关于再生纤维生产线中的微生物控制

新型Amox方案能够在对传统杀菌剂产生中和效应的还原性条件下提供有效的微生物控制机理

Microbiological control on a recycling line

The innovative Amox progamme provides powerful control mechanisms in reductive conditions that neutralise conventional biocides

对大多数杀菌剂来说，再生纤维生产过程中难以进行微生物控制，主要因为这些杀菌剂无法处理还原性条件下的高含量污染物。

亚马逊化工有限公司研发出了一种用于解决上述问题的创新方案。该新型微生物控制方案采用一种选择性化合物进行微生物控制。该化合物具备弱氧化性杀菌剂、非氧化性杀菌剂和抑垢剂等的多种功能，不仅能够在还原性条件下获得很好的微生物控制效果，而且能够长时间维持整个纸机系统的清洁。

研究证明，由于该产品结合了其它杀菌剂的特性，因而具备很好的协同效果。该产品能够帮助造纸工作者显著减少整个湿部系统的细菌污染物，大幅度提高纸机清洁度。

该方案能够与系统所采用的其它化学品相互兼容，并对纸机表面和网毯不产生任何损伤。该方案能够消除厌氧环境，从而减少厌氧细菌所产生的各种问题，并且不会形成对环境产生危害的难降解物质。

现今，由于环保和经济方面的压力，采用再生纤维原料变得越来越普遍。在过去，再生纤维最初仅仅用于箱板纸的生产，但是现在，几乎所有不同等级的纸种都在使用再生纤维。

A recycling line is a difficult environment for most biocide programmes. This is mainly due to the inability of these biocides to deal with a very high level of contamination in a reductive environment.

Amazon has developed innovative approaches to this situation. The new microbiological control programme utilises a selective combination of a mild-oxidising biocide, non oxidising biocides, and antiscale agent in one product. This combination provides powerful microbiological control mechanisms in a reductive environment and also persists through the paper machine system over a longer period of time.

It has been demonstrated that as a result of combining this product with other proprietary biocides, there is synergistic activity. Benefits to the papermaker include dramatic reductions in bacterial contamination throughout the wet end system, which greatly improves machine cleanliness.

The programme has been found to be compatible with other chemistries used in the system and is friendly to machine

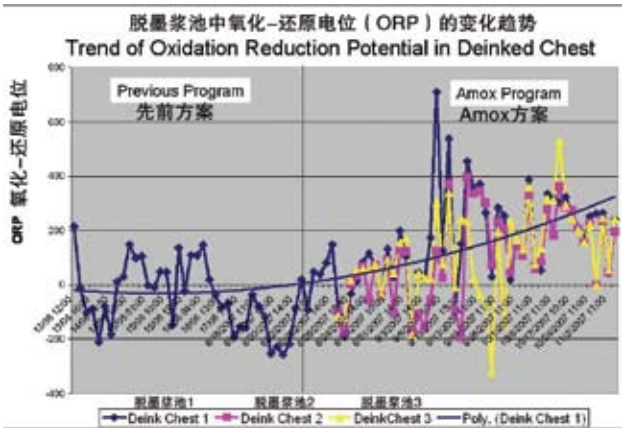

图1：由于添加了亚硫酸盐清除剂和Amox，所以高级纸生产厂的主脱墨浆池的氧化-还原电位(ORP)得到显著的提高
Figure 1: The de-ink chest in a fine paper mill. There is a significant increase of ORP as a result of sulfphite scavenger and Amox addition

再生纤维

然而，再生纤维的使用给微生物控制方面带来了挑战。回收的纸和纸板一般含有残留施胶剂、涂料、胶粘剂和胶液，这些组分都是微生物滋长的丰富营养源。一般情况下，营养源越丰富，纸业系统滋生微生物的潜力就越大。

此外，再生浆料一般受微生物污染的程度要比传统原生浆料严重的多。回收的纤维制品经常受干湿环境的影响，并且经常会储存于户外，无遮盖地暴露在地面上。

再生纤维所导致的高污染物含量和高营养条件将会加快耗氧微生物的生长。大多数耗氧细菌在生长过程中会分泌出聚合物质，该物质被称作生物膜。当该生物膜覆盖到造纸过程中经常使用的木材纤维、碳酸钙、瓷土和其它颗粒上时，会进一步生长扩大。

该生物膜长期在造纸系统中滋生会形成厚厚的粘液沉积物。当该沉积物破裂并落入造纸浆料中时，会产生孔洞、斑点等纸病，甚至会导致断纸。有纸病的纸张必须进行损纸回用再制浆或者是进行降级处理。

耗氧生物体的快速生长会导致原料和水系统中氧含量的降低。氧含量低会产生一个还原性的环境，进而给厌氧细菌生长提供理想的条件。

微生物生长

厌氧微生物生产会引起纸浆、浆料和化学添加剂的损坏。该微生物能够在缺氧的环境中快速生长，从而产生刺鼻的臭味，该臭味是由挥发性脂肪酸的产生所引起的。浆池的厌氧性损坏就意味着有氢气、硫化氢等易燃易爆气体的形成。

硫化氢的产生会引发微生物诱导侵蚀，这会破坏造纸设备金属结构的完整性。一组叫做梭状杆菌的厌氧细菌会产生纤维素酶。该纤维素酶会降解木材纤维的结构性组分纤维素聚合物，从而会导致纸张强度的降低。

另外一个需要考虑的因素是水封闭性的提高，这在再生纸生产方面非常普遍。水循环利用会产生固形物堆积，从而使得水温升高。

surfaces and clothings. It eliminates anaerobic environments, subsequently reducing problems associated with anaerobic bacteria without forming environmentally hazardous degradation products.

Nowadays, there is increased environmental and economic pressure to utilise recycled raw materials. In the past, recycled fibre was used primarily in boxboard mills, but today, it can be found in almost all grades of paper.

Recycled fibre

However, recycled fibre can create microbiological control challenges. Post-consumer paper and board often contains residual sizing, coating, adhesives and glues – components that are rich sources of nutrients for microbial growth. In general, increasing the amount of nutrients increases the potential for microbial growth on the machine.

Furthermore, a recycled furnish is usually contaminated with a higher loading of microorganisms than is typical with virgin pulp. Post-consumer fibres are generally subjected to moist and dirty conditions and are often stored outdoors, uncovered and exposed to the elements.

High nutrient levels and increased levels of contamination associated with the incoming recycled fibre can lead to increased aerobic microbiological growth. Most of aerobic bacteria are associated with the formation of exo-polymeric materials by bacteria; this is called biofilm. The biofilm can further increase in size as it entraps the wood fibres, carbonates, clays and other particles normally used in the papermaking process.

The biofilms in paper machines form massive slime deposits that can be an inch or more in thickness. When these deposits

The method a mill chooses to control microbiological deposit plays a large role in the performance and economics of the system. Frequent boilouts and washups may keep chemical costs low, but, at the expense of machine downtime

图2：经过处理之后，脱墨浆池的ATP得以显著降低
Figure 2: Following treatment, there was a significant reduction in de-ink chest ATP

水温的升高将会导致水中溶解氧的降低，这是因为氧的溶解度与温度成反比。这些变化会导致微生物群体从耗氧型向厌氧型转变。

水封闭性的提高同样会导致设备腐蚀程度的增大。这大多是由于高封闭系统中氯离子浓度的增加以及微生物活性的增强所致。水循环利用的程度加大会增加微生物诱导侵蚀的程度。

除了上述需要考虑的因素之外，再生脱墨纤维所采用的亚硫酸盐漂白将会中和大部分杀菌剂的官能团。这些杀菌剂受还原性助剂存在的影响，并在采用亚硫酸盐漂白时无法充分地起到杀菌的作用。因此，当处理脱墨浆料时，需要采用一种与众不同的杀菌策略。

控制方法

一个纸厂在微生物沉淀控制方面采用何种方法将对生产的整体性能和经济效益起到非常重要的作用。众所周知，采用合适的微生物控制助剂将会给纸机运行性能和维持产品质量带来很多好处。在停机的昂贵代价下，利用少量这些助剂并且结合运用化学清洗和洗涤等方法将有助于保持低的化学品成本。

使用常规的微生物控制助剂的主要缺点之一是它们无法很好地处理具备高污染负荷以及高还原性助剂用量的用于生产再生纸和纸板的浆料。有些杀菌剂在采用原生纤维浆料进行造纸方面能够起到很好的作用效果，但是对再生浆料来说效果不佳。

另外，由于再生纸张市场竞争非常激烈，一些再生等级纸张的生产只能承受成本相对低的化学品方案。微生物控制方案需要进行调整以便应付这些变化。为了确定能够解决这些不同挑战的微生物控制方案进而获得最佳成本效率，需要就产品正确选择性方面进行测试。

一种新的沉积物控制方法

传统用于再生纤维浆料沉积物控制的途径包括利用不同类型的杀菌剂。它们通过杀灭或抑制微生物从而起到控制微生物生长和防止纤维表面携带微生物。过去，像氧化性卤素、有机卤素、含硫物和重金属物质这样的杀菌剂一般用于造纸系统的微生物生长控制。

break loose and fall into the paper furnish, they result in end product imperfections such as holes and defects or even paper sheet breaks. When this occurs, the paper with the defects must be used as broke and re-pulped or downgraded.

The rapid growth of aerobic organisms can also deplete the oxygen content of the stock and water system. This low oxygen content creates a reductive environment which favours the growth of anaerobic bacteria.

Microbiological growth

Anaerobic microbiological growth can cause spoilage of pulp, furnish and chemical additives. They flourish in an oxygen-poor environment and produce unpleasant odours due to volatile fatty acids generation. Anaerobic spoilage of chests has also been implicated in the formation of hazardous and explosive gases such as hydrogen and hydrogen sulphide.

Hydrogen sulphide generation also triggers the microbiological-induced corrosion that attacks the integrity of paper machine metallic structures. One group of anerobic bacteria called Clostridia produce cellulase enzymes. The cellulases degrade the cellulose polymers found as structural components in wood fibres, and this can lead to a decrease in sheet strength.

Another important factor that needs to be taken into consideration is the increased water closure which is very common in recycled paper production. Water recycling causes the buildup of solids and increased water temperature. When temperatures climb, the dissolved oxygen levels of the water decrease, since solubility of oxygen is inversely proportional to temperature. This change can lead to a shift in the microbial population from aerobic to anaerobic bacteria.

Increased closure can also result in an increase in machine corrosion. Much of this is attributed to the increased chloride ion concentrations found in very closed systems as well as increased microbial activity. Microbial influenced corrosion appeared to be enhanced by increasing water reuse.

In addition to the factors mentioned above, the use of sulphite bleaching when recycling de-inked fibres, neutralises the function of most biocide chemistries. These biocides are affected by the presence of reducing agents and can not function properly when sulphite bleaching is used. Therefore, a different biocide programme strategy is required when dealing with de-inked pulp furnish.

Control philosopy

The method a mill chooses to contol microbiological deposit plays a large role in the performance and economics of the programme. It is well know that the use of microbiological control agents provides advantages in maintaining machine runnability and product quality. Minimal use of these agents

图3：采用Amox处理后，侵蚀试验块没有任何侵蚀迹象
Figure 3: Corrosion coupons show no evidence of corrosion after Amox treatment

但是现在，市场上倾向于采用环境友好型化合物。纸厂所使用的杀菌剂必须能够容易降解并对环境不产生任何伤害。如果适当使用杀菌剂，他们必须遵守地方政府的规章制度。

亚马逊化工有限公司最近推出了用于制浆造纸工业微生物控制的新方案。该技术叫做Amox，是一个高效又经济的沉积物控制剂，集弱氧化性助剂、非氧化性杀菌剂和抑垢剂于一身。

当运用时，Amox能释放出能够有效防止无机和有机沉积物堆积的沉积物控制剂。由于具备先进的加药设备和合适的应用及监测策略，Amox能够通过消除沉积问题来提高纸机效率，从而提高了生产效率、消除了厌氧微生物的生长、降低了生产成本和大大减少了停机清洗次数。

Amox被证明也能够很好的作用于具有高还原性环境的再生纤维浆料。该产品能够易于被降解成为没有任何危害的化学物质。

案例研究1: 高级纸生产厂

本次案例研究主要关注于Amox在以亚硫酸盐漂白脱墨浆为原料的碱性高级纸生产厂中的应用情况。

该纸厂具有4台纸机，总产量达到200吨/天，主要生产有色纸板和无碳复写纸。这些纸机都使用脱墨浆，有时其使用比例达到100%。在脱墨浆生产车间使用了2种漂白助剂：过氧化氢和甲脒亚磺酸(FAS)。这4台纸机共用一个脱墨浆池。

调查工作显示：脱墨浆料是细菌感染最严重的原料，并且A纸机和B纸机的还原性助剂残留很严重。该纸厂同意在保持现有控制方案的同时用3个半月的时间对Amox方案作为策略中一部分在降低杀菌剂成本方面的作用进行试验。作为必要条件的一部分，添加杀菌剂必须能够保证不增加纸机腐蚀程度和纸张的AOX含量。

试验：该策略是在脱墨备料工段(纸机之前)中对还原性环境进行中和。其途径是：在主脱墨浆池添加少剂量的Amisperse 8998和亚硫酸盐中和剂。紧跟着是在纸机上进行全氧化过程。

作为一种控制措施，除了要测量系统污染物含量和氧化剂残留量之外，氧化-还原电位(ORP)测量被用于监测系统电位从而进行化

in conjunction with frequent boilouts and washups will keep chemical costs low, but, at the expense of machine downtime. The total costs for machine downtime and downgraded product quality is much higher compared to these chemical costs.

One of the major drawbacks in the use of microbiological control agents is their inability to perform satisfactorily when dealing with a very high load of contamination and the high level of reducing agents commonly found in the production of recycled paper and board. Some biocides that worked well in papermaking with virgin pulps may no longer be products of choice for recycled pulps.

In addition, due to the high competitivity in recycled paper markets, some recycled grades can only afford the use of relatively low cost chemical programmes. The microbiological control programme needs to be adjusted to manage these changes. Proper product selection tests should be conducted to identify the most cost effective microbiological control programme required to meet these different challenges.

A new approach to deposit control

The traditional approach to deposit control in recycled grades involves the use of a wide variety of anti-microbial

The traditional approach to deposit control on a recycling line involves a variety of anti–microbial agents which are not considered to be environmentally friendly, that is to say, oxidising halogens, organohalogens, sulphur–based, and heavy metals

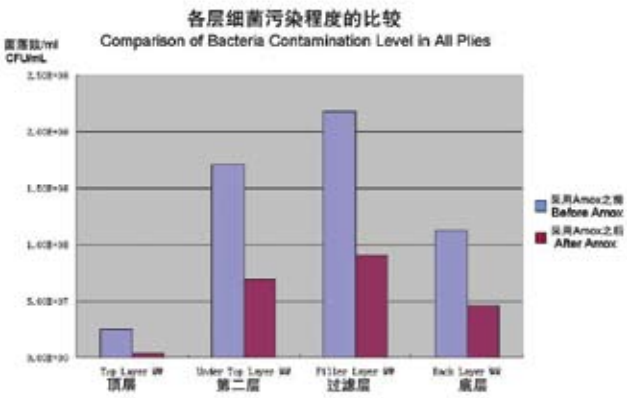

图4：Amox处理过程中细菌污染情况得以显著降低
Figure 4: A reduction in bacteria contamination during Amox treatment

学品用量调整。关于侵蚀程度方面的监测是通过安装侵蚀试验块从而每周对其进行检测来实现。

结果：图1曲线表明，由于添加了亚硫酸盐中和剂和Amox，所以主脱墨浆池的氧化-还原电位(ORP)得到显著的提高。进行氧化-还原电位(ORP)测量的同时，也采用三磷酸腺甙(ATP)法对每日细菌活性进行测量。图2曲线显示，经过处理之后，脱墨浆池的ATP得以显著降低。

在采用Amox方案后，4台纸机的平均处理成本比预计目标降低了40%，并对纸机性能不产生有害影响。每周进行的侵蚀试验块监测显示系统没有产生侵蚀程度上的增加。最终纸张中的AOX含量依然保持在较低的水平。

图3显示，安装在侵蚀架上的侵蚀试验块在71天当中的变化情况。采用Amox处理后，没有任何侵蚀迹象。

案例研究2：多层纸板机

本次案例研究主要关注于Amox在多层纸板机上的应用情况。

该纸板机采用原生纤维和再生纤维浆料为原料生产双面涂布纸板。该纸机采用非氧化性杀菌剂无法防止因粘液引起的断紙及纸病。在流浆箱内部发现有粘液沉积。

试验：亚马逊化工有限公司在该纸机上进行了有关Amox应用方面的试验。该方案运用于的纸板机每一层的白水中。在脱墨浆料中添加清除剂以便在系统添加Amox之前中和掉亚硫酸盐。

结果：图4表明，整个湿部的细菌含量得以显著降低，微生物控制得到显著提高。图5显示，纸机变得更加清洁。断纸率降低，从而使得纸机速度得以进一步提高，进而获得更高的生产能力。

Amox是中碱性造纸系统用于微生物控制和沉积物控制的理想助剂。它能够为造纸生产线提供一流的沉积物控制，从而能够提高生产速度、改进产品质量、降低生产成本和减少清洗次数。

Amox方案能够显著降低微生物污染程度，并且对湿部和纸机网毯不产生影响。该方案能够为湿部系统提高持续稳固的杀菌环境，从而提升了其它杀菌剂的杀菌性。

agents. These control microbial growth and prevent the attachment of microbes to surfaces by either killing or inhibiting the microbes. In the past, anti-microbials such as oxidising halogens, organohalogens, sulphur-based, and heavy metals were commonly used to control growth on paper machines.

But today, the marketplace is demanding more environmentally friendly compounds. The biocides that are used in the mills should be readily degraded and not harmful to the environment if properly applied. They should also comply with the regulations of local authorities.

Amazon Papyrus Chemicals has recently released a new microbiological control for the pulp and paper industry. The technology is called Amox, and is a highly effective and economical deposit control agent which combines a mild-oxidising agent, non-oxidising biocide, and an antiscale agent in one product.

When applied, Amox releases an effective deposit control agent which prevents the build up of inorganic and organic deposits. With state-of-the-art feed equipment as well as the proper application and monitoring strategy, Amox enhances the efficiency of the paper machine by eliminating troublesome deposition. This leads to increased production rates, the elimination of anaerobic growth, reduced manufacturing costs and longer time between shuts for cleaning.

It has also been proven that Amox works in recycled grades with a high reducing environment. The end products are readily degraded to non hazardous chemistries.

Case study 1: A fine paper mill

This case study focuses on the application of Amox in an alkaline fine paper mill using a sulphite de-inked furnish.

The mill's four machines produce up to 200 tons per day in total, making a combination of coloured board and "no carbon required" (NCR) paper. The machines use de-inked pulp, some times up to 100 per cent. Two brightening agents are used at the de-inking plant: hydrogen peroxide and formamidine sulfinic acid (FAS). The four machines share common chests that feed the de-inked stock to the machines.

Survey work showed that the de-inked furnish is a considerable source of bacterial infection and there is a significant carry-over of reducing agent to the machines A and B. The mill agreed to a three and a half month trial of the Amox programme as part of a strategy to reduce biocide costs while keeping the current control performance. As part of requirement, there should not be any increase to machine corrosion and AOX level in finished paper as a result of biocide addition.

Action taken: The strategy was to neutralise the reducing environment prior to the paper machines, at the de-inked stock prep stage. This was achieved by adding a sulphate scavenger

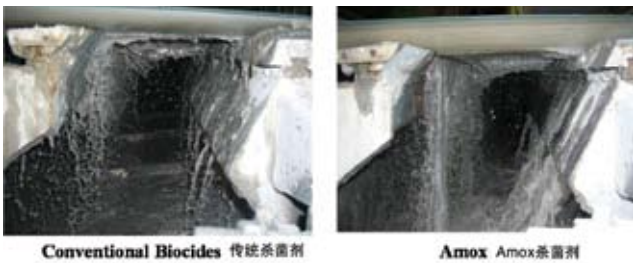

图5：采用Amox后纸机变得更加清洁
Figure 5: A cleaner machine when Amox is applied

结论

采用再生纤维和白水封闭循环系统给纸厂带来很大好处。为了充分利用这些好处，造纸工作者必须意识到它们的潜在问题，并且能够逐渐的减少使用再生纤维所产生的负面影响。

要想成功地使用再生纤维，对微生物活性进行操纵显得非常重要。Amox方案在这个领域已经获得成功。由于Amox能够提高纸厂的微生物控制性能，所以它是那些以再生纤维为原料的纸机的理想选择。

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along with a small trim dose of Amisperse 8998 at the primary de-ink chest. This was followed up with the full oxidant programme on the paper machines.

As a control measure, in addition to measurement of system contamination and oxidant residual, an ORP (Oxidation-Reduction Potential) measurement was used to monitor system potential and to make adjustments to the chemical dosage. The Corrosion level is monitored on a weekly basis by installing corrosion coupons.

Results: The graph in figure 1 shows a significant increase of ORP in the primary de-inked chest as the result of sulfphite scavenger and Amox addition.

Along with ORP measurements, daily bacterial activity was measured by the ATP method (Adenosine Tri-phosphate). The graph in figure 2 shows a significant reduction in de-inked chest ATP as a result of treatment.

The average treatment cost for all four machines during the conversion to Amox programme was almost 40 per cent below the mill target. This has been achieved with no detrimental impact on the machines' performance. The weekly monitoring of corrosion coupons revealed no significant increase of

system corrosion. The AOX levels of the finished paper are also maintained at low levels.

Figure 3 shows corrosion coupons collected from corrosion rack 71 days after installation. There was no evidence of corrosion after using Amox treatment.

Case Study 2: A multi-ply board machine

This case study focuses on the application of AMOX on a multi-ply board machine.

The board machine produces duplex coated board with a combination of virgin and recycled pulps. The non oxidising biocide programme used on this machine was not able to prevent slime breaks and slime defects from occurring. Slime deposits were found inside the headbox.

Action taken: Amazon conducted a trial of its Amox programme on this machine. The programme is applied into the white water tray of every ply. Scavenger was used in the de-inked furnish to help neutralise the sulphite before the addition of Amox to the system.

Results: Significant improvements in microbiological control were observed, as indicated by a reduction in bacteria levels throughout the wet end, figure 4 . This results in a cleaner machine, figure 5, and reduced sheet breaks. With the reduction in sheet breaks, paper machine speed can be increased, resulting in higher production capacity.

Amox is a broad spectrum antimicrobial and deposit control agent for a neutral to alkaline paper mill system. It provides superior deposit control in paper circuits which will lead to increased production rates, improved product quality, reduced manufacturing costs and extended time between shuts for cleaning.

The Amox programme reduces microbiological contamination levels with much less interference with wet-end additives and machine fabrics. The programme provides persistent background toxicity in the wet end system and this boosts disinfection by other biocides.

Conclusions

The use of recycled fibres and the closure of the system are of great benefit to paper mills. To take advantage of these benefits, the papermaker must be made aware of potential problems and take steps to minimise the negative aspects of recycled fibre usage.

The management of microbial activity is very important for the successful use of recycled fibre content. The Amox programme has proven success in this area. Since it improves a mill's microbiological control performance, Amox is a good choice for paper machines using recycled fibre. ■

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