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Porosity measurement of press felts on the paper machine (HSPT)

Scope

This Technical Information Paper¹ describes a test procedure for the measurement of relative airflow through a felt running on the paper machine.

Correlation between Huyck-Smyth Porosity Tester (HSPT) readings and void volume (1) and between HSPT readings and water removal (2,3) have been reported. This tester has been used by numerous mills to monitor changes in felt porosity throughout its life.

Safety precautions

Standard mill safety procedures and personal protection equipment should be properly utilized when taking measurements with the HSPT. Special care should be given to handling air line in the press section around moving components.

Content

Summary

The porosity tester is essentially a miniature suction box used under standardized conditions for indicating the relative porosity of running felts. This property is measured by the vacuum developed in the tester head as a result of pressure drop through the felt.

There are other state of the art instruments which are used to measure the performance capability of wet felts. One such device is the Feltperm. This instrument uses water permeability, and pressure differential through the felt to measure the resistance to water flow into the felt. Both porosity and permeability measurements are a function of felt design, degree of filling, level of compaction, and felt density. The operation of the Felt Perm unit, and a more detailed discussion of water permeability in wet felts can be found in TAPPI TIP 0404-43. Both the felt's air porosity and water permeability characteristics can be used during monitoring to indicate the felt's ability to absorb, carry, and release water. The HSPT may not detect small areas that are plugged or narrow bands of wet streaks in the machine direction, which may be detected by the feltperm. However, it does provide an economical means of measuring general cross direction porosity profiles. Both instruments are useful tools in assisting the papermaker with monitoring felt filling,

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maintenance, troubleshooting, and press section optimization.

Significance

Because the instrument can be used to place a number on running felt porosity, the test is of great value in the comparison of one felt with another or in showing changes across the profile of a given felt. It also can be of substantial assistance in differentiating between machine problems and felt problems, evaluating felt cleaning methods, predicting end of felt life, and troubleshooting.

Both instruments are tools used to assist in measuring felt and press section performance, maintenance, and troubleshooting.

Definition

For the purpose of this method, the term “porosity” is used to describe the relative resistance to airflow developed by wet felts during their use on paper machines. While not technically accurate, the term has been used widely in the industry to describe the general openness characteristics of felts. While the term *porosity* describes the openness characteristics of the felt, the HSPT value is reported in terms of “percent closed.”

For additional explanation, and more accurate use of terminology, industry convention will be used in the context of this method. Again, HSPT values are reported as “percent closed”. See Fig. 1 Assembly diagram.

Apparatus

Porosity tester (Fig. 1), consisting of a hollowed head with a side arm for connecting to a suitable vacuum source, 15 m (50 ft) of 13-mm (½-in.) inside diameter hose for connecting the instrument to the mill vacuum source, a globe shutoff valve, a T fitting, a spanner wrench, and a vacuum regulating valve capable of handling available vacuums in the 250-700 mm (10-28 in.) range. A vacuum gauge is connected to the top of the head through a swivel joint which permits rotation and tilting of the gauge for easier reading. In the event that available mill vacuum is low, a lightweight regulator valve spring capable of handling available vacuums in the 76-380 mm (3-15 in.) range is used.

NOTE 1: A prime requirement for the tester is a readily available mill vacuum supply. To permit readings of sufficient accuracy, the vacuum source should be reasonably constant and, desirably, should have a vacuum level of at least 380 mm (15 in.) Hg with 510 mm (20 in.) Hg or more being preferred. It also should have a high volume capacity so that the volume of air passing through the tester does not significantly affect the vacuum level at the source. The HSPT with all valves and face plate open, will pull a maximum of 0.85 m³ /min (30 ft³ /min) at the operating vacuum to a vacuum source operating at 508 mm (20 in.) Hg vacuum. This figure drops sharply for lower vacuum sources or when resistance (felt) covers the face plate. The best source is at the vacuum pump; however, a suction couch or a vertical header from the pump to a suction roll vacuum box is also adequate. Horizontal headers are not as suitable, and connections to the bottom side of a horizontal header are unacceptable because of the possibility of water lying in the line. All fittings from the vacuum source to the porosity tester be at least 13 mm (½-in.) inside diameter.

Calibration

Normal procedure

Assemble the porosity tester as shown in Fig. 1 and make a connection to the mill vacuum, preferably through a gate shutoff valve at that point. With the face plate completely sealed by covering with the hand:

1. Open fully the installed valve at vacuum source connection.
2. Open fully the globe shutoff valve at the end of the tester side arm.
3. Determine the maximum available mill vacuum by placing two fingers over the side bleed holes of the regulating valve and noting the lowest point of fluctuation on the porosity tester gauge over a period of about 2 min.
4. Uncover the side bleed holes and adjust the spring on the regulating valve to bring the vacuum 25-50 mm (1-2 in.) below the lowest point of fluctuation noted above. Record this new reading as available vacuum. Try to achieve this available vacuum in future tests on the same felt position.

Special procedure

For dense, low porosity felts, see Additional Information.

Sampling

The felt used in the mill operation, as available on the return run, when it is not in contact with the web, constitutes the sample.

Test specimen

For profiling purposes, divide the running felt width into 300-mm (12-in.) segments by measuring and marking floor, catwalk, or handrail for reference. It is not necessary to measure outside of sheet width. Standard mill safety procedures, and personal protection equipment, should be properly utilized when taking measurements with the HSPT. Special care should be given to handling air line in the press section around moving components.

Procedure

Test each segment by moving the tester back and forth across the full width of the segment and observing the vacuum gauge reading. The needle may be expected to fluctuate; normally the variation will be within 50 mm (2 in.) Hg. Record the average gauge reading. A variation of over (50 mm) 2 in. Hg could indicate a locally filled area or a non-uniformity in the felt.

NOTE 2: Place the face plate of the porosity tester flatly against the felt surface when making readings. Normally, only slight pressure is required to have a good seal because the vacuum draws the felt to the face plate. It is very important, however, that the face plate be applied flatly to the felt. Take special care with lightweight felt so as not to wrinkle the felt by bearing down too hard.

NOTE 3: Free water (water which may be drawn from the felt) will give erroneous readings, and it is therefore necessary that the test be made at a relatively dry position in the felt return following the nip. Measurements made on a vertical run or the underside of a horizontal run are less susceptible to this type error. Any felt washing showers between the press nip and the test position should be shut off prior to testing unless it is felt that shutting them off could cause sheet break or other production problems. The hose from the vacuum source to the tester should be reasonably straight and contain no vertical loops where water removed from the felt can lodge.

NOTE 4: Make porosity measurements at the same location each time when comparing several felts, or when following this period of usefulness of one felt.

Report

Report the average gauge reading (HSPT reading) to the nearest 10 mm or ½ in. vacuum Hg. Record adjustments or changes in continuous cleaning equipment and occurrence of shutdown washes which are significant. Note also grade changes, large changes in machine speed and press loadings, and position of trade lines. Report also the available vacuum at the time of the test as determined in the calibration procedure.

NOTE 5: Large differences in machine speed will affect readings. Higher speed will result in higher vacuum reading.

Calculation of H-S number

In order to relate porosity measurements taken at different positions or on the same position where the level of available vacuum varies considerably, report the porosity as the H-S number or percent of available vacuum. Figure 2 shows the results obtained from five samples with varying porosities. The H-S number (recorded vacuum divided by available vacuum × 100) is the same for each sample regardless of the level of available vacuum. Fig. 2. displays H-S number vs. reading at different available vacuums.

Development of a standard porosity curve

From the data of several tests on the same felt take the average gauge reading across the profile for each test and convert it to an H-S number by dividing it by the available vacuum for that test and multiplying by one hundred. On

graph paper, plot the H-S number on the vertical axis vs. days life on the horizontal. The resulting curve should be similar to that shown in Fig. 3. When taking data for the development of a standard porosity curve, readings should be taken as frequently as time permits but under no circumstances less than every other day through felt life until the standard curve has been developed.

Felt profile

To develop a felt profile, convert the HSPT readings to H-S numbers and plot them vs. felt width as shown in graph on Figure 4. There were 14 points of measurement in the cross machine direction. The chart above the top graph, labeled "Porosity Across Felt" shows the different vacuum readings taken by the HSPT and the corresponding calculated porosity. The top graph shows the porosity as calculated and displays them in the graph below the chart. The bottom graph shows the porosities taken on a given felt over a 47 day period. Note that the porosity increases as the felt age increases. Comparison between different mills may be attained on the basis of relative H-S numbers.

Note: In Figure 5 the effectiveness of batch washing can be displayed. The graph plots the porosities taken at 10 different location in the cross machine direction, on the same felt.

The "Before Batch Cleaning" felt cross directional porosity profile shows with maximum peaks on the felt edges of approximately 83 (indicating percentage closed), and minimum peaks in the center of approximately 72 (average porosity of felt before cleaning is 79).

The bottom portion of the graph displays porosity profile in the cross direction taken on the same felt, but "After Batch Cleaning". The maximum peaks of the felt after cleaning are approximately 65 (indicating percent closed) as shown on left edge and in the middle section (average porosity after cleaning is 63). This is a 20.2% improvement in decreasing HSPT number or reduces the percent closure of wet felt.

Precision

The precision of this procedure has not been determined.

Special calibrating procedure for dense, low porosity felts

In the event that the felt being measured is dense and has a low porosity at the start, a special procedure can be used for calibrating the device to allow a greater sensitivity or better discrimination between readings throughout the life of the felt. To accomplish this calibration, place a rubber disc with a 6.3-mm (1/4-in.) hole punched in it over the face of the tester head so that all holes except the center hole are covered. Throttle the globe valve at the end of the tester side arm to a value about 2/3 or less of the available vacuum. Figure 4 shows results obtained in comparing this procedure with the conventional calibration.

Assuming that a fabric started out with a H-S number of 74 and was considered completely filled when the value reached 95, the standard procedure with 670 mm (26 1/2 in.) available vacuum would result in a reading of 495 mm (19 1/2 in.) mercury at the installation of the felt and 645 mm (25 1/2 in.) at the time it was removed. This would yield a total change of only 150 mm (6 in.) throughout the life of the felt and make day-to-day changes hardly noticeable. Using the rubber disc and throttling procedure described above and calibrating to 380 mm (15 in.) before taking the readings, the same felt would give readings of 380-610 mm (15-24 in.) of mercury for a spread of 230 mm (9 in.) throughout the life of the felt. Calibrating in the same manner at 250 mm (10 in.) results in a spread of 330 mm (13 in.) throughout the life of the felt. The results can then be related back to the conventional H-S number using a chart similar to Fig. 6.

Evaluation of felt cleaning methods

Figure 7 is a representation of effect of felt cleaning methods showing the deficiencies of a shutdown cleaning procedure as compared to continuous cleaning. The chart displays the trend of felt porosity over time for a felt which is untreated, has batch wash cleaning only, continuous treatment only, and one which is both continuously treated and batch washed. By comparing two continuous cleaning curves, one can demonstrate the superiority of one wash formula over another.

Predicting time to batch wash and end of felt life

Where felt fill-up is the determining factor in felt removal, H-S number vs. days life curve may be used to predict the end of felt life once the critical H-S number for the position and felt design has been established (Fig. 8). The critical H-S number is defined as that at which crushing, marking, or other adverse conditions associated with lack of felt porosity occurs. Experience has shown that after initial major changes have taken place in felt openness, further changes often become linear with time. When the curve begins to straighten at about half-life, it can be extrapolated to the critical H-S number for that position and an end-of-life prediction made. This allows the papermaker to schedule felt changes in coincidence with wire changes or other mechanical shutdowns and also to assist him in efficient scheduling of critical grades.

Based on previous felt performance, a sub critical H-S number can be based on some percent below the critical H-S number. The desired percent in reduction could vary depending on the felt and the stage in the felt life. For example, if the critical H-S number is 90% at the end of a typical 23-day felt life and 70% at 12 days into the felt life, target to batch when HSPT number reaches 20% below midpoint target ($70 - 20 = 50\%$) or 60% closed and target to batch again when HSPT number reaches 10% below endpoint target ($90 - 10 = 80\%$) or 80%.

This allows the papermaker to apply preventative maintenance and control felt contamination and filling. The final result will provide improved performance during the economical felt life and/or extend the felt's useful life.

Comparing two or more felts

The comparison of one felt design with another is one of the more valuable uses of the porosity tester. By observing H-S number vs. days of life for two or more felts run on the same position, comparisons can be made easily in terms of rate of porosity change. See Fig. 9. Woven felt (A) vs. needled felt (B).

Irregularities

1. *Crown vs. load.* Curve A of Fig. 10 is an extreme case of a press position which is running with a roll that is over crowned.
2. *Localized fill up.* Profiles similar to Curve B of Fig. 10 are frequently found on the press positions when a localized fill up condition exists. It is generally attributable to a machine condition such as plugged shoe-type felt conditioner, poor seal strips or declasser on the suction roll vacuum box, plugged holes in that area of the suction roll, or increased press loading or increased water removal necessitated by a wet sheet in that position. Frequent profiling of the felt throughout its life permits early identification of plugging problems and enables the papermaker to make corrective action before the problem becomes serious. Figure 11 compares the porosity changes of a given felt at four different stages of the felt life (new, 5 days, 12 days, and 19 days). It can be noted that at day 12 and 19 a significant increase in porosity numbers are shown on the back section of the felt as measured in the machine cross direction.
3. *Wear streaks or areas.* Figure 12 shows the progressive wearing of the center of a felt throughout life. Low HSPT number in the center indicates excessive wear as the felt ages. If a machine condition is causing this wear, the same general profile will be repeated in future felt runs.

Keywords

Porosity, Press felts, Wet felts, Felts

Additional information

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