FPAutospeck™ – A First Online Analyser for Stickies and Macrocontaminants

FPAutospeck™--- 最新颖的在线胶粘物和杂质分析

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ABSTRACT

摘要

A new image analysis based instrument has been developed for measurement of contaminants with emphasis on heavy stickies and light macrocontaminants in deinked pulp or whitewater. The unit is coupled to a pulp classifier that serves to separate the contaminants from pulp prior to their transfer to a chamber that facilitates image capture and analysis. When operating in the online mode with autosamplers delivering the samples to the pulp classifier, the instrument provides macrocontaminant determinations every 15 minutes. The total count and surface area of both light and heavy macrocontaminants per kilograms of pulp can then be sent by direct link to the mill data control system allowing an effective follow-up of macrocontaminant changes in process pulps and waters. The unit also allows the user to view images of the contaminants. The analyser results obtained in terms of number and area of macrocontaminants show a linear relationship with the Tappi standard method T-277. Because macrocontaminants are not flattened by a pressing step, the total area of the contaminants measured by the analyser is lower than that measured by the Tappi method but the value is more representative of the actual contaminant size as found in pulp slurry.

一种基于图像分析的新仪器已经开发出来，应用于杂质测量，对脱墨浆或白水中大胶粘物和轻杂质具有重要意义。该装置连着浆料筛分，在进入下一个工段前将杂质从浆料中分离出来，便于图像采集和分析。当开启在线测试模式时，自动进样器将样品送入浆料分级器，仪器每15分钟提供一次杂质测量结果。每千克浆料中的轻杂质和重杂质总数量和表面积都可以通过数据线传到工厂数据控制系统，允许对浆料和水中杂质变化进行有效的后续分析处理。该仪器也允许用户观察杂质的图像。该分析仪获得的杂质的数量和面积结论与Tappi标准T-277的结果呈线性关系。由于杂质没有经压平，所以该分析仪测试出来的杂质总面积低于用Tappi标准测试出来的值，但分析仪测出来的值更接近于浆料中杂质的实际尺寸。

INTRODUCTION

介绍

Stickies are by far the most detrimental class of contaminants in recycled pulps. These contaminants embrace a large variety of lipophilic compounds that originate from pressure sensitive adhesives (PSAs), hot melts, toner, waxes, coating and binders that are used in labels, tapes, envelopes, stamps and paperboards for a variety of functions like binding, sealing, coating and printing. Once introduced in recycling plants with recovered papers, these contaminants are subjected to intense mechanical action during pulping, screening, pumping, dispersion and kneading leading to their fragmentation into a wide range of particle sizes. The release of these sticky substances in the water phase leads to the production of off specification pulp from the deinking plant, increased chemical costs for their passivation and solvent cleaning, poor runnability at the paper machine and in press rooms, and poor product quality. Though vital for efficient control of recycling operations macrostickies measurement is infrequent, due to personnel shortages and the tedious nature of the manual methods [1-4]. Despite the seriousness of the problem, very few devices have been developed for online monitoring stickies in pulp streams [5-10].

目前再生浆中的胶粘物是最有害的杂质，包括大量的脂溶性物质。这些脂溶性物质来自于压敏胶（PSAs），热熔胶，碳粉，蜡，涂料和粘合剂，广泛用在标签、胶带、信封、邮票和纸板的粘合、密封、涂布和印刷。曾在回收工厂的回收纸中介绍过，这些杂质在制浆、筛选、泵送、分散和搅拌过程中受到强烈的机械作用，导致其碎片粒径范围分布广泛。胶粘物在水中释放产生的影响有：脱墨工厂出来的浆不合格、用于胶粘物钝化和溶解清洗的化学药品用量增加、纸机和印刷运行性能差和产品质量变差。由于人员不足、测试方法劳动量大，高效管理再生产纸生产中的大胶粘物还不常见[1 - 4]。虽然问题严重，但目前很少有检测装置已经开发了在线监测浆料中的胶粘物[5 - 10]。

Of the few online analysers that claim to measure stickies, four of them use fluorescent dyes to detect hydrophobic components in pulp passing through a laminar flow cell [5,8,9,11]. One of the problems with this method is that fibres, fines and shives rich in lipophilic extractives such as triglycerides and fatty acids may interfere in the measurement of stickies [12]. Moreover, some of these methods do not distinguish between macro- and microcontaminants while others do not discriminate stickies from pitch because both classes are hydrophobic in nature. Another drawback of some of these methods as an online device for monitoring macrocontaminants is that they use hydrodynamic focussing to align particles in a laminar flow prior to their detection. Because the sample size handled by such cells is small in the order of milliliters per minute, the time required to measure a sufficient amount of sparse contaminants in a larger mass of fibres becomes impractically long. Some flow cells analyzers capable of handling larger volumes have been known to measure dark particles or specks such as bark, metal, and toner contaminants present in kraft [13] and recycled pulps (Simpatic, PapTech). Although suitable for measuring contrasted contaminants, these analysers have trouble detecting contaminants that are not visually very different from the pulp, such as stickies [14]. Moreover, all of the methods described do not permit enumeration of stickies based on their area or type.

少有的几家在线分析仪器自称能测量胶粘物，他们在纸浆通过层流单元时用荧光染料探测纸浆憎水成分[5,8,9,11]。这个方法存在的问题是脂类抽出物含有丰富的纤维、粉末和碎片，例如三酸甘油酯和脂肪酸可影响胶粘物的尺寸[12]。而且,其中有些方法不能区分大的和微细胶粘物，另外一些则不能区别胶粘物和沥青（因为这两种物质都是憎水性的）。另一个缺点是有的仪器在线监测大胶粘物时，在探测前使用水压聚焦来定位层流状态下的微粒。因为这类单元控制的样品大小在每分钟通过的量很小，测量大量纤维中稀少的杂质时要检测要达到足够多的量就需要无限延长时间。众所周知，一些流动单元分析器能够容纳较大体积来测量黑色粒子或污点，如牛皮纸浆和再生纸浆中的树皮、金属和有机颜料杂质（西门子、PapTech）。虽然适合于测量反差大的杂，,但这些分析仪难以检测出那些不可见的与浆完全不同的杂质，如胶粘物[14]。而且,上述方法不能根据面积或类型计算胶粘物的数量。

Like many other groups worldwide, the Recycling Group of FPInnovations, has used several methods over nearly 20 years to identify, quantify and measure stickies. These methods included deposition testers, standard laboratory methods such as Tappi T-277, microscopy, malleability tests with needles, image analysis, FTIR, pyrolysis GC/MS, tack determination and thermogravimetric analysis [1-4,15-18]. With practice and time, it was noticed that for the most part, isolated stickies could be correctly identified visually. This prompted the development of an automated stickies analyser that uses image analysis as a means to identify and quantify stickies. When image analysis is used for objects discrimination and quantification, the presence of fibres impedes proper detection of contaminants especially when the number of contaminants is small. To circumvent these problems, the beta version has a commercial pulp classifier (Pulmac MasterScreen) to first separate the contaminants from the fibre and to isolate enough contaminants to permit a statistically sound analysis. The classifier was modified to allow online sample injection by autosamplers and to facilitate the transfer of isolated contaminants to the analyser. Once in the analyser an image of the light and heavy macrocontaminants can be taken, and their type, number and size determined by image analysis. When operating in the online mode with autosamplers delivering the pulp samples, the instrument provides fast, reliable macrocontaminants determination every 15 minutes. The total count and surface area of both light and heavy macrocontaminants per kilograms of pulp can then be sent by direct link to the mill data control system allowing an effective follow-up of macrocontaminant changes in process pulps and waters.

像许多其他世界性组织一样，FPInnovations循环利用组织近20多年来一直用几个方法来鉴别、量化和计量胶粘物，包括沉淀法、标准实验室方法例如Tappi T – 277，显微镜观察法、针可压延性测试，图像分析， FTIR，高温裂解GC / MS，粘性测定和热重分析[1 - 4,15 - 18]。经过长时间实践，人们注意到大部分可见的游离胶粘物可以正确鉴别出来。这促进了用图像分析的自动胶粘物分析仪的发展，鉴别和量化胶粘物。当图像分析用于鉴别和量化时，纤维的存在阻碍了杂质的特有检测，尤其当杂质数目很小的时候。为避免这些问题,第二代产品有了筛分仪（pulmac masterscreen ），先将杂质从纤维中分离出来，分离出足够的杂质来进行统计分析。筛分仪经改进，可通过在线自动取样器进样，易于分离出来的杂质传送到分析仪。当分析仪获得轻杂质和重杂质的图像，通过图像分析即可获得他们的类型、数量和大小。用自动取样器在线输送纸浆样品,仪器每15分钟提供一次快速可靠的测定值。每千克纸浆中轻杂质和重杂质的总数目和表面积都能通过数据线直接发送至工厂数据控制系统，从而对纸浆和水中的大杂质的变化采取有效的控制措施。

In this first of a series of reports on stickies monitoring and control, we present the basic features of an automated macrocontaminant analyzer. Some preliminary results obtained with the beta unit are presented and validated by comparison with a standard Tappi method for stickies quantification. Though, the Tappi Method is not discussed here, it is not free of pitfalls as will be shown in a subsequent report.

在胶粘物监控的一系列报告中，我们先介绍自动大杂质分析仪的基本特征。一些初步的结果可由PULMAC

MASTERSCREEN实现，可通过与标准Tappi方法验证比较进行胶粘物量化。然而, Tappi方法不在这里论述，它的缺点会在后面的报告中体现出来。

Description of the Online Macrocontaminant Analyser

在线大杂质分析仪描述

Figure 1 shows a picture of the first industrial prototype of the macrocontaminant analyser retrofitted to a commercial pulp classifier. For this installation, two autosamplers are shown entering into the feed receptacle of the pulp classifier. Figure 2 is a schematic diagram that describes the components and steps that the analyser uses to identify contaminants. The analyser was designed to be either a stand-alone unit with an incorporated screening system or it can be retrofitted to an existing commercial pulp classifier. Pulp or white water streams are added to the inlet of the pulp classifier either manually or via auto-sampler. When samples are added manually by the operator to the pulp classifier feed tank, the unit operates in Survey Mode. Samples can then be treated by the macrocontaminant analyser or drained to the filtering device unit of the pulp classifier for manual determination of stickies by a method such as the Tappi Standard Method T-277 [4]. This flexible mode allows mill operators to rapidly screen recycling plant unit operations for their efficiency in macrocontaminant removal. In the Survey Mode, the instrument's software asks for input of the sample name, volume and consistency from the operator. In the Online Mode, all operations of the autosamplers, pulp classifier and macrocontaminant analyser are automated with the resulting data directly linked to the mill data control system. This mode of operation will allow mills to monitor macrocontaminant changes in process pulps and water and to develop strategies of control for enhanced removal. Because the instrument can simultaneously capture and analyse images while the pulp classifier is screening the next sample, the online mode can process four samples per hour.

图1是第一个由胶粘物筛分仪改进而来的在线分析仪原型的照片。在这套设备里，可看到有2个自动取样器连接到筛分仪的原料贮存器里。图2是分析仪鉴别杂质的组成部分和流程示意图。分析仪设计成可合并筛分系统的作为一个独立单元或者可改装成已有的胶粘物筛分仪。可手动或通过自动采样器将纸浆或白水注入纸浆筛分仪。当操作者手动添加样品到给料槽时，仪器应处于Survey模式。然后分析仪处理样品或者样品排干水分到过滤单元，用传统方法例如Tappi T - 277 [4]标准方法手动测定胶粘物。这灵活的方式使得车间工人快速地筛选回用浆，提高了去除大杂质的的效率。在Survey模式下，仪器的软件要求操作者输入样品的名称、体积和浓度。在online方式下，自动取样器、筛分仪和分析仪都是自动控制，结果直接输送到工厂数据控制系统。这个运行模式允许工厂监控纸浆和水中的大杂质的变化，提供控制方法以提高去除率。当筛分仪在筛分下一个样品的同时分析仪可以捕获和分析图像，所以online 模式下可以一个小时处理4个样品。

Figure 1. The analyser cabinet is in the forefront of the picture. The unit is linked to the pulp classifier and two autosampler lines.

图1. 分析仪在图片的最前面，与筛分仪和两条自动取样器线连接

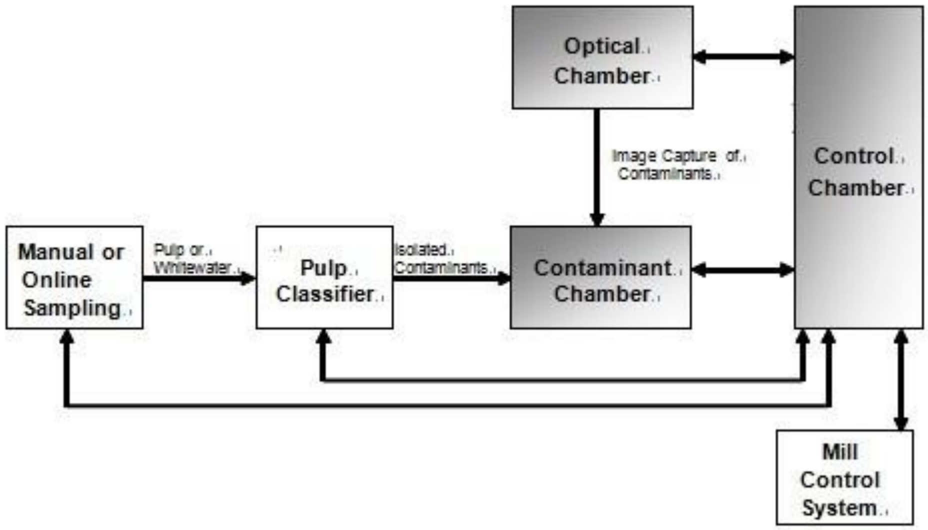


Figure 2. Block diagram of steps and components that the analyser uses to identify macro- contaminants. The components of the macrocontaminant analyser are indicated in gray boxes.
图2　鉴别大杂质的流程图 灰色方框是分析仪的组成部分。

In order to obtain a clear image for subsequent analysis, the macrocontaminants are first separated from the fibrous material and concentrated using a screening system with slot apertures of a 0.006”. After screening has removed virtually all the fibres, the isolated macrocontaminants dispersed in water are automatically discharged to a specially designed contaminant cell.
为了获得清晰的图像进行后续分析，用一个筛板缝隙大小为0.006"的滤水系统将大杂质优先与纤维材料分离并集中。筛选后移走全部地纤维，分离出来的大杂质分散在水中自动地排出到一特别设计的杂质单元。

Figure 3 shows a schematic diagram of the cell. In this cell, contaminants discharged from the pulp classifier in water are first dispersed to provide a uniform distribution for image capture and analysis. Macrocontaminants will then separate according to their difference in density with water. Light-weight macrocontaminants such as waxes, low-density stickies (i.e. pressure sensitive adhesives and hotmelts); plastics and varnishes float to the top of the cell whereas the contaminants denser than water settle to the bottom of the cell. Heavy-weight contaminants include macrostickies, shives, high-density plastics, varnishes, and black contaminants such as toner. The material and colour of the settling plate and lighting conditions assure adequate visualization and discrimination of contaminants prior to image capture by cameras focused on either the top of the water phase or at the bottom of the contaminant cell. Contaminant dispersion in the water phase of the chamber, image capture and image analysis are repeated to assure that the number of contaminants measured are sufficiently high to ensure statistical significance of the results. The data from all the images of the sample are averaged and a report is prepared that includes the total number and area of heavy- and light-weight contaminants. The report can be visualized on the computer screen of the analyser or sent to mill data base and control systems. Data is stored in the processor with a link to the original image of the contaminants. This data storage will also allow the user to view the historic trends of the total number and area of each contaminant type.
图3是杂质单元的示意图，杂质离开筛分仪进入水中首先分散，均匀分布好进行图像捕捉和分析。大杂质将按照密度差与水分开。轻杂质如蜡、低密度的胶粘物（即压敏胶和热熔胶）、塑料和油漆浮到顶部，而密度大于水的则沉到底部。重杂质包括大胶粘物、碎片、高密度塑料、清漆，还有黑色杂质例如墨粉。底板的材质颜色、照明条件要保证用相机集中在水相顶部或杂质单元底部捕获图像前足够目测和鉴别杂质。杂质分散容器内的水相阶段中，重复图像捕捉和图像分析保证杂质数目足够多，保证结果的统计显著性。样品图像的数据进行平均，出具报告包括轻杂质和重杂质的总数量和总面积。报告可从分析仪的屏幕计算机上看到，或者发送到工厂数据库和控制系统。数据保存在与杂质图像连接的信息处理器中。数据存储也允许用户查看各个杂质类型的历史数量和面积的趋势。

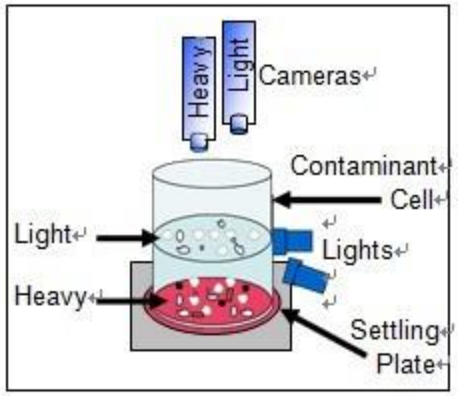


Figure 3. Simplified diagram of contaminant chamber that shows the contaminant cell containing water, heavy contaminants settled on plate, light contaminants floating on water surface, lighting and a camera focused on either the settling plate or water surface.

图3 杂质容器简图：杂质容器含水，重杂质沉淀照在底板,轻杂质浮在水面上，灯和一架相机聚焦在沉积底板上或者水表面。

RESULTS

结 论

In this section, a few examples of the type of data obtained with the macrocontaminant analyser are presented with a comparison to results obtained by the Tappi T-277 standard method for the measurement of heavy stickies and to an in-house modified Tappi method for the analysis of light macrocontaminants in OCC, such as waxes. The in-house method uses many of the same steps as the standard Tappi method where stickies are isolated from pulp using a pulp classifier and are subsequently filtered through a black coloured filter paper. The filter paper is then sandwiched between a coated sheet and pressed at 90°C for 5 min. This method identifies contaminants that stick to the coating matrix as stickies. The non-coated material is then rinsed off under a jet of water and the sheet dried for image analysis. To subsequently analyse waxes, the filter paper is rewet to reveal grey-shaded areas of the filter paper against the black filter paper background. These hydrophobic areas contain waxes that were melted and absorbed into the black filter paper. These grey spots are manually counted and their size estimated using a dirt size estimation chart produced by Tappi.

在本节，分析仪得出的数据给出几个例子，和Tappi T - 277标准方法得到的结果进行重胶粘物的尺寸比较，和内部改进的Tappi方法比较OCC中轻大杂质的分析，如蜡。这个内部的方法使用许多与Tappi标准方法相同的步骤，用筛分仪分离纸浆中的胶粘物，然后用一黑色滤纸过滤。然后将滤纸夹在涂层薄纸之间，在90°C下压榨至少5分钟。这方法鉴别出粘住涂层物质的杂质即胶粘物。非涂层物质在水流下刷洗，干燥后进行图像分析。接着分析蜡，滤纸重新弄湿，在黑色滤纸背景下显现滤纸的灰色阴影面积。憎水的面积包含熔化的被吸收到黑色滤纸里的蜡。对灰点进行手动统计，大小用Tappi生产的污点大小判断图表来估算。

One of the most interesting features of the macrocontaminant analyser is the ability of the user to visualize the types of macrocontaminants present in each stream. It is worth mentioning that of the different types of recycled furnishes examined to date, OCC pulps were found to present the greatest challenge for an image analysis based analyzer because they contain a larger variety of contaminants than other pulps as well as numerous fibres bundles often held together by sticky material. Despite the difficulties encountered with this complex furnish, results presented below will show that the analyser provided reliable measurements of heavy and light macrocontaminants.

大杂质分析仪最大的一个有意义的特征是用户能够观察到各种浆料里存在的大杂质类型。值得提到的是通过考察不同类型的回用原料来看，迄今未止，OCC纸浆给基于图像分析的分析仪造成最大的困扰，因为OCC纸浆比其他纸浆包含大量不同种类的杂质、许多的纤维束经常被粘性物质结合在一起。尽管会遇到复杂的原料，下面的结果给大家表明分析仪可以提供可靠的轻重大杂质尺寸。

Heavy Stickies and Light Macrocontaminants

重胶粘物和轻大杂质

Figure 4 a – b shows a portion of each image obtained from the first mill trial with the unit in an OCC plant.

The variable nature of the heavy macrocontaminants is evident in Figure 4 a; the whitish contaminants include stickies, hotmelts or plastics and the black contaminants comprise toner, brown fibre bundles, shives and fibres. At this time, in the heavy stickies images, only the white particles are identified, counted and measured as heavy stickies by the software of the analyser. Future releases of the analyser will be able to measure black contaminants and shives in addition to these whitish contaminants.
图 4 a - b显示在OCC工厂进行第一个工厂试验获得的图像。重大杂质的易变性在图4 a中非常明显；发白的杂质包括胶粘物、热熔胶或塑料，黑色杂质包含墨粉、褐色纤维束、碎片和纤维。在这次试验中，重胶粘物图像中，仅白色微粒是通过分析仪软件鉴别、统计和测量出来。等将来分析仪发布出来，除白色杂质之外也能够计量黑色杂质和碎片。
Figure 4 b shows an image of the light macrocontaminants that float on the surface of the water. In this OCC pulp, the light macrocontaminants are mainly waxes, a notorious contaminant of pulps made from recycled board, but may also include low density stickies, hot melts and plastics. Presently only contaminants with a high contrast with the background are measured in this fraction.
图 4 b显示复杂水表面的轻杂质的图像。在OCC纸浆中，轻大杂质主要是蜡，回用纸板中产生的臭名昭著的杂质，但也可能包括低密度胶粘物、热熔胶和塑料。不久以后背景形成高对比度下的杂质将用百分数来计量。

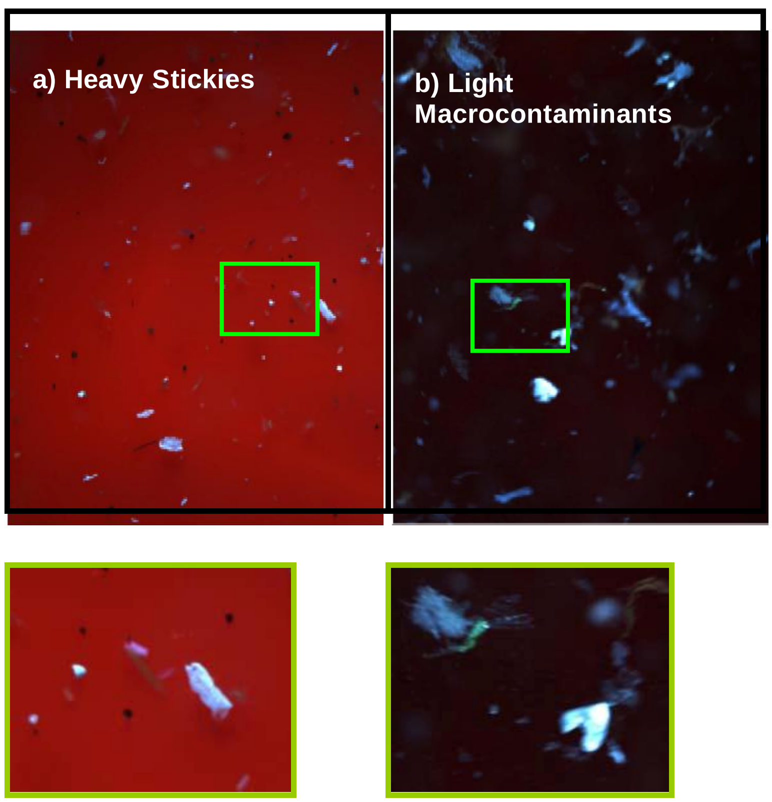


Figure 4 a - b. Images taken with the macrocontaminant analyser of heavy stickies and light macrocontaminants from online analysis of pulp from OCC mill.

Sitholé *et al.* [2] had stated that the major problem with image analysis was the selection of the colour of the contaminants that ranged from clear to black and the determination of a threshold to do the measurements. The macrocontaminant analyser images gets around this problem in several ways. The lighting and settling plate colour optimize discrimination between the different types of contaminants and the image analysis parameters are modified to allow determination of each type of contaminant separately.
Sitholé等指出图像分析法主要的问题是杂质颜色从透明到黑色的选定范围的和尺寸临界值的判定。大杂质分析仪图像避免这些问题有几个途径。轻的和沉淀底部颜色最适合区分不同类型的杂质，图像分析参数调整至能够单独测定每种杂质。

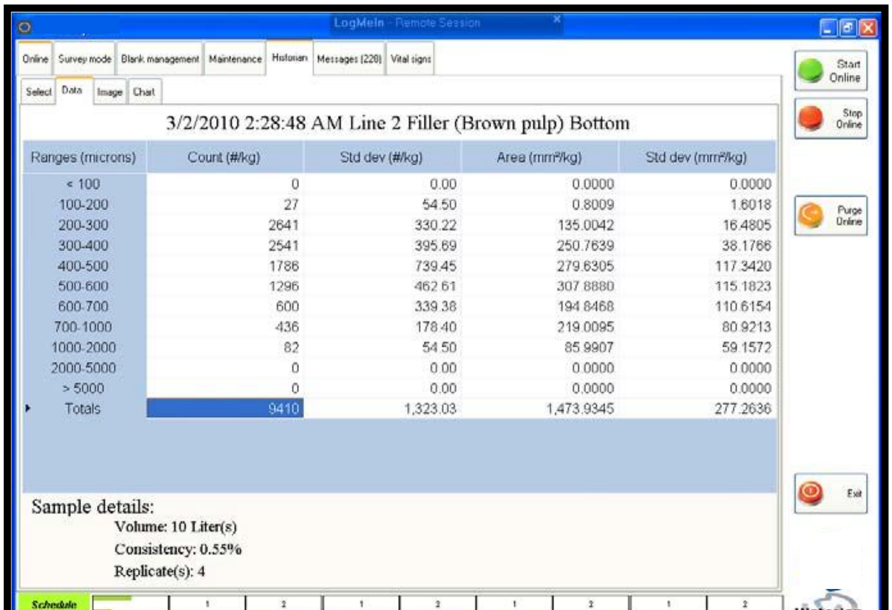
Windows Based Operating Software Features

基于Windows的操作软件特征

Figure 5 a – b shows shots of the analyzer report screens for heavy stickies image of an OCC pulp. The table and bar chart in Figure 5 a and b show the number and area of stickies in each size range with their respective standard deviations. With the macrocontaminant analyser, a 14% coefficient of variation is measured for the total number of stickies and 18% for the total area. These values are comparable to those observed for OCC pulp using the Tappi standard method T-277 [4]. Sample details, such as consistency, volume and the number of images taken are indicated at the bottom of Figure 5 a.

图 5 a - b是OCC纸浆重胶粘物图像分析报告的屏幕截图。图 5 中的表和柱状图给出了各尺寸范围胶粘物的面积和数量、相应的标准偏差。大杂质分析仪中胶粘物总数目偏离系数14%，面积总数偏离系数18%。这些值可媲美Tappi标准方法T - 277测出来的值[4]。样品详细信息，如浓度、编号和图像张数都在图5 a下方给出。

(a)



3/2/2010 2:28:48 AM Line 2 Filler (Brown pulp) Bottom

Ranges (microns)	Count (#/kg)	Std dev (#/kg)	Area (mm²/kg)	Std dev (mm²/kg)
< 100	0	0.00	0.0000	0.0000
100-200	27	54.50	0.8009	1.6018
200-300	2641	330.22	135.0042	16.4805
300-400	2541	395.69	250.7639	38.1766
400-500	1786	739.45	279.6305	117.3420
500-600	1296	462.61	307.8880	115.1823
600-700	600	339.38	194.8468	110.6154
700-1000	436	178.40	219.0095	80.9213
1000-2000	82	54.50	85.9907	59.1572
2000-5000	0	0.00	0.0000	0.0000
> 5000	0	0.00	0.0000	0.0000
Totals	9410	1,323.03	1,473.9345	277.2636

Sample details:
Volume: 10 Liter(s)
Consistency: 0.55%
Replicate(s): 4

(b)

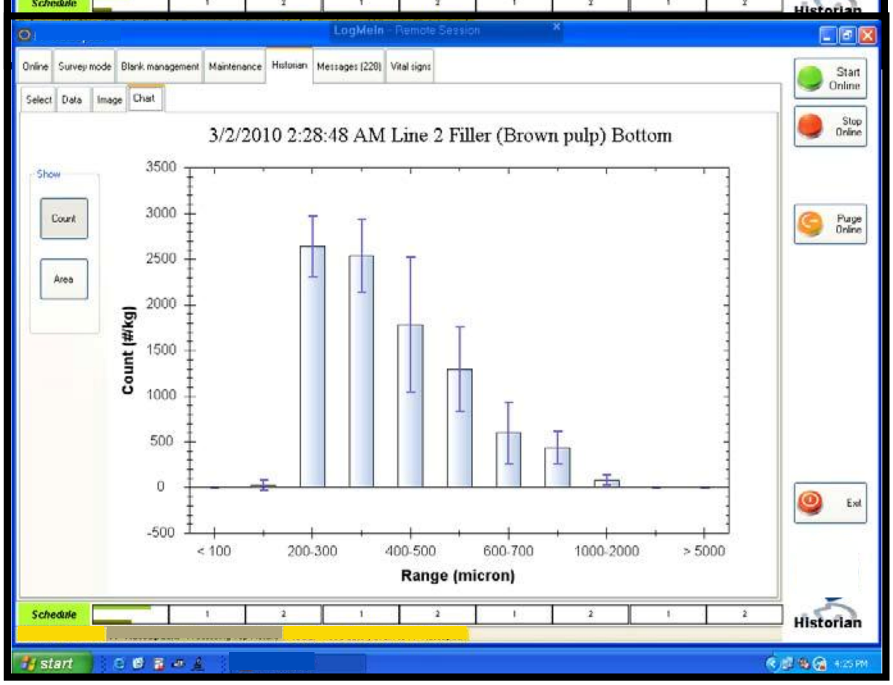


Figure 5 a – b. Macrocontaminant analyser screen views of mill data from an OCC plant brown pulp stock including a table (a) and chart (b) showing the heavy stickies counts and area ± standard deviations in given size.

The first row of tabs at the top of each screen shows the different windows of the operating software accessible by the instrument operator. *Online* and *survey* refer to the two modes of instrument operation described earlier. *Blank management* allows the user to follow the quality of the last blank or water control performed. For example, too high a content of particles on the contaminant settling plate might indicate that the chamber was improperly cleaned between runs. The *vital signs* tab allows the user to set limits for various operating parameters of the macrocontaminant analyser. When these limits are surpassed, the software will provide warning and error messages to indicate problems with the pulp classifier or the macrocontaminant analyser. Two main types of messages are generated by the software program: 1. Error messages stored under the *messages* tab provides information to the user or 2. A warning message appears on the screen indicating that the unit has stopped and requires manual intervention of the user. For example, a long screening time may indicate plugging of the pulp classifier screen or problems with the volume and consistency of the sample. Both messages allow an easy troubleshooting of the equipment by the operator. The *maintenance* tab allows manipulation of the mechanical components of the pulp classifier and the mechanical and optical components of the analyser. Through this tab, the operator will verify start-up sequences and perform calibration tests. The *historian* tab allows the operator to select a sample and examine the image, data table (Figure 5 a) or chart (Figure 5 b). In the chart, either the number or area of contaminants can be viewed. Online data that is conserved for a period of two months can be easily transferred to the operator either via a USB interface or by the remote online software program. This remote software permits complete access of the data obtained in survey and online modes as well as complete control of the instrument from the user's computer.

在屏幕最上方，第一行标签显示操作软件不同窗口，操作人员易于操作。如前所述，仪器操作提供在线和独立测量两种模式。空白管理允许客户跟追踪上次空白的质量或者水的控制。例如，杂质沉淀底盘上颗粒浓度过高就表明容器运行过程中不够干净了。标签列表允许用户设定大杂质分析仪各个工作参数的限定值。当超过设定范围时，软件将给出警告和错误信息，指出在筛分仪或在大杂质分析仪上的问题。软件程序主要产生二种类型的信息：1.信息表下的错误信息给用户提供报告；2.屏幕上给出警告信息，指出设备停止，要求用户人工干预。例如，筛选时间过长表明筛分仪的筛网堵塞或样品体积和密度有问题。两个信息都允许操作者进行简单的仪器调试。维修标志允许调整纸浆筛分器的机械构件和分析仪的光学部件。通过这个标签，操作者能检查启动程序和执行校准测试。历史记录标志允许操作者选定样品调出图像、数据表（图5 a）或图表（图5 b）。在图表中，杂质的数量或面积都可以看到。在线数据可保存二月的时间，能够很容易地通过USB接口或者用远程联机软件程序传递给操作者。通过远程软件控制可像用户用电脑控制仪器一样获得离线操作或在线测试两种模式下的数据。

Figure 6 a+b shows the trend of the online data for the number of heavy stickies from autosampler line 2 processing an OCC pulp grade. As the unit can be hooked to several sample lines and the unit operated in survey mode on some days, a change in the frequency of sampling times can be noted on the *x* axis. When the unit is operating online, the online tab allows the user to set the sequence and frequency of online sampling for each sample line and to view the data trend for either the number or area of light macrocontaminants or heavy stickies. The user can also view the data and image for the last sample analysed. The set-up tab allows easy addition of an autosampler line for up to five individual sample lines and their respective operating parameters. The trend line shows that the unit responds well to changes in stickies content and the inherent variability of contaminants in mill process pulps.

图6 a+b是2#自动取样器取得的OCC 纸浆中重胶粘物在线数据的趋势图。仪器有些时候可挂断几个取样管线进行离线测试，采样频率的变化可在x轴上记录下来。在线操作时，在线标记允许用户设置各个取样管线的在线样品序号和取样频率，察看轻大杂质或者重胶粘物的数据趋势。用户还可以观察前一次测试样品的数据和图像。设定的列表允许自动取样线累积取到5个单次样品和设定他们相应的工作参数。趋势线表明仪器对纸厂加工纸浆中的胶粘物成分和杂质的固有易变性响应很好。

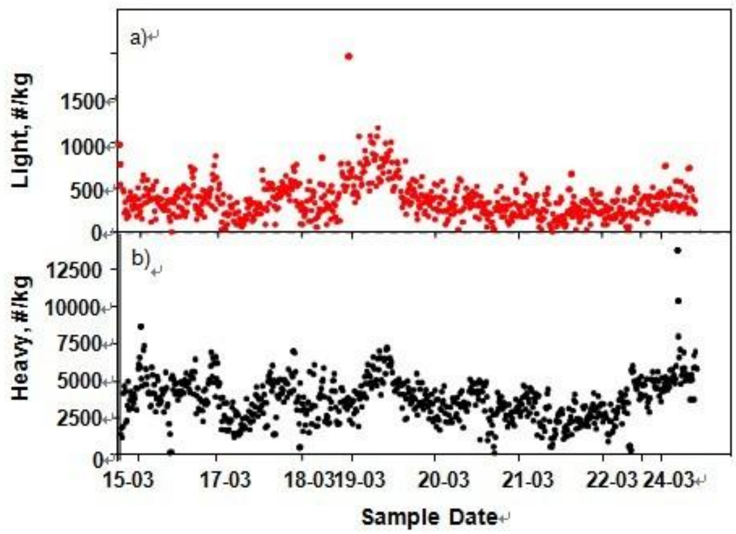


Figure 6. Macrocontaminant analyser screen of the online window trend of the number of light (a) and heavy (b) stickies over time.

Responsiveness of the Macrocontaminant Analyser and Comparison to Standard Tappi Method
大杂质分析仪作出的响应与标准Tappi方法进行比较

Figure 7 a – b shows that the number and area of heavy and light macrocontaminants increase proportionally with sample weight of OCC cleaner feed pulp entering the analyzer. The upper limit of the measurement is related to the capacity of the pulp classifier screening system to handle large samples in a reasonable time frame necessary for online measurement. The quality of image can also be hampered when too many contaminants are viewed in the field of detection. At high contaminant content, the volume of the pulp fed to the pulp classifier can be reduced. For low contaminant content, although an online measurement at a frequency of 4 tests/hour improves the user confidence with the mean value obtained for a given pulp, the only way to circumvent this problem is to increase the sample size. A pulp classifier with higher capacity is currently being designed to integrate into the macrocontaminant analyser.

图7 a - b给出了OCC清洗后不同重量的浆料进入分析仪得到的重大杂质和轻大杂质数量和面积增加趋势。测量的最大范围与纸浆筛分系统在线测量中设计的合理周期内处理大量样品的能力有关。检测范围内太多杂质也可能妨碍图像质量。杂质含量高时，进入筛分仪的纸浆量可适当减少。低杂质含量时，4次／小时在线测量得到的平均值增加了用户信心，避免这种问题的办法是增加样品定量。高处理能力的纸浆筛分仪目前已设计包含在了大杂质分析仪里。

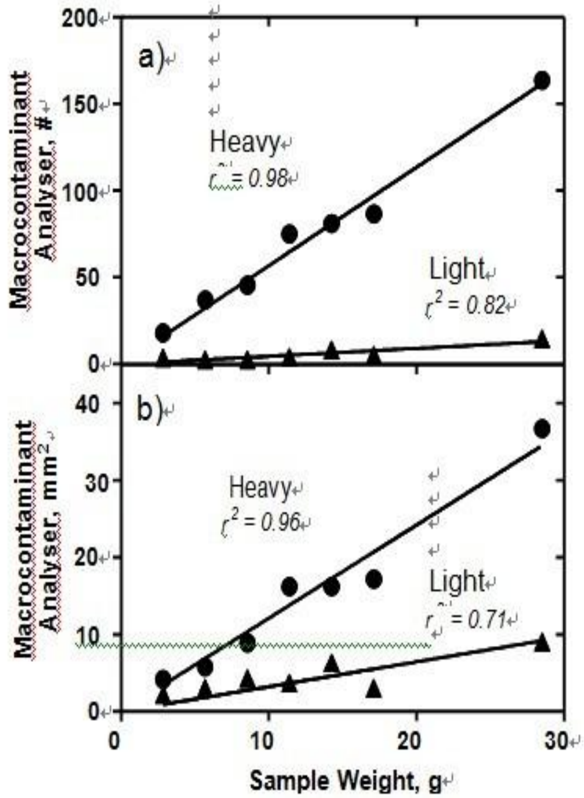


Figure 7 a - b. Relationship between sample size and the number and area of heavy stickies and light macrocontaminants.

Figures 8 and 9 show a good linear relationship between numbers of macrocontaminants measured by the analyser and Tappi methods. Note that the Tappi Standard Method T-277 was used for quantification of the heavy stickies and a modified method T-277 was used for counts of the light macrocontaminants. The values are obtained from different pulp samples taken in an OCC and SOW recycling plant. The relationship between the two methods is linear for the number and area of light macrocontaminants (r^2 = 0.83 and 0.78, respectively) and for the number and area heavy stickies (r^2 = 0.77 and 0.85, respectively). A high Pearson's correlation was found between the values obtained for the Tappi and the macrocontaminant analyser measurement methods based on number: 0.88 for the heavy stickies and 0.94 for the light macrocontaminants (not shown). The chance or probability of randomly obtaining such a strong correlation between the two methods of analysis is less than 0.0001 in both cases.

图 8 和 9 显示了分析仪和Tappi方法测出来的大杂质数量之间良好的线性相关性。注意：Tappi标准方法T - 277用于重胶粘物定量分析，修正的T - 277方法用于轻大杂质的计数。数据是用OCC和SOW回收浆厂获得的不同纸浆样品测出来。这两种方法得到的数据线性相关，轻大杂质数量和面积（r2 分别为 0.83和0.78），重胶粘物（r2 分别为 0.77和0.85）。Tappi和大杂质分析仪得到的值具有高Pearson ' s相关性：重胶粘物0.88，轻大杂质0.94（未给出）。两个例子中这两种分析方法之间获得如此强相关性的机会或概率小于0.0001。

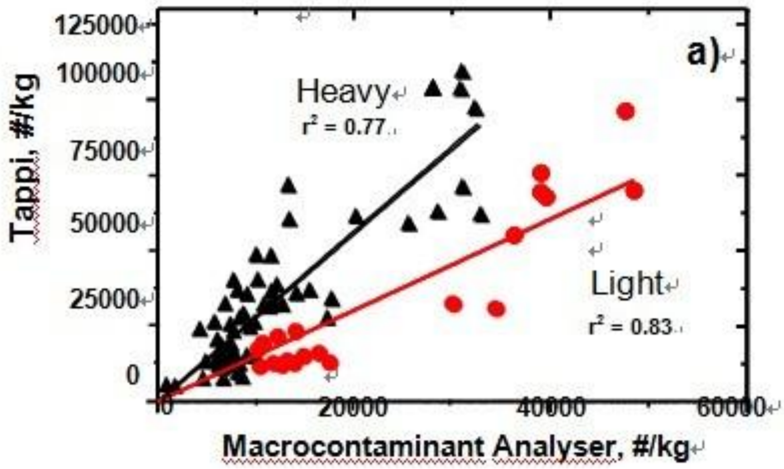


Figure 8. Relationship between number of macrocontaminants measured using the macrocontaminant analyser results and Tappi standard method for stickies analysis and a modified Tappi method for light weight contaminant.

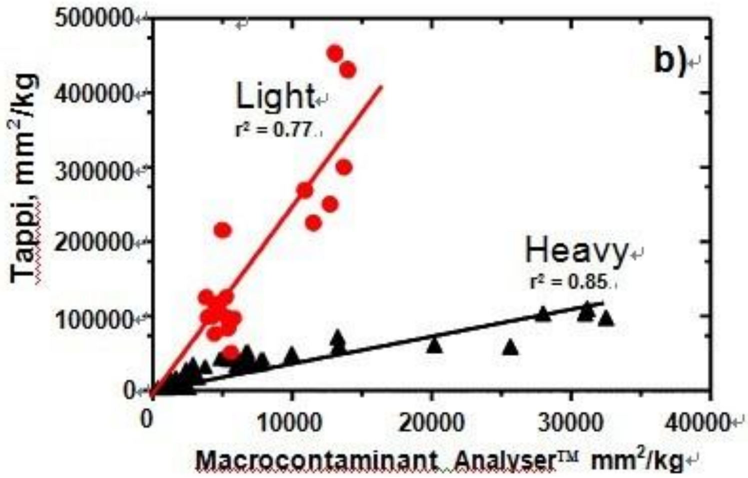


Figure 9. Relationship between area of macrocontaminants measured using the macrocontaminant analyser results and Tappi standard method for stickies analysis and a modified Tappi method for light weight contaminant.

In general, counts with the macrocontaminant analyser are lower than those measured by the Tappi methods. The discrepancy arises from several sources. Foremost, the Tappi method does not distinguish sticky particles based on their density in water (heavy or light). In addition, the Tappi method measures sticky contaminants on the tendency of the contaminants to stick to a coated sheet after a hot pressing step at 90°C [4]. Because this temperature is higher than those temperatures observed on the paper machine and on dryer cans, particles that are not typically sticky at mill paper machine operating conditions are coated by the Tappi method. Such particles include toner, plastics and hotmelts. This pressing step also flattens the stickies to different extents, increasing their measured width by image analysis. As such, the Tappi method therefore tends to overestimate the number and size of stickies. The differences between the two methods will be elucidated in more detail in a future report. Added features of the macrocontaminant analyser through the measurement of black contaminants such as toner will minimize the discrepancies between the Tappi Standard Method in the measurement of the mean number and area of heavy stickies. This added feature will be available within the coming year.

总的来说,大杂质分析仪统计的数值比Tappi方法要低。差异源于几个方面。最主要的是Tappi方法不区分粘性颗粒在水中的密度（重或轻）。而且，Tappi方法计量粘杂质是杂质粘附一层涂层纸后经90°C热压后再测量的[4]。因为温度高于纸机和干燥罐，Tappi 方法涂层得到的颗粒不具有工厂纸机操作条件下的典型粘性。这样的颗粒包括墨粉、塑料和热熔胶。压榨段也不同程度的压平了胶粘物，在图像分析时就增加了他们的计量宽

度。这样Tappi方法趋向于过高预计胶粘物数量和大小。这两种方法之间的差异将在以后的报告中有更详尽的说明。大杂质分析仪附加的特征通过黑色杂质的测量例如墨粉可将重胶粘物的平均数量和面积的测量值与Tappi标准方法差异最小化。这一增加的特征将在未来一些年内应用上。

Measurement Repeatability

测量重复性

Table I shows the repeatability of the survey measurements for the OCC cleaner feed and the survey and online measurements for the composite OCC and SOW pulps samples. The composite sample was tested in our pilot plant. For online sampling, two autosamplers were connected to a 2 m^3 feed reservoir containing a mixture of SOW and OCC pulps sampled from a mill and stored at room temperature for 72 h. When measurements are made in the survey mode on the same composite sample, the coefficient of variations for light and heavy contaminants are between 5 and 15%. These values are similar or lower than values cited in the Tappi standard method [4].

表1列出OCC清洁处理后原料的离线测量值、OCC和SOW混合纸浆在线测量和离线测量值的可重复性。混合试样在中试车间进行测试。做在线样品时，二个自动取样器连通一个2m^3的存放SOW和OCC纸浆混合样的供料槽，这些浆样从工厂取来并在室温下存放了72小时。当用离线测量模式测试统一的混合样品时，轻杂质和重杂质的偏离系数在5和15%之间。测得的值与Tappi标准方法的值相近或更低[4]。

The coefficient of variation doubles when measurements are taken in the online mode. The increased variations can be attributed to errors due to autosampler sampling, inadequate sample mixing in the reservoir and age of the sample. Despite this, coefficient of variations of 20% based on number and 31% based on area are still considered low for an online instrument. For although the Tappi method cites coefficients of variation between 12 – 19% in the standard method [4], the standard error for this manual measurement often approaches 25% in our laboratories.

在线测量时偏离系数加倍。变化增加可归因于自动取样、不适当的样品混入储罐、样品的储存时间。尽管这样，数量偏离系数为20%、面积偏离系数为31%对在线测试仪器来说是认可的。尽管Tappi方法提到标准方法中偏离系数在12 - 19%之间[4],而在实验室手动测量的标准误差常常接近25%。

The cleaner feed sample has a lower number of both heavy and light contaminants. With mean heavy stickies number of 5584/kg and area of 1894 mm^2/kg, the coefficient of variation is as low as those obtained for the composite samples despite having half the number of contaminants. Further analysis of the images obtained for this sample show that almost all of this difference, ~45%, could be attributed to the presence of black contaminants or dirt. However for the light macrocontaminants, the coefficient of variation is increased 10-fold. In this case, the higher variation is related to the low content of light macrocontaminants in this pulp. Again, the addition of a higher capacity screening system to the macrocontaminant analyser should allow the measurement of pulps with low macrocontaminant levels.

净化后的原料样品重轻杂质数量都会较低。重胶粘物平均数量5584/kg和面积1894 mm^2 / kg,尽管只有半数的杂质，但偏离系数和混合试样一样低。图像更进一步分析显示，这个差异～45%，几乎所有的都可以归因于黑色杂质或污垢的存在。然而对轻大杂质来说，偏离系数增加10甚至数倍。在这，高变化是因为浆中的轻大杂质含量低。再一次说明，高处理能力的筛分系统加入到大杂质分析仪将能够测试低大杂质水平的纸浆。

Table 1. Repeatability of Macrocontaminant Analyser Measurements

	Heavy Stickies				Light Macrocontaminants			
	Survey Mode		Online Mode		Survey Mode		Online Mode	
	#/kg	mm^2/kg	#/kg	mm^2/kg	#/kg	mm^2/kg	#/kg	mm^2/kg
Composite Sample (OCC & SOW)								
Number of Measurements	4	4	43	43	4	4	43	43
Mean	11814	2508	17602	4489	11850	4676	8866	6820
Standard Deviation	1120	390.8	3595	1404	639.7	284.1	1800	1995
Standard Error of the Mean	560.1	195.4	548.2	214.1	319.9	142	274.5	307.9
Coefficient of Variation, %	9.5	15.6	20.4	31.3	5.4	6.1	20.3	29.3
OCC Cleaner Feed								
Number of Measurements	7	7			7	7		
Mean	5884	1194			508	424		
Standard Deviation	591	193			344	210		
Standard Error of the Mean	224	73			130	79		
Coefficient of Variation, %	10.0	16.2			67.6	49.6		

CONCLUSIONS

结论

A new image analysis based instrument has been developed for measurement of light macrocontaminants and heavy stickies in deinked pulp. When operating in the online mode with autosamplers delivering the pulp samples, the instrument provides fast, reliable macrocontaminant determinations every 15 minutes. The total count and surface area of both light and heavy macrocontaminants per kilograms of pulp can then be sent by direct link to the mill data control system allowing an effective follow-up of macrocontaminant changes in process pulps and waters. The unit also allows the user to view images of the contaminants. The results obtained from the analyser in terms of number and area of macrocontaminants show a linear relationship with the Tappi standard method T-277, one of the most widely used methods in mills [2]. Because macrocontaminants are not flattened by a pressing step, the total area of the contaminants measured by the analyser is lower than that measured by the Tappi method.

基于图像分析的新仪器已经发展到可进行脱墨废纸浆中的轻大杂质和重胶粘物测量。用自动取样器取纸浆样品在线测试时，仪器提供快速可靠的大杂质测定，每15分钟测定一次。每千克纸浆中轻大杂质和重大杂质各自的总数目和表面积可连线发送到工厂数据控制系统从而允许执行有效的后续控制，控制加工纸浆和液体中大杂质的变化。分析仪也允许客户观察杂质的图像。分析仪得到的结果按照大杂质的数量和面积给出与Tappi标准方法T - 277（工厂最广泛的测试方法之一）的线性相关性[2]。因为大杂质没有经压榨步骤变扁平，所以分析仪测得的杂质总面积比Tappi方法测出来的值要低。

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