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Research Progress of Airlaid Technology in Dry Papermaking

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Abstract

The development of air-laid technology in dry papermaking in recent years is reviewed, the problems of air-laid process equipment and reinforcement technology are analyzed, and the related application research progress of air-laid technology is summarized.

Keywords

Dry Papermaking; Airlaid; Netting Process.

1. Introduction

Airlaid technology of dry papermaking mainly uses fluff pulp as the main raw material, and a method of producing non-woven fabrics through airlaid technology and other reinforcement technologies[1]. Dry papermaking technology is very different from traditional textile technology, it can process natural fibers, synthetic fibers, glass fibers and some other special fibers[2], in the manufacturing process, air is used instead of water as a medium for dispersing and transporting fibers, and air is not dehydrated during forming, but the fibers are formed into paper webs without causing water pollution. Therefore, the air-laid technology of dry papermaking has attracted more and more attention, and its products have been widely used in daily life, medical treatment, decoration and clothing, automobiles and so on.

2. The Historical Origin and Development of Dry Papermaking

Dry-laid papermaking technology is a kind of non-woven fabric technology. Dry-laid paper is called air-laid paper in Europe and Japan, dryformed paper in the United States, and dust-free paper by many people in China. According to the different raw materials used, it can also be divided into air-laid fabrics or non-woven fabrics. Dry-laid paper was first invented in the 1930s by Dimtrier and Bonderenk using man-made fibers combined with air. In the 1960s, Denmark's Niro Separation Fibretech and Japan's Honshu Paper Company each developed a dry-laid paper machine using wood pulp as raw material. In 1991, Finland's Rauma-Repola and Denmark's Dan-web established the world's first dry-laid paper production line using fluff pulp and chemical short fibers as raw materials, with an output of about 7,000t a year. In 1989, Taiwan Province of my country introduced a dry-laid paper production line with an output of about 7000t from Denmark's M&J Company, and it was named as clean paper in Chinese for the first time. In 1996, the earliest dry-laid papermaking production line in my country's inland was built by Ningxia Wuzhong Ruite Paper Co., Ltd., with an annual output of about 4,500t. Using fluff pulp as raw material, it mainly produces household paper, hospital paper, and industrial wiping paper[3].

The airlaid technology of papermaking has grown rapidly in recent decades. In 2019, the global output of drylaid paper is about 1.5-1.65 million tons, which is almost several times higher than that of 10 years ago. Dry-laid papermaking is now valued by many countries, of which Europe occupies 50%

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of the market, the United States and Asia occupy 28% and 14% of the market respectively. In addition to the above-mentioned regions, South America and the Middle East have also begun to vigorously develop the forming, production and application of dry-laid paper. Figure 1 shows the distribution of airlaid output in various regions of dry papermaking.

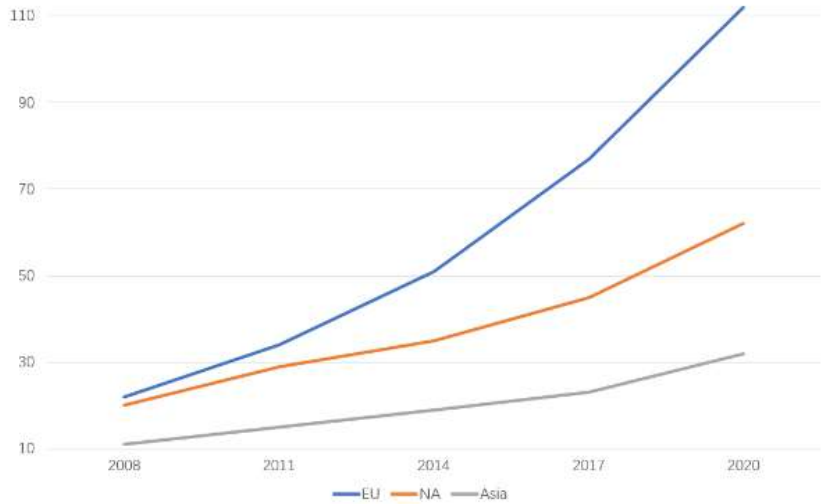

Figure 1. Airlaid output by region/10,000t

3. Development of Airlaid Technology and Equipment Technology for Dry Papermaking

3.1 Airlaid Technology of Dry Papermaking

The air-laid process is roughly divided into three steps: the first step is to open the fluff pulp and other raw materials to form dispersed single fibers; the second step is to re-form the fibers into a uniformly dispersed and disorderly web by air-laying ; The third step is to reinforce the fiber web through different bonding methods, and the processing flow is also different by forming different products.

The production process generally uses 100% fluff pulp as the raw material, and its composite fibers are appropriately added according to the different products it produces. After the pulp board is screened, separated and other pretreatment, the pulp board is first processed by the fiber crusher, and then enters the crusher through the pipeline for the defibration process. Because the blades of the crusher are very dense and fast, so The mechanical action carried out can obtain a single fiber, and there are screens around the crusher through which the single fiber can pass. , separate and collect the fibers and impurities being processed, and the centrifugal fan can provide positive and negative pressure difference, so that the single fibers in the dust cage can fall on the forming conveying device in a disorderly, dispersed and uniform speed. When the paper web is just formed, the strength is very low and the density is very thin. After being compressed by the hot pressing roller, the number of interwoven points between the fibers can be increased, and a preliminary fiber web can be formed. The embossing system is mainly to generate a pattern with a cloth texture for the product, and can further make the fiber web more compact and firm. Spray glue generally has front glue and reverse glue. It is a porous moving spray tube that sprays water-soluble latex to the paper web, and applies different types and amounts according to the different products it produces. Finally, it enters the drying and drying process through the transmission device. After high-temperature heat treatment, the chemical molecules are fully combined, that is, the formed product can be shaped. After adjustment, rewinding, and slitting, it can be packaged and put into storage. In this way, the entire process flow is completed.

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3.2 Equipment and Development of Airlaid in Dry Papermaking

Most of the air-laid processes used at home and abroad before the use of Dan-Web and M&J equipment produced in Denmark. Hubei Tongshan Machinery Factory and Ningxia Wuzhong Ruite Paper Co. Ltd. are Dan-Web Forming, and Tianjin BBA introduced M&J Fibertech[4].

With the continuous research at home and abroad, the air-laid technology is also being improved year by year, especially in the forming equipment or the internal structure of the formed air duct, many innovations have been made. Li Lei[5] designed an airlaid machine. He analyzed and built a model around the cylinder, the air duct, and the inside of the condenser in the airlaid machine. By improving the design of the airlaid uniformity, the designed airflow The net machine can be fed continuously or indirectly by feeding the fibers. Through the research on the air-laid air duct, the design can control the fiber conveying air duct and the air flow rate blown in, so that it can also be air-laid for other fibers. In the formed fiber web, the fibers are all The disordered and disordered arrangement improves the tensile and shear resistance properties of the formed fiber web in all directions. Liu Jianwei[6] and others mainly invented a negative pressure suction device for an airlaid machine, including a suction pipe connected at the bottom of the output curtain and an exhaust pipe on the side of the suction fan. By installing a negative pressure suction device, an artificial downward airflow can be generated between the output curtain and the hot rolling mill, so as to offset the upward airflow generated by the high temperature of the hot rolling mill, so that the fiber web can enter the heat smoothly. For the rolling mill, the exhaust pipe of this device adopts a PPR plastic pipe with a diameter of 150mm, and the connection of the exhaust pipe is connected by a PPR joint and an elbow, which makes the installation and disassembly very convenient. In addition, a filter is installed at the air inlet of the suction fan. , you can filter the remaining cotton on the condensate, so as not to block the suction fan. This increases the operating efficiency of the airlaid machine. Zhang Jiayuan[7] set up input and output curtains at both ends of the airlaid device shell, respectively. The fiber products enter the device through the input curtain, and after being rolled and flattened by the internal rollers, they are first treated with sawtooth beaters, and then pulled by the rollers to make them again. Rolling, and finally transported out of the device through the output curtain. During the pressing process, the internal vacuum cleaner will absorb the dust generated on the fiber cloth and the inside of the device, so that the dust will not adhere to the inside of the device, and the vacuum cleaner can adjust by adjusting the button, so the vacuuming work is completed. The vacuum cleaner not only absorbs the dust inside the shell in a large area, but also the dust pulled by the sawtooth beater will not be scattered and attached inside, so that the dust content in the fiber product is also less, and manual cleaning is not required, which improves the work efficiency efficiency. Fu[8] has developed a new method for the drafting airflow of the roller. According to the arrangement structure of the inner fibers in the fiber web, it is divided into single fibers with a conventional drafting roller, and the airlaid fiber web is drawn in the processing roller. Then, the fibers are collected layer by layer to form a fiber web on a stainless steel mesh conveyor belt with suction air. By preparing polyester webs, their basis weights are divided into different densities. The results of the reinforcement were compared with those of conventional drylaid webs, and the results showed that the formed webs had improved strength and elongation. This process produces high-quality fabrics with uniform fiber distribution on the resulting web, with little variation in strength in the machine and cross directions.

4. Dry-laid Papermaking Reinforcement Technology and Development

Dry papermaking technology is a network-like structure formed by fibers through opening, impurity removal, and carding, and then a certain reinforcement process can form a stable structure[9-10]. Fiber reinforcement methods are generally divided into mechanical reinforcement, chemical bonding and thermal bonding[11]. Different reinforcement methods are only related to their raw materials, and they need to be adapted to each other to get better results, and some surface characteristics such as the length, thickness, density, crimp, heat resistance, and electrical conductivity of the fibers need to be considered[12].

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4.1 Needling Reinforcement

Acupuncture uses the puncturing action of the needle to repeatedly needle the fluffy fiber web, and through the up and down reciprocating movement of the needle, the fibers are entangled with each other during the movement to form a material with a certain thickness and strength. The needle is an important element of acupuncture. Usually the needle has a triangular cross-section and three different barbs at different distances from the edge. Different felting needles can be selected according to different products, mainly including felting needles and structural needles[13]. Generally used in the production of curtains, automotive interiors and some industrial non-woven fabrics.

4.2 Spunlace Reinforcement

Spunlace is a method of impacting the fiber web with the help of high-speed and high-pressure water flow, so that the fibers can be entangled with each other to saturation, so as to achieve the purpose of reinforcement. Spunlace is affected by the diameter, length, cross-section, roughness, strength and elongation of the fiber itself, so usually the materials used in spunlace are polyester materials. Generally used in the production of bedding, hygiene products and household products.

4.3 Chemical Bonding Reinforcement

The chemical bonding method refers to applying chemical adhesives on both sides of the fiber web formed by fluff pulp, so that the single fibers are bonded together by the adhesive, and finally dried to achieve the purpose of reinforcement. For different fibers, different binders can be selected to produce different products. Generally used in the production of medical supplies, meat packaging products, etc.

4.4 Hot Rolled Reinforcement

The hot rolling method mainly uses the rolling of the hot rolling mill to make the fluff pulp fiber and some other composite fiber webs form a structurally stable fiber web under the hot extrusion of the machine. The product after hot-rolling reinforcement is more stable than other products in terms of its elongation or density. Generally used in the production of carpet wiping materials, medical clothing, moisture absorbing products, etc.

4.5 Composite Reinforcement Process

4.5.1 CAC Composite Reinforcement

The CAC process is mainly a multi-layer composite production process (carded web - airlaid - carded web - spunlace composite). The main method is to carry out two carding in the steps before and after the air laying. After the first carding, a carded web on one side of the surface layer can be formed. Carding to form a carded web on the surface layer on the other side, and finally reinforced by spunlace, a product with good water absorption and stable tension and strength can be formed. This composite technology not only has good protection measures for the environment, but also greatly improves the efficiency of production. Generally, products such as hygiene and cosmetics can be produced.

4.5.2 SAS Composite Reinforcement

The SAS process is mainly a multi-layer composite production process (spunbond-airlaid-spunbond-spunlace). The main method is to add the unrolled spunbond material in the front and rear steps of the air-laid, and finally perform the spunlace reinforcement, so that the purpose of composite reinforcement technology can be achieved. The technical advantage of SAS over CAC is that the production speed and production efficiency are required. higher. Because spunbond and airlaid technologies are similar in production speed and efficiency, SAS combines the two to make production even more efficient. It is generally used to produce products with an areal density of 40~120g/m2, mainly to produce wipes with good water absorption, high strength and good wear resistance.

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4.5.3 ASA Composite Reinforcement

The ASA process is mainly a multi-layer composite production process (dry papermaking - spunbond - dry papermaking). The main method is to unwind the spunbond material between two airlaid heads and rebond it so that the product has a higher strength. Composite spunbond materials can also be used to avoid delamination of the product after thermal bonding. The main advantages of ASA products are that they can produce high vertical and horizontal strength, high wet strength, low raw material loss and high production speed. Generally used to produce wipes and other products.

5. Application of Airlaid Technology in Dry Papermaking

Airlaid products of dry papermaking have now been widely used in life and industry, as shown in Figure 2 it can be roughly divided into four categories: traditional industry, heat insulation industry, automobile industry and other industries. How to use the air-laid technology of dry papermaking, understand and master the development of its products, and develop it into a wider range of applications, are some of the main problems in future research.

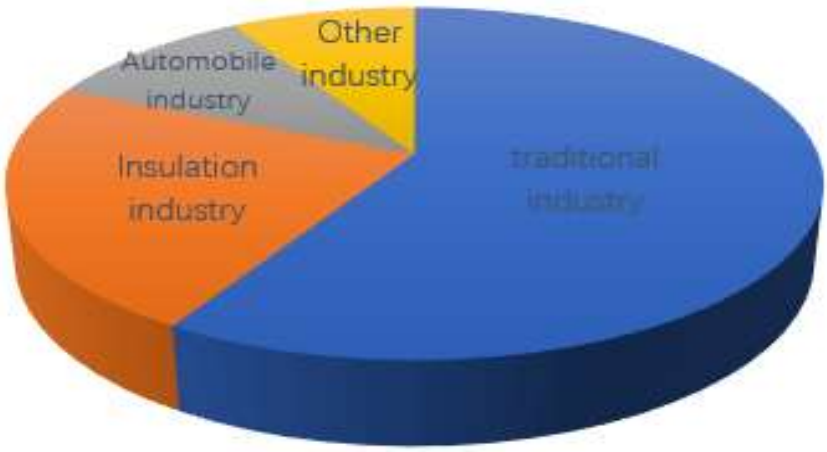

Figure 2. Airlaid product application industry

5.1 Traditional Industry

According to the current production scale of airlaid products, traditional industries account for the vast majority. Included are the areas of daily life, such as wet and dry wipes, cleaning wipes, hygiene products, medical supplies, decoration and clothing. Zhou Binghua[14] and others disclosed and invented an activated carbon dry-laid paper, based on the air-laid process, adding or mixing activated carbon powder, particles or fibers to make activated carbon paper, which can absorb excrement and odor. It can effectively reduce the emission of peculiar smell, so as to achieve the purpose of eliminating peculiar smell. The paper has adjustable performance, is economical and applicable, and can be widely used in sanitary products. Ren Jichun[15] and others invented an air-laid method to produce a high-efficiency absorbent core with novel structure, strong absorption, ultra-thin and ultra-soft disposable sanitary products. They used the air-laid process to use the first layer of toilet paper as a low liner, the cellulose fibers and polymer water-absorbing resin in the second and third layers as the inner liner, and applied on the fourth layer of fibrous web formed of cellulose fibers. Emulsion, so that the middle of each layer can be connected, and finally this new type of sanitary product absorbent core can be produced completely. Qu Caixin[16] used mulberry bark as raw material, extracted the mulberry bark fiber, used its air-laid technology and spunlace reinforcement technology, and finally removed the water of the formed fiber network by drying, so that the hand can be obtained. A soft, hygroscopic, breathable, antibacterial, and biodegradable nonwoven product for medical use.

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5.2 Insulation Industry

With the development of airlaid technology for dry papermaking, its methods are also more and more used in the thermal insulation and thermal insulation of materials. This includes a wide range of other fields of application, such as building materials insulation materials, industrial insulation materials, etc. Chen Zhaofeng[17] and others invented a method for ultra-fine glass wool non-woven lightweight felt. After opening, air-laid process, atomization spraying, curing and other steps, ultra-thin and ultra-low bulk density glass wool can be obtained. Felt, the product made of not only has a uniform surface, low fiber damage rate, but also has thermal insulation and sound absorption properties, and can be used in many thermal insulation materials for aircraft, ships, and high-speed rail. Tong Junfeng[18] used waste textile fibers, opened the fibers, and then compounded the fibers with flame retardants and curing agents through an airlaid machine to make a fiber web. After drying, the two sides or one side were bonded without Spun cloth or aluminum platinum, and finally got a thermal insulation board. The thermal insulation board is not only simple in process, but also belongs to resource reuse, which not only saves the cost, but also increases the strength and thermal insulation effect of the thermal insulation board. This product can be used in a large number of building materials for thermal insulation according to its thermal insulation performance, which can improve the utilization of high value. Ge Shouxiang[19] provided a method for greenhouse insulation felt, which was prepared by mixing wool fibers and hot-melt fibers by airlaid technology. The wool fibers have good flexibility and high tensile strength. Thatch, Pu mat and other materials are not easy to operate, have poor thermal insulation effect, short life and fast wear. After technical processing, it not only improves the thermal insulation effect of the greenhouse, but also makes a certain contribution to the intensification and standardization of modern greenhouse planting.

5.3 Automobile Industry

The development of the automotive industry is closely related to the development of modern technology. It represents the display of some front-end technology forces in today's society, among which air-laid technology is applied to the interior of the car. Elena[20] and others studied that the fibers in waste feathers can be processed into non-woven feather fiber composite mats through air-laid technology. The resulting composite mats are composed of fiber webs, and their products have good thickness and density And compared with other materials, it is found that the produced feather fiber mat has an improved sound absorption coefficient and can be used in interior sound insulation materials in automobiles. Wei Yiwen[21] et al. processed micro-nano PP fibers, bamboo charcoal fibers and hollow fibers in PET into a fiber web through the air-laid process, and covered the surface layers on both sides of the fiber web. The warm non-woven layer or aluminum foil can be formed into a sound-absorbing material after lamination, embossing, and ultrasonic edge sealing. This material has the advantages of sound absorption and sound insulation, deodorization, flame retardant, etc., and the process is simple, pollution-free, and can be recycled. It can meet the requirements of low VOC in automobiles, and can be widely used in automobile interiors. Zhao Yanyan[22] and others used air-laid technology to open and mix kenaf and polypropylene (pp) fibers to make fiber webs, and then used needle punching and hot-pressing to manufacture plates needed for automotive interiors. Among them, through the mixing ratio of kenaf and PP fibers, as well as the conveying speed of the web-forming machine and various parameters of the air-laid machine, the optimal web-forming process parameters are analyzed, which can obtain the bending strength and tensile strength. The materials with excellent impact strength and performance provide some new ideas for hemp fiber in the development of automotive interiors.

5.4 Other Industry

Today, the application of airlaid technology is also reflected in many fields. Although the scope of use is not very broad, as the technology continues to improve, more industries and research will use this technology to produce more and better products. Chen[23] used the clean paper produced by air-laid technology as the substrate, and used the polymerization method to make paper electrodes with high performance and good air permeability. This electrode has excellent synergistic effect of

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conductance, and has high wettability and porous structure. By testing it, it is found that the paper electrode has excellent bending, stretching and deformation, and can be made into a water-based supercapacitor. Liu Tao[24] and others developed a new battery electrode material by combing the uniformly mixed polyacrylonitrile fiber and pitch fiber through air-laid process and needle punching. This material has the characteristics of oxidation resistance, corrosion resistance, good electrical and thermal conductivity, and has a low body resistance, thereby reducing the battery internal resistance of the battery, thereby improving the voltage efficiency and energy efficiency of the battery. Zhang Yingchen[25] and others invented a method for preparing graphene fibers by air laying. They used the expanded graphite oxide worm powder to act on the surface of the microporous nickel mesh through air laying, and then passed the mirror stainless steel membrane and the microporous nickel mesh. The graphite oxide worm powder is pressed into a graphite film by rolling, and the graphene fiber is finally formed by continuous action on the film. The obtained fiber has high twist, close interlaminar, and uniform surface structure, and can be applied to other products as a composite graphene fiber.

6. Summary

Although the air-laid method of dry-laid papermaking is not as widely used as wet-laid papermaking, with the continuous development of technology, the air-laid method has been applied to many special manufacturing. The unique forming method of airlaid and the formed fiber web have the characteristics of large thickness, good softness and good water absorption, and more and more people realize the feasibility of development. I think the air-laid method is combined with its reinforcement process, and it is integrated with it through other different means, and it is continuously improved in terms of materials and processes. In the future, it is necessary to increase investment in research and development of new composite fiber webs, continue to innovate and develop, and improve the comprehensive performance of new composite fiber webs.

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