



# A STUDY OF FLY GENERATION DURING WEFT KNITTING PART I : LITERATURE REVIEW

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## ABSTRACT

The study of fly generation during weft knitting has attracted the attention of many workers for decades. Among all fiber properties, the fiber length has the greatest effect on the amount of fly generated during knitting. Blending with a synthetic fiber type also reduces the fly generation due to an increase in the fiber mean length. Additionally, yarn moisture content, stitch length, yarn speed and input tension, and package conicity have a significant effect on the fly generation. Although there is no listed literature for fly prediction techniques, fiber and yarn properties, along with knitting parameters, can be used for fiber-fly prediction during knitting.

**Key Words :** Fly generation, Weft knitting, Yarn hairiness, Fly prediction

## ATKI ÖRMECİLİĞİ ESNASINDA UÇUNTU OLUŞUMU ÜZERİNE BİR ÇALIŞMA 1. BÖLÜM: KAYNAK TARAMASI

### ÖZET

Atkı örmeciliği esnasında oluşan uçuntu yıllarca pekçok kişinin ilgisini çekmiştir. Örne esnasında lifin bütün özellikleri yanında lif uzunluğu uçuntu miktarı üzerinde en fazla etkiye sahiptir. Sentetik lifler ile karışım ortalama lif uzunluğunu arttırdığı için uçuntu miktarında azalmaya sebebiyet verirler. Ayrıca iplikteki nem miktarı, örgü uzunluğu, ipliğin besleme hızı ve gerilmesi ile ipliğin sarı olduğu bobinin konikliği uçuntu miktarı üzerinde büyük etkiye sahiptir. Uçuntu miktarının önceden tahmin edilmesi üzerine herhangi bir çalışma olmamasına rağmen lif ve iplik özellikleri örme parametreleri ile birlikte kullanılarak, örme esnasındaki uçuntu miktarı tahmin edilebilir.

**Anahtar Kelimeler :** Uçuntu oluşumu, Atkı örmeciliği, İplik tüylülüğü, Uçuntu tahmini

### 1. INTRODUCTION

The study of fly generation during weft knitting has attracted the attention of many workers, especially after the extensive work on the mechanical properties of yarns and studies about the yarn hairiness. In experimental studies of the fly generation, a theoretical yarn hairiness model has been used as the basis for these studies. It was the interest of many workers that led to the investigation of the yarn hairiness (Pillay, 1964; Pillay 1964a; Barella, 1966; Goswami, 1969; Subramanian et al.,

1971; Barella et al., 1971). Fly generation is being considered as a bigger problem than it used to be because of the high speed knitting machines available for today's market as well as for a healthier working environment. Not only does fly generation cause an unhealthy work environment, but it also affects the quality of the product due to possible contamination of the fly to the fabric being produced. It also causes yarn breakage and needle damage, especially in finer machines (Lyne, 1955; Brown, 1978; Lee and Ruppenicker, 1978; Ruppenicker and Lofton, 1979; Lawrence and

Mohamed, 1996). In this paper, fly generation during weft knitting will be reviewed emphasizing the role of fiber properties, the influence of yarn spinning parameters, the effectiveness of “processing aids” and possible techniques that may be used to predict fly generation during weft knitting.

## 2. FACTORS AFFECTING FLY GENERATION

Studies describe the fly distribution along the thread line according to the length and percentage of fibers. Most of the short fibers are removed from the yarn at the unwinding section. As yarns move to the knitting point, the length of the fly increases. The distribution of the fly collected along the thread line appears to be different for the total amount of fly generated at different part of the knitting machine. Further, even fiber-fly is a major problem for today’s knitting industry. Unfortunately, it has been reported that the knitting industry cannot expect this problem to be rectified in foreseeable future. Knitting machine manufacturers also cannot offer a complete solution system for the fly problems (Bühler et al., 1987; Bühler et al., 1988; Bühler et al., 1990).

### 2. 1. Effect of Fiber Properties

Fly generation is a problem for the staple, especially in cotton yarns, mostly due to the variation on the length distribution and structure of the yarns. The effect of the fiber length, fineness, and fiber strength has been investigated by many researchers, including Ruppenicker and Lofton (Ruppenicker and Lofton, 1979). Their findings indicate that fiber length has the greatest effect on fly generation during knitting than any other fiber property. The result of many workers indicates that as the fiber mean length increases; the amount of the fly decreases significantly (Subramanian et al., 1971; Brown, 1978; Ruppenicker and Lofton, 1979; Lawrence and Mohamed, 1996). It is well known that a yarn spun from fibers having longer mean length gives better structure than that spun from shorter fibers. The frictional forces among the fibers with longer length distribution are higher than those of shorter length distributions. The longer length distribution aids frictional forces and results in better cohesion between fibers. Increasing the mean length of the fiber also reduces the number of loose ends that cause yarn hairs to appear on the yarn surface. Figure 1 shows the effect of fiber mean length on the mass of fly generated during weft knitting. It is evident from this figure that as the mean length of

fiber increases in the amount of 3.2 mm, the total fly generated during knitting decreases almost 27 %.

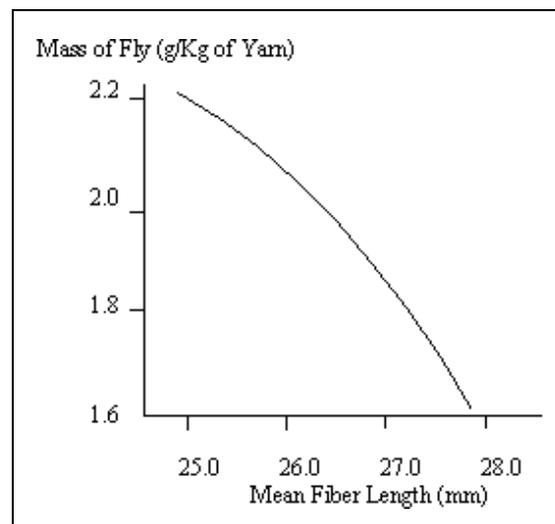


Figure 1. Effect of the mean fiber length on the fly generation (Lawrence and Mohamed, 1996)

It has been reported that a longer mean fiber length yields less amount of short fiber content. This results in a greater contact length between the fibers and less hair occurrence on the yarn (Barella, 1966; Goswami, 1969; Ruppenicker and Lofton, 1979; Lawrence and Mohamed, 1996). Since the length distribution of synthetic fibers can be controlled, blending cotton with synthetic fibers gives longer mean length with more uniform distribution. This helps to reduce the total amount of fly generated during knitting. Ruppenicker and Lofton (1979) reported that increasing the percentage of polyester fibers in the cotton blend yarn decreases the mass of fly proportionally to the percentage of polyester present in the yarn. Figure 2 shows the effect of the percentage of polyester on the fly generation with the mean staple length. This fact was also confirmed by Lawrence and Mohamed (1996).

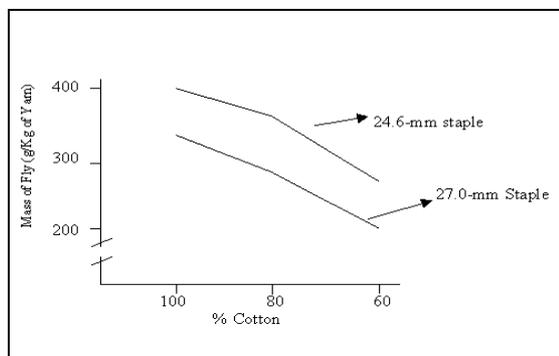


Figure 2. Effect of polyester blend on the fly generation (Ruppenicker and Lofton, 1979).

Fiber fineness is another factor affecting the amount of fly generation; yet, it is not directly obvious as it is in fiber length. Since finer fibers also have long lengths, it can be assumed that the effect of fineness is nested under the fiber length. Yarns spun from finer fibers have more fibers per cross section; hence, this raises friction within fibers. Consequently, finer fibers with long mean length is the key factor to reduce the amount of fly generated during knitting.

## 2. 2. Effect of Spinning Parameters

In the spinning process, combing is widely used to reduce the amount of short fiber content in order to have longer mean length distribution. This, in turn, provides better yarn quality and fewer end-breaks during manufacturing. (Pillay 1964, 1964a; Barella, 1966) claim that combing, even at low percentage of waste being produced, reduces the hairiness of the yarn significantly relative to that of carded yarns. Since combing reduces the percentage of short fibers, combed yarns should provide less amount of fly during knitting. Lawrence and Mohamed (1996) confirmed that combed cotton yarns do give less fly than carded yarns. Pillay (1964) also studied other spinning parameters affecting the yarn hairiness such as spindle speed, traveler weight, draft ratio, and twist level on the yarn. He reported that high spindle speeds would give more hairiness. As the weight of traveler increases at the constant spindle speed the hairiness of the yarn decreases. High draft ratios increase the hairiness on a single draw frame; however, as the number of drawing frames increases, the hairiness decreases. Since increasing the number of draw frames increases the attenuation of fibers in the yarn, the result will be fewer loose ends coming from yarn surface. This would result in reduction of the total mass of fly being produced during knitting. In addition, he also reported a converse relationship between the number of twist and the hairiness of the yarn. Figures 3 and 4 show the effect of twist levels on the fly generation. As the twist level increases, the amount of total fly generated during knitting decreases. The reason for the decrease of fly with the increase in the amount of the twist is attributed to the increase of the frictional force among the fibers with increasing twist. This contributes tremendously to the cohesion and stability of fibers in the yarn structure (Ruppenicker and Lofton, 1979; Lawrence and Mohamed, 1996). Simpson and Fiori (1975) reported that yarns produced at lower twist level had better uniformity and imperfection. This suggests that the improvement on yarn uniformity may cause more hairiness due to reduced cohesion among fibers.

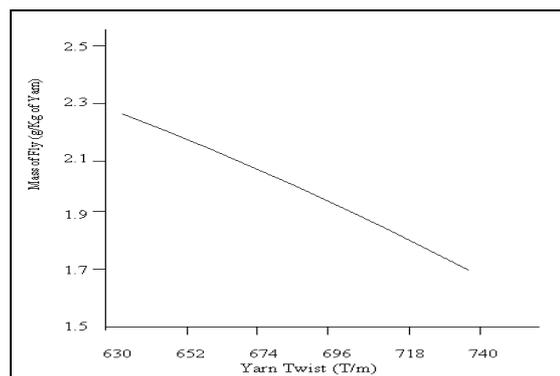


Figure 3. Effect of yarn twist on the fly generation (Lawrence and Mohamed, 1996)

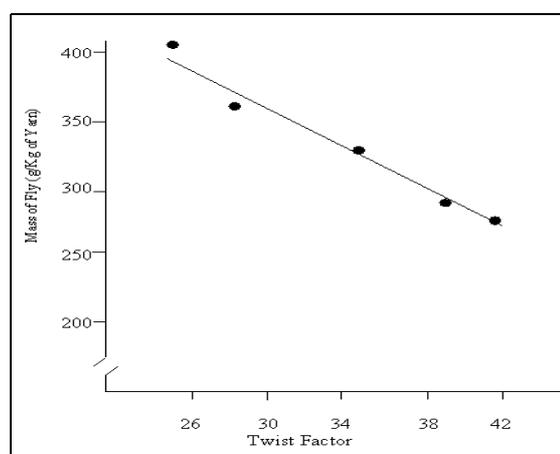


Figure 4. Effect of yarn twist factor on the fly generation (Ruppenicker and Lofton, 1979)

Studies showed that there was a good correlation between the amount of fly generated during knitting and yarn types. Yarn spinning parameters have direct effects on the fly generation as well as yarn hairiness (Pillay, 1964; Barella et al., 1971; Lee and Ruppenicker 1978; Lawrence and Mohamed, 1996). Among the all spun yarns, carded ring spun yarns have the largest amount of fly generation, while open-end yarns have the least fly generation (Lee and Ruppenicker 1978; Lawrence and Mohamed, 1996). Carding speed also seems to have a bearing on fly generation. The higher the speed and production rate, the higher the amount of fly. As the speed of the carding machine increases, the mean length of the fiber distribution decreases due to the fact that some fibers are broken during the process. As seen from Figure 5, which shows the effect of yarn type and fiber blend on fly generation, open-end yarns have the least fly generation. It is widely known that rotor yarns do not have a true twist; yet, they do have wrapper fibers on the surface that cover the core fibers. When this type of yarn comes in contact with machine parts, the wrapper fibers act as a shield to reduce the amount of fly. The concept of

wrapper fibers is more common in air-jet spinning systems. Even polyester blend yarns are widely produced by using air-jet spinning systems; they are not used in weft knitting. Therefore, there is no literature listed for fly generation on air-jet spun yarns. Since polyester blend and wrapper fibers have a significant effect on the tendency of yarn to shed fly, air-jet spun yarns should generate less fly than open-end yarns. However, this fact needs more theoretical and experimental studies.

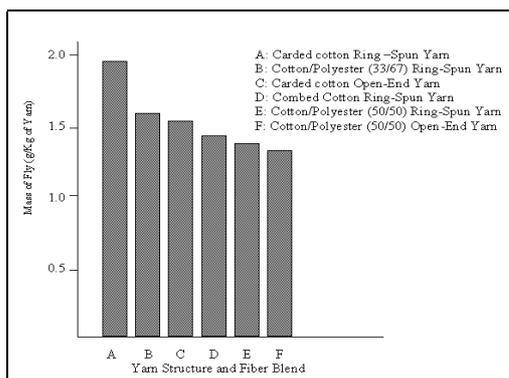


Figure 5. Effect of yarn structure and fiber blend on the fly generation (Lawrence and Mohamed, 1996)

Yarn linear density also influences the fly generation; as linear density of yarn increases, the amount of fly decreases. Lawrence and Mohamed (1996) explained and suggested that coarser yarns contain more fibers throughout the cross section. This contributes to a greater frictional force between the fibers in the yarn body and prevents slippage of the fibers. Consequently, a lower amount of fly is produced during knitting as a result of this. However, this phenomenon conflicts with the results reported by Barella et al. (1971) and Ruppenicker and Lofton (1979). Barella and Ruiz-Cuevas (1958) stated that coarser yarns had higher hairiness, whereas, Ruppenicker and Lofton (1979) reported that fly was related to the yarn hairiness. Therefore, Lawrence and Mohamed's explanation is not reasonable taking yarn linear density into account. They also gave an 'Influencing Factor' for yarn linear density as + 0.04, however, it should be -0.04 because they stated that a negative value of FD represents a reduction in the amount of fly as the value of a particular factor increases. One

explanation for this could be that the yarn linear density increase causes linear decrease in the length of 1-Kg yarn. Thus, coarser yarns do not make contact with the parts of the knitting machine that thinner yarns do. As a result, less surface contact would reduce the amount of fly generated during knitting.

### 2. 3. Effect of Coating The Yarn Surface

In order to reduce the amount of fly during the knitting operation, some coating materials are applied to the yarn surface. This treatment is similar to the sizing operation in weaving; however, coating the yarn surface is not as effective as it is in weaving due to the yarn speed on knitting machines. As known, the speed of yarns (warp yarns) is slower in weaving than that of knitting. It is reported that there is substantial rise in fly generation with high speed. This is effective especially after about 160 m/min (Lawrence and Mohamed, 1996). At low production speed, coating the yarn can reduce the amount of fly but it does not help at high speeds. Brown (1978) reported that the addition of a wax lubricant to the surface of the yarn had no effect on the amount of fly generated during knitting. Waxing the yarn surface is practically trying to reduce the frictional force. However, as seen in Table 1 and Figure 6, the fly generation is not influenced by the frictional characteristics of yarn. Lee and Ruppenicker (1978) reported a different treatment option that reduces the fly considerably. They suggested that the yarn should be sized after applying solid wax.

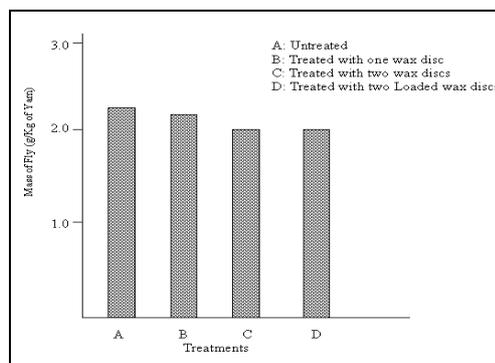


Figure 6. Effect of waxing the fly generation (Lawrence and Mohamed, 1996)

Table 1. Total Weight And Weight Distribution Of Fibers Along The Knitting Line For Cotton Yarns (Brown, 1978)

Yarn Type	Weight of fly (g)	Distribution (%)			
		A	B	C	D
Untreated	4.7	47	23	5	25
Disc wax	4.5	42	20	10	28
Emulsion wax	4.8	46	20	7	27
Film 1	82	70	14	2	14

Lyne (1955) studied dynamic friction of some types of yarns. He concluded that at the high speeds, the coating material was not preventing the yarn from high friction due to the fact that the wax coating of a yarn softened and increased friction between the yarn surface and machine parts. Similar facts are also reported by Bühler et al. (1988). Röder (1953, 1955) gave an alternative explanation. He claimed that at higher speeds, the viscosity of the lubricant was increased and the lubricant was absorbed into the yarn; consequently, the sliding resistance increased. Figures 7 and 8 show the effect of the yarn speed during knitting.

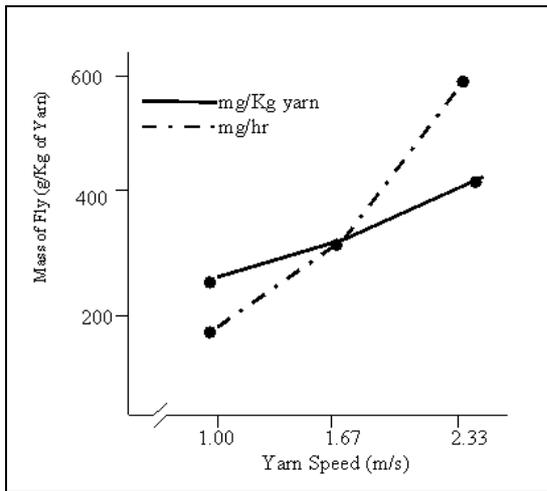


Figure 7. Effect of yarn speed on the fly generation (Ruppenicker and Lofton, 1979)

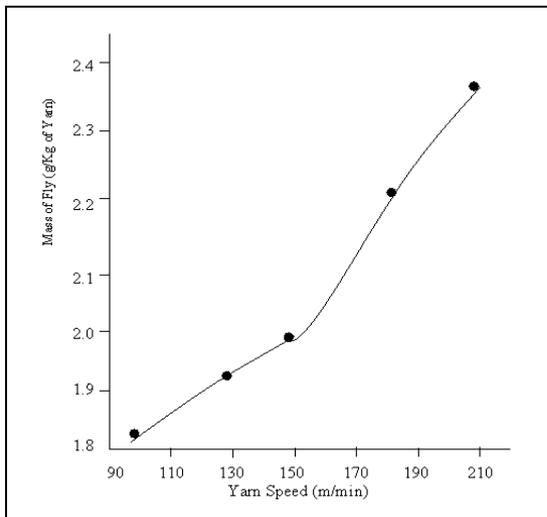


Figure 8. Effect of yarn speed on the fly generation (Lawrence and Mohamed, 1996)

As seen in the figures, the increase in yarn speed in the amount of 3 m/s causes a huge increase in fly generation. The frictional force on the surface of a yarn is also related to the yarn input tension. As seen

from Figures 9 and 10, the higher the input tensions the higher the amount of fly. Frictional force exerted on the yarn also depends upon the shape of the package as well as the tightness factor (Ruppenicker and Lofton, 1979; Lawrence and Mohamed, 1996). Fabric tightness factor is defined as  $K = 10\sqrt{y_n}/l$ ; where  $y_n$  is the milligram per meter of yarn and  $l$  is stitch length in millimeter (Munden, 1962). Complete discussion about the tightness factor and other knitted fabric parameters were given by (Munden 1959; Munden et al., 1961; Munden, 1962; Knapton, 1972). Figures 11 and 12 show the effect of tightness factor and Figure 13 shows the effect of the conicity of the package. As seen in Figures 11 and 12, as tightness factor increases, fiber-fly also increases. It is evident from Figure 13 that as the conicity of a package increases the amount of fiber-fly decreases.

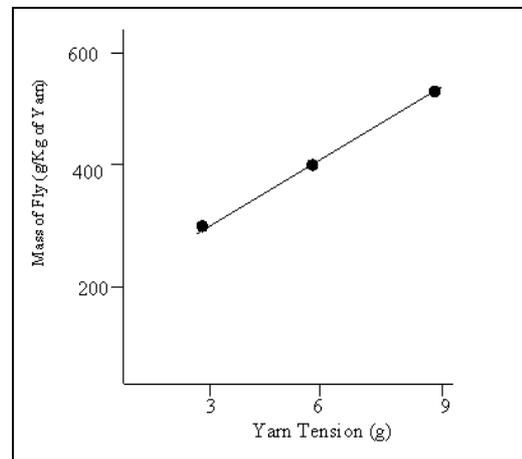


Figure 9. Effect of yarn tension on the fly generation (Ruppenicker and Lofton, 1979)

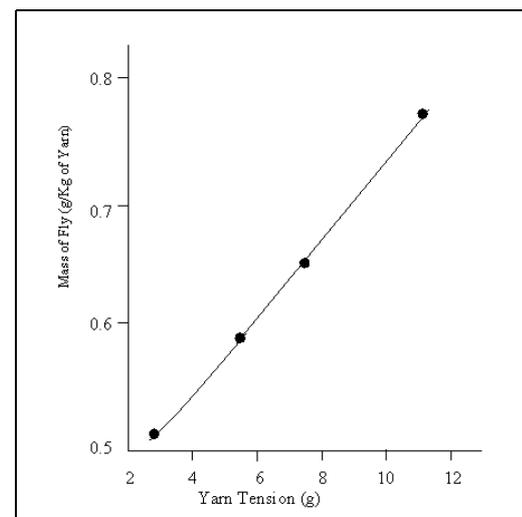


Figure 10. Effect of yarn Tension on the fly generation (Lawrence and Mohamed, 1996)

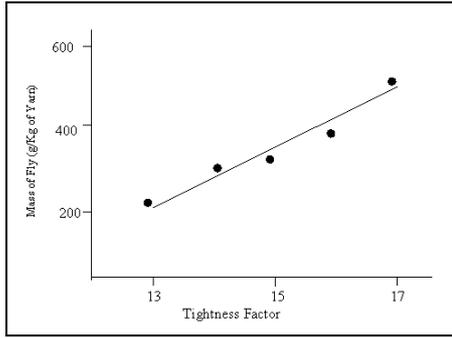


Figure 11. Effect of tightness factor on the fly generation (Ruppenicker and Lofton, 1979)

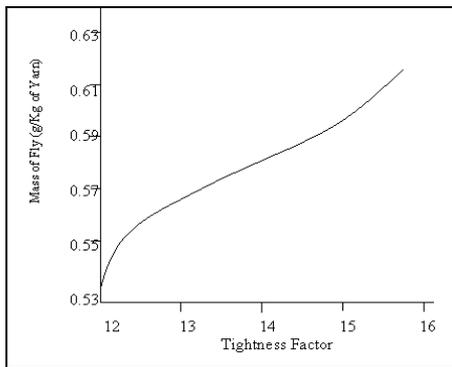


Figure 12. Effect of tightness factor on the fly generation (Lawrence and Mohamed, 1996)

On the other hand, it was reported that as moisture content of the yarn increases, fly generation decreases (Bühler et al., 1987; Lawrence and Mohamed, 1996). Increasing the moisture content results in a swelling of fibers and provides higher friction between fibers. Figure 14 shows the effect of moisture on the fly generation. However, increasing the moisture content may bring rust problems for the metal components of the knitting machine (Bühler et al., 1987).

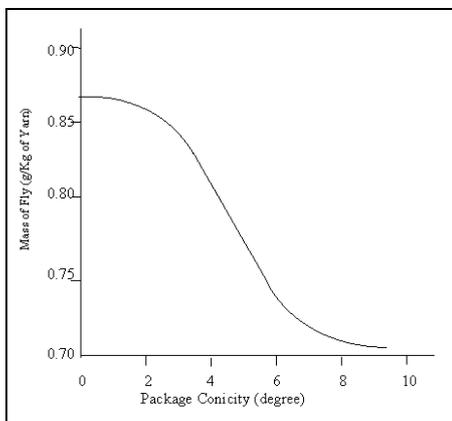


Figure 13. Effect of package conicity on the fly generation (Lawrence and Mohamed, 1996)

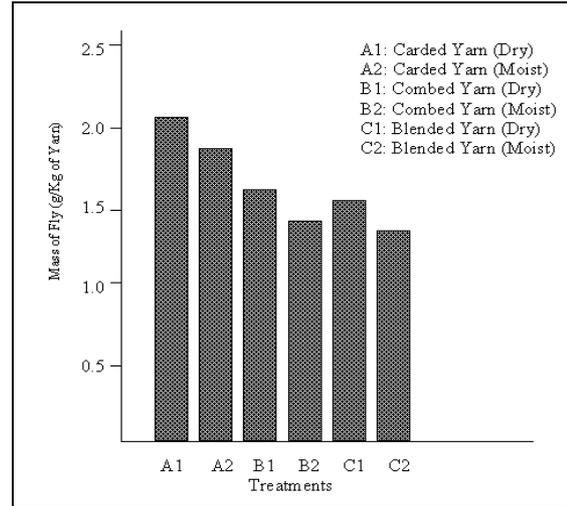


Figure 14. Effect of moisture content on the fly generation (Lawrence and Mohamed, 1996)

#### 2. 4. Distribution of Fly along the Thread Line and Fly Prediction

Brown (1978) reported that almost 50 % of the total fly (most of them were less than 2 mm in length) released during knitting is deposited at the cone unwinding section. Lawrence and Mohamed (1996) disagree with Brown (1978) by stating that almost 44 % of the total flies were released at the unwinding zone. However, in either case, they agreed that the majority of the fly released is generated at the unwinding point. The rest of the fly was distributed among the top-stop motion control, positive feeder, and in the knitting area. This suggests that most of the fibers protruding from the yarn surface have been shed at the unwinding point. As a matter of fact, the unwinding section is the first zone along the knitting thread line. Since there is a positive tension on the yarn in addition to the frictional force between yarns (depending upon the shape of the cone), it is reasonable to have a large amount of fly at the unwinding section. In order to investigate the effect of the unwinding section on the fly generation, further analysis could be done. For example, the same type of yarns from the same production facility could be taken and then one of the yarns should be singed and conditioned before knitting process. It is well known that the singeing method reduces the hairiness of the yarn (Barella et al., 1958; Goswami, 1969). From both yarns, the fly should be collected at the unwinding section. Then the mass of fly should be compared between the singed and unsinged yarns. This will give the effect of yarn hairiness on fly generation at unwinding zone as well as for other points along the knitting thread line.

### 3. CONCLUSION

Although fiber-fly is not a new problem for knitting industry, there is no literature listed for fly prediction techniques. Fiber-fly may be predicted from the properties of fibers, yarns, and knitting parameters. For example, as discussed above, longer mean length generates less fiber-fly during knitting. Therefore, fiber length distribution could be used for prediction. Another factor affecting the fly generation is yarn hairiness, which can be measured (Barella et al., 1971). As a result, the hairier the yarn is, the more fiber-fly it will produce. However, this prediction may not be measured quantitatively. For the factors given in this paper a chart might be prepared and the amount of expected fly could be categorized as low, medium, or high. This scale may be prepared by using the numerical values given for the mean logarithmic fly decrement (Table 2) as a basis (Lawrence and Mohamed, 1996). Each factor in the chart should also be scaled depending upon the factor of influence, i.e.: this scale could range between 1 and 10. Then an empirical table might be developed for this purpose. While using this empirical table, The numerical value of each factor should be read from the table. The reading should also be weighted by an appropriate coefficient. Then, all values should be added up and the mean of the total should be computed. Finally, according to the number calculated, an overall projected fiber-fly could be given as low, medium, or high.

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