MXM) product line of enzyme based fibre development products. The enzymes in the various products are similar in that they come from the same general family of enzymes, but each product contains different enzymes. A given enzyme will do one or two jobs only. Having a line of products allows the right fit to be made for a given mill and their production requirements.

Enzymes have temperature and pH ranges that affect their activity and these ranges can vary greatly from enzyme to enzyme. In addition there are compounds that will destroy or denature the enzyme molecule and others that will block or inhibit the activity of the enzyme. In all additive programmes it is important to know your system. This is especially true for an enzyme based programme. Tank and chest sizes and operating levels, flows, pH, temperature and additives are all important information that is required to design the best application point and programme.

The use of the MXM products has allowed tissue mills to realise a number of benefits. Replace virgin kraft with deinked pulp or replace softwood virgin kraft with hardwood. Reduce or eliminate mechanical refining. Elimination of strength additives. Reduction in basis weight while maintaining strength. All of these benefits will result in lower cost of production or enhanced sheet qualities. It all depends on what are the goals. MXM gives you an additional lever or tool to use to meet your product goals. The details of a MXM mill application can be found in Roy *et al* (2010)[12].

Conclusion

In the production of premium tissue products, strength and softness are important requirements to gain customer loyalty. Replacing virgin kraft pulp with deinked recycled pulp creates challenges in meeting these goals. Issues include lower strength of the recycled pulp and the presence of stickies contaminants. Many tissue producers do want to increase the use of deinked recycled pulp as part of their sustainability goals and also to reduce the overall cost of production.

Optimising all parts of the process from deink plant to reel is important. Do as much as possible to produce the brightest, cleanest pulp possible in the deinking process. The same goes for stickies removal; the more done in the pulp mill the fewer problems there will be on the machine. Auditing the deinking process is an essential tool in making the best use of the unit operations in the plant. There are a number of well established, proven products for stickies control: one is the enzyme based OPP product line.

Strength can be enhanced with the use of the MXM products. These enzyme based products develop the fibre in a similar way to mechanical refining but are gentler on the fibre. The MXM products give more flexibility in the tissue making operation, allowing operator to make the operational moves required to meet their product goals. ■

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