An Automated Internal Navigation System for the Removal of Fibre Fly in Knitting Industry

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Abstract - Knitting industry is one of the flourishing business in India in recent times. This knitting industry provides huge collection of knitted fabrics in different forms and styles. Apart from the fabrics they also provide employment to lot of people. A drastic problem in this industry is the fibre fly generation. These fibre fly are generated in the knitting machine from cotton yarns in different zones of the knitting machine which may be due to friction, yarn breakage and bending of yarns at the needles, sinkers, guides and other regions. They may also be produced due to rotational movement of yarn in the cone unwinding and guiding zone, vibrations during the movement of yarns and friction occurring due to interaction between yarns. At present these fibre fly are removed by using large blowers in large scale industry. These blowers are not affordable in small scale industries due to the cost of blower, power consumption after installation, etc... People exposed to these fibre fly may suffer from serious diseases which may have acute and chronic symptoms. This is a serious problem which can be overcomed by using the dust (fibre fly) collector. It can be used by all types of knitting industry and also removes maximum dust produced. This paper is about the dust collector in knitting Industry. This paper briefly discusses about the technique used in the fibre fly collector for removing the dust in knitting industry and how to avoid the risk of air pollution and effect of fibre fly.

Keywords - fibre fly, knitting needle, blowers, air pollution

1. Introduction

Knitting industry plays a vital part in the textile manufacturing process. Knitted fabrics are produced in different styles and textures. In India variety of knitted fabrics are produced. In order to produce high quality and superior form of knitted fabrics lots of new machinery are being implemented. Nowadays works are done by knitting machine manufacturing industries in order to increase the speed of operation of the machine and also to avoid the possibility of manufacturing defective fabrics. However, people fail to focus on another major problem that occurs in knitting industry. It is the generation of fibre fly from the knitting machine. This is the serious indoor problem that is to be taken into consideration since it causes lots of respiratory diseases to the people working in these industries. Apart from its effect on labors it also creates lint and holes in the knitted fabrics and sometimes also leads to fire accidents. Researchers found that fibre fly is the major problem in knitting industry when compared to other problems.

Role of India in Knitting Market

In India, knitting industry provides lots of job opportunities. The textile market share of India is about 22 percent in Europe. Of the total revenue from knitted fabrics Asia holds about 70.2% of the shares. In Asia China holds about one third of the shares and is the main exporter. After China India is the next largest exporter of fabrics. In the textile and apparel market, USA holds about 10% of the shares and India holds about 32.6% shares. Exporting of Knitted fabrics in India yield to about 15% of the total National income of the country as per 2018. In the textile industry market about 45% is being contributed by the knitting industry and is in a growing scale. However, the demand for knitted fabrics in India is low when compared to the global market demand.

2. Fibre Fly Generation

Fibre fly liberation from knitting industry is a major problem that is to be taken into consideration. The fibre fly are generated from the machine in three regions namely the cone unwinding region, guide region and the knitting region. The accumulation of fibre fly in knitting zone is shown in Figure 1. These fibre fly are classified into different classes based on the length whose accumulation ratio varies with respect to the region. Majority of fibre fly generated are less than 11 mm in size. These fibre fly are basically particulate matter. The particulate matter is found in all divisions of the textile manufacturing industry. However, they are produced in large quantities and in smaller size in the knitting machine [1].

Fig. 1: Fibre fly accumulation

On the knitting machine the fibre fly are generated from various regions. This occurs either due to friction, bending or twisting of yarns in the feeders, sinkers, needles or other interferences. Due to friction the short
fibres are broken from the cotton yarns mainly in cone unwinding zone, knitting zone and guide zone of the knitting machine. Fracture of yarns due to loose gripping or pulling of loosely held fibre in the yarn produces fibre fly in cone unwinding zone. Friction in yarn surface and twisting of yarns leads to fibre fly generation in the guide zone. In the knitting zone, the fibre fly are generated from the protruded fibres due to friction of yarn and surface in the needles, sinkers and also on the old loops surface during formation of new loops.

Fibre Fly Liberation in Cone Unwinding Zone
In the spinning process, when the cotton yarn is processed the edge fibre are abraded from different parts of the machine. This results in finer fibres with poor strength than the virgin fibres. These edge fibres produces hairiness in the yarn that originates from the spinning zone.[2] The amount of hairiness further increases in the cone unwinding zone. The protruding fibres when interacting with the cone surface produces fibre fly in the cone unwinding zone[3]. Also, they are generated in the yarn blooming zone where the yarn is guided to the yarn guide zone. Majority of the fibre fly generated in this region are of shorter length [4]. The percentage of fibre fly based on their length in the cone unwinding zone is shown in Figure 2 and Figure 3. In this zone, about 90% of the fibre fly produced are less than 11mm.

Fibre Fly from Guide Zone
From the cone unwinding zone, the fibre is now transferred to the guide zone shown in Figure 5 before reaching the knitting zone. In this zone, the amount of fibre fly that were liberated based on their length as shortest, shorter, short and long are about 14%, 38%, 30% and 18% respectively as shown in Figure 4.

Fibre Fly from Knitting Zone
In this zone, majority of the fibre fly are less than 11 mm in length. The fibre fly accumulation in knitting zone is shown in Figure 7. About 30% of the fibre fly in this region are less than 1 mm, 36% are between 2mm and 6 mm, 28% are between 7mm and 11mm. Only 6 % of the fibre fly are greater than 12mm [6]. The amount of fibre fly from the knitting zone based on the length is shown in Figure 6. In this zone, the fibre fly are generated due to protruded fibres. These fibres generates fibre fly due to friction either due to rotational speed of yarn or interaction of yarn and the surface of needles sinkers or loops. Also, it may be produced due to the twists when the fibre is bended and unbended during the knitting process[7].

Of these fibre fly generated about 82% are less than 11mm in length. Here the fibre fly are produced due to protruded fibres. When these fibres are subjected to the rotational speed of the guide surface and strong frictional resistance of the yarn surface, fibre fly are liberated. Also, the loosely held protruded fibres produces fibre fly of length of about 12-16mm due to twisting of these protruded fibres either in the yarn surface or in the guide surface [5].
3. Adverse Effects Due to Fibre Fly

**Effect on Machine**

The performance and efficiency of a knitting machine depends on the quality of yarn, production parameters and right choice of the type of knitting machine. Even though the above factors are met with, the performance is degraded due to the accumulation of fibre fly. It not only causes damage to the finished fabrics(products) but also cause damage to the knitting machine. They may cause holes in the knitted fabrics as a result of yarn breakage. Also, it damages the needles used for knitting by bending the head and shearing which further causes damage to the knitted fabrics and also produce lint [8]. These defective needles are very difficult to find since they are huge in number and so degrades the performance, increases the cost of these needles and also much time is required to find the fault needle which may cause the machine to stop operating for a long time. These fibre fly are the reason for one fourth of the defective fabrics and also reduces the fabric weigh by 0.5 % to 1 %. Large scale accumulation of these fibre fly when left uncleaned for long period of time may even lead to fire accidents within industry and even pollution within and around the knitting industry which in turn pave way for diseases.

**Air Pollution due to Fibre Fly**

The fibre fly are generated in knitting machine in various regions in variety of classes. These fibre fly causes problems to the production. Currently The fibre fly are blown off from the knitting zone by using fans that blow off the fibre fly when they are produced and so the needles are not damaged [9]. However, these fibre fly fall around the machine. These when left uncleaned causes adverse effects to the people working there and also to the machines. Since these fibre fly are minute particles they easily get accommodated in air which becomes a cause for air pollution in those areas. The Particulate matter emission from various textile process is shown in Figure 8 and Figure 9. When compared to various textile process it was found that the amount of particulate matter suspended from knitting industry is very much high when compared to other process.

**Effect on Human**

These fibre fly that are blown off from the machine does not cause any damage to the knitted fabrics. However, it leads to severe problem for the people working in the knitting industry. The fibre fly are particulate matter that poses health hazards to people working in the knitting industry and mainly causes pulmonary diseases such as asthma, chronic bronchitis and emphysema[10] . The extent to which people are affected depends on the level of contamination of fibre fly along with other particulate matter in atmosphere and the length of these fibre fly. A normal human respiratory system can defend up to 10µm to 2µm of foreign particulate matter. Also, the amount of the foreign substance inhaled plays a major role in the respiratory defense mechanism. It is observed that maximum of the fibre fly is generated from the cone unwinding zone and knitting zone when compared to other regions. According to a survey the amount of fibre fly generated from these regions based on the different classes of fibre fly is as follows. In the cone unwinding zone approximately 24.5% of the fibre fly are about 1 mm long, 40% are 3mm long and only less than 11% are greater than 5mm. About 27% of the fibre fly generated in knitting zone are 1 mm long, 44% are 3 mm long, 18.5% are 5 mm long and less than 7% fibre fly are greater[11] . These fibre fly leads to respiratory problems like asthma, Byssinosis, emphysema, chronic bronchitis. These fibre fly leads to decreased lung function [12] and at times long term exposure to these fibre fly leads to lung cancer [13]. These fibre fly induces the release of histamine from the human lung tissue. Other side effects include continuous cough, low hemoglobin and poor immunity.

4. Existing Process

**Cleaning Processes for Indoor Pollution Control**

In order to control the fibre fly one of the common methods is the application of lubricant. The yarn is coated before undergoing the knitting process in order to reduce the fibre fly generation [14]. Apart from this lint blowers are used to remove fibre fly so that they do not settle on the machine surface. Once these fibre fly settle on the machine, the only solution is through regular cleaning...
which can be done with the help of blow gun as shown in Figure 10. However, it also has requirements such as improved ventilation and an extraction system for fibre fly removal. This may reduce the risk of fire accidents and indoor pollution caused due to fibre fly accumulation. Cleaning and removal of fibre fly at regular intervals of time, improving ventilation, reducing the generation of fibre fly are few ways to get rid of the pollution caused by fibre fly.

**Manual Cleaning**

Manual cleaning is not done regularly as people fail to know about the effects of these fibre fly over them. Also, this may lead to lot of problems such as fire accidents due to huge accumulation of fibre fly, damage of fabrics produced, etc. This type of manual cleaning is generally practiced in small scale knitting industry.

**Existing Systems for Fibre Fly Removal**

The return air system is used to remove the fibre fly by means of filter which are cleaned automatically. This reduces the need for operators. However, the main disadvantage of this system is the cost and the power consumption. The efficiency of these system is also low [15]. A blowing apparatus can be used for fluff removal which also has a drawback that it only blows off the fibre fly from machine rather than collecting them[16] . Also, there are dust removal device which removes dust only from knitting zone[17] .

5. **Proposed Methodology**

Fibre fly collector can be used in both small scale and large-scale industry for removal of fibre fly. In this process an automated Fibre Fly collector is made to move around the knitting machine in order to collect the fibre fly in regular intervals of time. The path for the movement of the fibre fly collector is defined by means of coverage path planning algorithm. As shown in Figure 12, the start and end points are defined and the collector moves around the machine collecting all the dust. The ultrasonic sensor is used to detect if any obstacles are found in the path and redefine the path whenever obstacle is found.

The dust sensor is fixed in the knitting machine with a transmitter. The threshold value for the dust is fixed initially. The dust sensor continuously monitors the dust level around the machine. Whenever the dust level goes beyond the threshold value the transmitter sends a signal to the fibre fly collector. The fibre fly collector begins to operate as soon as it receives the signal and starts to define the path for the movement. The fibre fly collector consists of a receiver module for receiving the signal from the dust sensor, a fibre fly collecting setup for collecting the fibre fly, a motor driver for movement of the collector, a sensor module for detecting the obstacles. All these modules are controlled by means of a controller.

The coverage path planning algorithm is used for defining the path for the movement of the fibre fly collector. For simulation, Python language is used. When a sample image (Figure 13) is given, first the image is processed and the path for the movement of the fibre fly collector is defined. When the path is defined, it starts moving from the starting point and moves in the defined path until it reaches the ending point (shown in Figure 15).

For path planning using the coverage path planning algorithm, the entire region is divided into cells. The starting point is the parent cell. The process occurs in the counter clockwise direction. For defining the path, each free cell to the right of the parent cell is identified and it goes on until the last free cell is occupied. When it reaches the extreme end, now the direction occurs in a spiral manner. The free cell is identified in the upward direction and when the extreme end is reached it shifts to the left by one cell.

**Blowers**

There are different kinds of blowers currently available for fibre fly removal in knitting industry. The fan blowers are the widely used ones (shown in Figure 11). They are fitted on the machine and starts once the machine starts to operate. The number of fans depends on the size of the machine. They push the fibre fly outwards so that they don't cause any damage to the knitted fabric. This prevents the fibre fly from being accumulated in the machine which may cause a lot of malfunction in machine as well as defects in the knitted fabrics. However, the fibre fly that were blown off must be removed. Or else this may cause harmful effects to the people in those regions.

**Manual Cleaning**

Fibre fly can be cleaned at regular intervals of time manually. This can be done through vacuum cleaners or blow guns. In few industries these fibre fly are blown off using the air pressure by means of a blow gun. However, Manual cleaning is not done regularly as people fail to know about the effects of these fibre fly over them. Also,
Now it moves downwards until the last cell in that row is reached provided all the cells to the left of it is occupied. After reaching the extreme end, it shifts by one cell to the right and moves upwards until the last free cell is reached provided all cells to its right are occupied. The process repeats till all the free cells in the room are occupied. When an obstacle (occupied cell) is found in the path, it shifts to the next free cell to the left or right depending on the available free cell. By this process the path is defined (as shown in Figure 14) such that it covers the entire region over which the fibre fly collector needs to operate.

When an obstacle is found the motor stops. The path for the movement of the collector is again redefined and the motor begins to operate. This process continues until the end point is reached. Again, the dust sensor starts to monitor the dust level and the process continues.

**Advantage**

It is of great use to the small-scale knitting industries, as it is of lower cost it can be implemented. Also, it consumes less power than the conventional cleaning methods and the space occupied is also much less. It does not require any additional setup for implementation and the setup cost is also less. Since it collects the dust on regular intervals the fibre fly does not mix with air and so air pollution is controlled. Since the air pollution is reduced the people working there also will not suffer from respiratory diseases. The need for manual cleaning is reduced and so it saves time for the people working over there.

6. Conclusion

The fibre fly generated during the knitting process has harmful effects both on people working there as they cause respiratory problems to people and also on the growth of the industry as it causes defects in the fabrics and also damages the knitting machine. Mechanical removal methods which are currently being used to remove fibre fly from the point of production of fibre fly are not the exact solution for this problem as this is ineffective at some point. Hence by using the fibre fly collector the fibre fly can be removed as and when it is produced.
References