Effect of Stitch Geometry on Particle Bypass in Air Filter Bags

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Abstract: Fabrics used as a filter media in dust control may have satisfactory efficiency. However, the sewn areas of the filter fabric sleeves may cause a bypass of fine particle size dust through needles holes or bent areas of fabric layers. The present study focuses on the filtration and cleaning efficiency of the sewn areas of filter fabrics using different particle size of solid material. Four types of stitch formation type EFa-1, SSa-1, LSc-1 and BSa-1 according to British Standard BS 3870 were used.

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Keyword: Filter Bag – sewing stitch – sewing machines- sewing threads

1. Introduction:

Filter fabrics are tested and examined for physical and mechanical properties subsequent to usage and application in a typical industry. Nevertheless, it is more important to measure the filter performance in terms of air permeability, filtration efficiency, cleaning efficiency and pressure drop. From the practical point of view, the fabrics having particular air permeability and filtration efficiency may be used in a particular type of industry. Early investigations[1-4] show that air permeability of different materials and fabrics used with gaseous and liquid media were measured using different methods, e.g., by drawing air through filter fabrics via suction fans or compressed air, and then measuring the pressure drop using water manometers or gas meters.

Different filtration apparatus were described in previous literature by Lamb[5], Igwe[6], Chatterjee[7] and Saad [8-10] . However, the main parameters influencing the filtration efficiency of the filter media are deduced from different variables, which are as follows:

1. Yarn variables: Count, twist and napping.
2. Woven fabric variables: Woven staple fibers: weave – set, woven monofilament: weave - filament denier and woven multi filament: weave-intermingling – number of filaments per cross-sections.
3. Nonwoven fabric variables: Mechanical web weight, needling density, needling penetration, number of barbs, needle arrangement, shape of holes in bed plate and needle gauge and type.
4. Field variables: Pressure drop and flow rate, rate of jet-pulse, duration of jet-pulse, quality and size of dust particles and dust moisture content.

The aim of the present work is to optimize the factors affecting seam efficiency of different parts of the filter bag. During filtration and cleaning process such parts are subjected to stresses and dust bleed through the sewing lines might happen.

Sewing machines:

Nowadays, industrial sewing machines are much diversified and packed with mechanical and electronic high-technology. Nevertheless, all of the basic mechanisms of stitch formation remain similar to those created during the second half of the 19th century.

Stitch and seam type classification:

Stitch formation is the actual process by which threads are interlaced in or around a material resulting in a stitch. When a stitch is used with a defined geometry for material layer positioning, a seam is formed. Stitch and seam types are classified in specific international and national standards [11-17].

Seams perform many different functions, and all of the standards regarding their classification are quite extensive. Fig. 1 shows examples of seams and their representation, classified according to the British Standard 3870 [11].

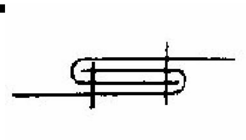
Stitch types are chosen for a seam depending on the functional or aesthetical requirements of the seam. All of the referenced standards are very similar in the way stitch types are classified.

Stitch Formation:

The over-edge, or over-lock stitches, class 500, are performed according to Portuguese standards [11].

Filter Bag Sewn Parts:

The following options can be manufactured as part of the standard bag design or used to compensate for minor equipment or system problems [15].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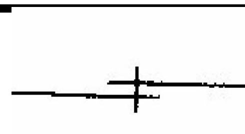
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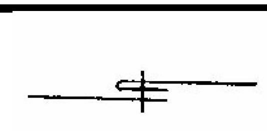
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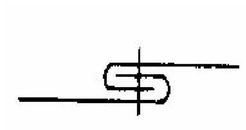
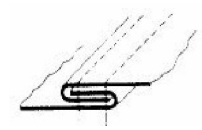
Type LSc

Fig. 1: Seam examples, 3D and 2D representation, classified according to [11]

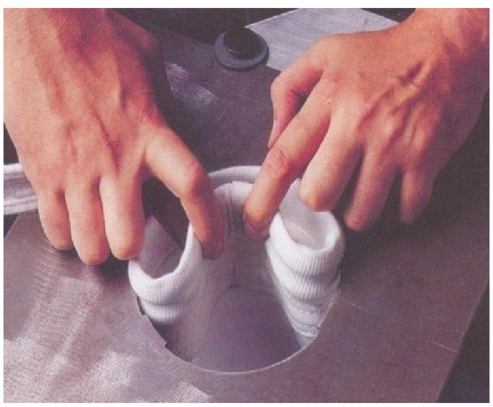
Fig. 2 Snap band 3-notch designs eliminates the separate tool needed to lock and release the collar, making removal and installation easier


Fig. 3 Discs (metal rings) are sewn to the filter bag with an over lock stitch

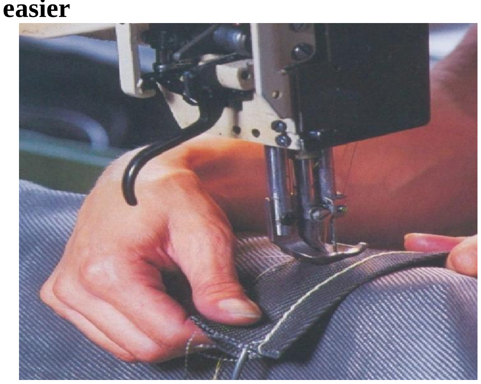
Fig. 4 Anti-collapse rings into filter Bags using lock stitching

Fig. 5. Woven fiber glass bags are sewn with three needle chain stitch in vertical seam

Sewing Threads:

Factual information about sewing threads and sewing needles suitable for various kinds of fabrics is provided by YLI Corporation [19].

The proper sewing needles selection is determined by two key factors:
1) the thread to be used and 2) the fabric to be sewn. Thread/ Machine Needle Charts are a good guide in the industry in order to minimize thread breaks caused by a number of variables including:

- Using the wrong thread for the application.
- Incorrect needle or damaged needle.
- Thread defects.
- Too much elongation.
- Being sewn with too much tension.
- Worn machine parts.
- Machine out of adjustment.
- Operator handling.

Fabrication and description of filtration apparatus:

Due to non-availability of a standard and reliable apparatus for measuring filtration efficiency of filter fabrics, an attempt was made to build up a simple apparatus with facilities to allow direct evaluation of filtration efficiency, flow rate, pressure drop and cleaning efficiency. The main purpose behind the design and development of the concerned apparatus is to ensure the efficiency and durability of filter fabrics to avoid risking failure when a proposed filter is introduced. Inefficient filter means production interruption as well as higher dust emissions. Using such apparatus may well lead to less cost and to reliable decisions in selecting filter fabrics, Figures (7 and 8) show the photographs of the apparatus, it consists of the following parts:

1. Particle separator unit air sampler
2. Master filter.
3. Test filter sample
4. Glass dust collection chamber.

Fig.6. Nonwoven filter bags are sewn with an over lock stitch consisting of approximately 16" of thread per linear inch

5. Flexible joint.
6. Electronic control unit for jet pulse system.
7. Differential pressure gauge.
8. Dust vacuum chamber
9. Dust feeder.
10. Air compressor
11. Magnihelic (differential pressure device).
12. Low pressure inlet (downstream).
13. Nozzles for air circulation
14. High pressure inlet (upstream).
15. Clean air inlet to jet pulsing.
16. Residual Collected dust.
17. Tested Sample.

A) Particle Separator Unit Air Sampler:

This unit is based on inertial impact system adapted to be used in work sites of different dust concentration and suction flow rate up to 500 l/ min. The unit also has the facility to use a range of pressure drop between 2 and 18 cm WG.

b) Dust Feeder and Dust Chamber:

Dust is fed through a conical tube at controlled rates into a glass chamber whose the dimensions are 75 × 50 × 50 cm. It has the facility to clean the dust via compressed air, so as to obtain uniform scattering inside it and also to prevent sticking of dust against chamber walls.

c) Fabric Sample Holder:

The fabric sample holder is designed so that a wide range of fabrics of different thickness could be accommodated and tested conveniently. They range between the extremely thin and the very thick nonwoven fabrics. The area of fabric under test has a circular diameter of 11.3 cm; it is cut with a standard sample cutter to give a total cut area equal to 100 cm^2 to facilitate clamping into the fabric holder.

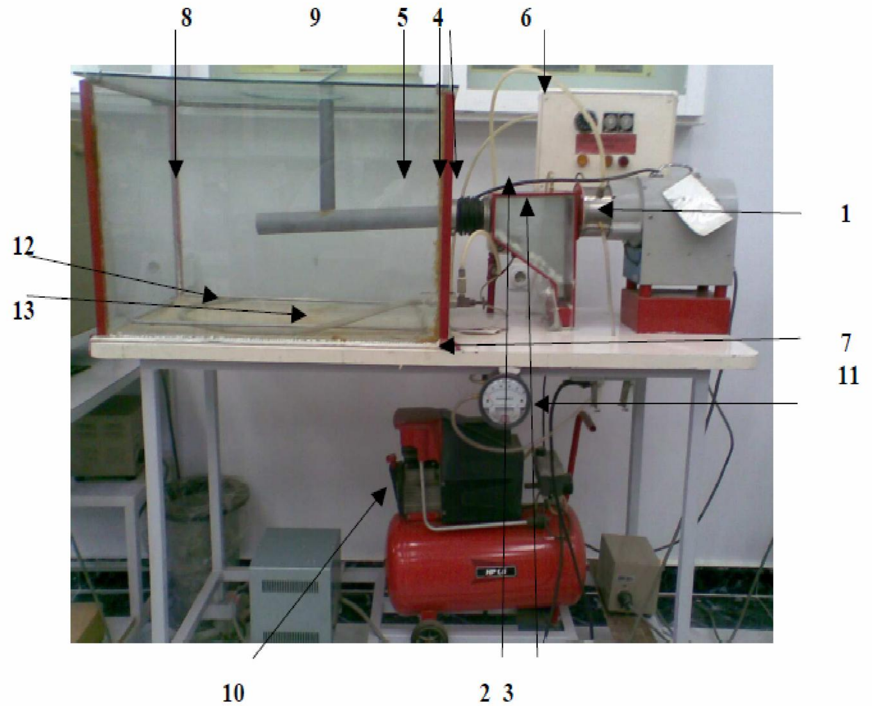

Fig. 7 Photograph of the filtration efficiency apparatus

Fig. 8 Close up photo of test zone

d) Jet-pulse unit:

An electronic control unit is used to apply different rates of jet-pulses and changeable duration of pulses similar to field conditions. Applicable pulse range is between 0.5 and 60 pulse/min.

e) Heat sensor:

Hot gases and heated dust are used to test filter fabrics used in some industrial sites, particularly cement plants. A heat sensor is provided in order to obtain different temperatures of the dust particles and gases inside the vacuum chamber. Temperature up to 90° C could be reached.

f) Pressure Gauge:

The air sampler unit is provided with a pressure gauge to adjust the flow rate of gas through the tested fabric.

2. Materials and Methods:

Test method

The fabric sample to be tested is placed in contact with a vacuum chamber fed with different concentrations of dust having a certain quality and characteristics. The particle separator evacuates air from the dust chamber through an outlet port for emitting air. The vacuum is indicated on a scale. The separating unit is provided with a master filter made of glass fibers, housed at the front face of the air sampler to prevent micro dust particles that may escape through the tested filter fabric sample. During the evacuation of dusty air through the tested sample, the cleaning action is automatically performed, and could be adjusted to normal and field conditions. The pressure drop is automatically monitored and measured in the filtration experiments. Mass efficiency is obtained by weighing the amount of fly dust on the surface of the sample filter. The filtering-cleaning cycles are run for each filter sample and the efficiency is measured after time intervals of 15 minutes. And thus filtration efficiency (E %) is given as:

$$E\% = \frac{\{(\text{Mass of dust fed}) - (\text{Mass of dust deposited on master filter})\}}{\text{Mass of dust fed}}$$

Materials

All fabrics tested using the present apparatus were successfully used as bag filters in a number of filtration applications, where woven fabrics and conventional scrim supported needle felts are used in application. These include cement, aluminum, iron and steel, fertilizers and other industries. The article is the outcome of an experiment in which needle punched nonwoven fabrics were produced with the following specifications:

- Fabric quality: Polyester (3 denier), Nomix (3 denier).
- Nominal fabric weight 200, 300, 400, 500, 600 (g/sq.m).
- Needle penetration 3/8 inch.
- Scrim Support Fabric: 2/2 twill polyester woven scrim fabric, 22 warp / inch, 19 weft / inch, 130 g / sq m weight.
- Surface finish: Heat set at 220° C on one side and raised on the other side.

Sewing Variables:
Stitches: SSw- LSc- LSb
Threads: Nomix and Polyester.

Sewing Machine:

JUKI LH-3100 with 2-needles, Lock-stitch Machine.

Experimental

Both kinds of nonwoven fabrics (Polyester & Nomex) were sewn using the seam types shown in fig. 1 and nomex thread for nomex fabric and polyester thread for polyester fabric. Lock-stitch, class 500 was used according to BS. Thread count and needle number were selected according to charts provided by YLI Corporation [18].

Fig. (9) Shows all samples of the fabrics represented in this study: Snap band cuff (see#1), Flange Top (see#2), Ring Top (see#3), Sleeve Top (see#4), Hem Top (see#5), Raw Edge (see#6).

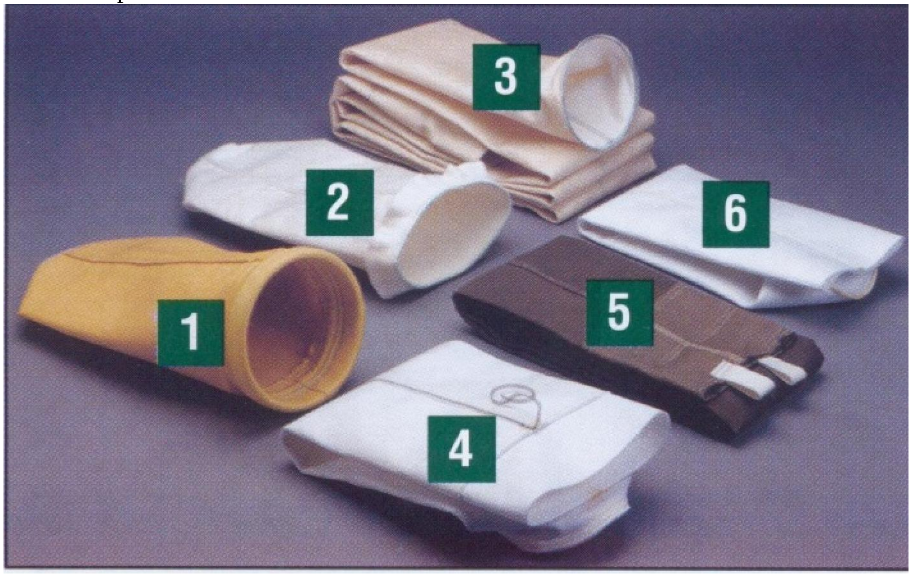

Fig.9 Samples of filter fabrics represented in study

3. Results and Discussions:

Typical bag-houses have cylindrical bags hanging vertically in the unit, representing a critical component of operation. Bag fabric and design should be designed for maximum filtration efficiency, cake release, and durability.

Pulse-jet and plenum pulse bag-houses collect dust on the outside of the filter. Dust laden gas floods the bag-houses, and clean air exits through the inside of the bag while the dust particles collect on the outside filter surface. A support cage prevents bag collapse during filtration and aids in the re-distribution and cleaning of the dust-cake. A wide variety of filter bag can be manufactured to meet specific application needs.

Results of measuring filtration efficiency of sewn areas for both styles of nonwoven fabrics are given in table (1).

Table (1) Optimum sewing factor for both Polyester and Nomex fabric weights.

Nominal weight gm/m2 / sewing	200	300	400	500	600
Seam Type	SSw	SSw	LSc	LSc	LSb
Thread NO. "Tex"	16	16	24	24	35
Needle Count	70/11	70/11	80/11	80/11	90/14
Filtration Efficiency"%"	99.9	99.9	99.9	99.9	99.9

Filtration Efficiency of sewn areas:

Different seam stitches shown in fig. (1) were tried for both kinds fabric samples. The filtration efficiency test using the apparatus shown in fig. (7) was run for all sewn samples. Table (1) show the suitable stitch, needle and thread to achieve an efficiency value of 99,9%. The criterion for assessing optimized factors of sewing is not to experience any distortion or wear away of the sewn part.

4. Conclusions:

1-The most suitable stitch for the fabric weighed 200,300 g/cm^2 is SSw with needle count 90/14.

2-The most suitable stitch for the fabric weighed 400,500 g/cm^2 is LSc needle count 80/11.

3-The most suitable stitch for the fabric weighed 600 g/cm^2 is LSb needle count 70/11.

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