PROCESS ZONE ENVIRONMENTAL CONTROL-WEAVING

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Abstract

As weaving production rates and resultant stresses on warp and filling yarns increase so do emissions of heat, noise, dust, etc. It is increasingly difficult to control environment conditions in both the process zone and in the personnel zone. Conventional air conditioning system designs, which have a common environment for these two zones, necessitate compromises. A new design, employing modular environmental control apparatus (MECA), partially or completely separates the two environmental zones and thereby partially or completely reduces constraints of compromise. MECA concepts are described in this first of two publications on the subject.

Process Zone Environmental Control-Weaving

I. Concepts

I. Background

Ladies and gentlemen, after 4 years of silence, since the 1992 Beltwide and Bremen Conferences, it is a genuine pleasure for me to speak again to this group of cotton people that I so much respect and enjoy. And it feels right to again devote Christmas-New Year holiday time to preparation of a Beltwide paper.

Our work on Process Zone Environmental Control (PZEC) began in the early 1980s with applications to fiber processing, such as cleaning and carding, and to yarn processing such as weaving and knitting. There are several open and patent literature publications on fiber processing by Schaffner Technologies people and various Customer-employed Colleagues. The weaving work has been kept secret until recently.

It may interest some of you to note that these weaving process developments began in ModuFil at about the same point in time that fiber testing instrument developments began in Schaffner Technologies. Limitation of resources forced us to make a difficult choice in the mid 1980s in favor of emphasizing STI's developments of MTM and AFIS.

In 1989, Zellweger Uster acquired rights to STI's fiber testing instruments only. STI and its sister Companies, ModuFil and ppm, retained all rights to aerosol instruments and fiber processing. After leaving Zellweger at the end of 1992, the first author returned to work on textile processing in general and on the PZEC developments in particular that we had chosen to de-emphasize earlier. This paper reports some of this reactivated work and is the first of two papers on PZEC W.

II. Weaving Basics

Figure 1 schematically represents an end cross sectional view of the open shed of a weaving machine. In the plane of Figure 1, the shed is defined by the upper and lower extremities of the warp yarn and extends from the whip roll 1, through the drop wires 2, harness 3 (which contains the heddle wires), reed 4 to the point at which fabric is formed 5, and finally to rollers 6 which provide tension for the warp ends and take-off for the finished fabric. Perpendicularly, the shed is defined by the width of the cloth, including selvages. Once per machine revolution or "pick", filling yarn is inserted, the reed moves forward and "beats" it into fabric, and the harness and whip roll shift.

These basic processing actions impart various stresses in and on the warp and filling yarn. Some of the stresses are intense or nonuniform and cause "stops" of the weaving process. Assuring efficient or stop-free processing of first quality fabric is a primary goal in weaving. Further, these vigorous actions on the yarn in the process zone cause emissions of heat, noise, ions, gases, and various contaminants (dust, fly, oils, etc.) from the shed. These emissions are collectively represented by the "wavy" arrows labeled EM. Other actions-mechanical, pneumatic, electrical, even chemical, take place, of course, and are therefore also part of the weaving process zone by definition. For this discussion we will focus on the shed as the primary portion of the weaving process zone. We shall further restrict our remarks to controlling the process zone environment.

These basic weaving process actions are repeated at increasing production rates. Weaving machine pick rates have increased from ~ 80 per minute in the 1950s (shuttle), to 300 per minute in the 1970s (projectile, rapier) to 600+ per minute in the 1980s and currently (air jet) to perhaps 1000s per minute in the near future. It follows that providing maximally profitable conditions within the weaving process zone and dealing with the various emissions from it have been increasingly difficult environmental control problems. Optimally solving these problems calls for new approaches, one of which we now describe.

III. Separation of Process Zone and Personnel Zone Environments: Concepts.

It is obvious and broadly accepted that environmental conditions EP in the shed or process zone affect weaving performance as well as affect emissions EM. Figure 1 also pictorially represents another basic component of the

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weaving process-weaving personnel. Weavers, fixers, warp, filling and cloth handlers, and other workers have relatively narrow ranges in personnel zone conditions EW which are acceptable. Considerable expense is incurred in weaving operations to control or "maintain conditions" which are acceptable first for personnel (EW) and, second, for the process zone (EP). Such compromised environmental conditions include humidity, temperature, dust and fly concentrations and deposition fluxes, gas flows, ion concentrations, noise, etc. These compromised conditions can, among other design options, be controlled by central air conditioning systems indicated in Figure 2. The typical A/C supply and return design currently in favor in shown. (Not all weave rooms have under loom air returns as shown.)

To emphasize: except for a few research trials, all weaving operations today supply air to and return air from a common environment generally as seen in Figure 2. Large, inflexible, and costly (capital and operating), central air conditioning system designs are today the favored norm. Such central A/C designs have the further and fundamental disadvantage that process zone environmental conditions EP are necessarily derived from and limited to environmental conditions EW that are acceptable by weaving personnel. Humidity versus distance H(x), as illustrated in Figure 3, makes the "compromise" point: high humidities, at the edge of personnel discomfort, can unfortunately lead to lower humidities than optimal in the weaving process zone. In view of increased emissions and power dissipation with increased pick rates, one has to ask if there are better ways.

The simplistic approach of increasing room air exchange rates helps but, in our opinion, is not optimally profitable and is well beyond the point of diminishing returns. Directing supply air toward the shed or placing air returns under it also help but cannot go far enough.

It will become obvious and, hopefully, broadly accepted eventually that there is a better design, namely, to environmentally separate the personnel zones from the process zone as seen in Figure 4. This design concept has the important consequence of enabling uncompromised choices for those process zone environmental parameters which are most profitable. The cross-hatched thermodynamic envelope indicates perfect separation. H(x), like all other environmental parameters, can be chosen independently-and therefore without compromise-for both the process zone and for the personnel zone. The arrows into and out of the envelope represent utilities (electricity, heat transfer fluids, compressed air, etc.) and information signal lines.

To dramatize the "no-compromise" point: if profits justified the design, weaving could take place in a sealed envelope in argon at 50°C while weavers and others in the personnel zone could perform their work in comfortable, quiet air.

IV. Separation of Process Zone and Personnel Zone Environments: Practical First Steps; MECA

Figure 5 shows a first step design that technologically moves from the common environment of central A/C designs, as seen in Figure 3, toward the ultimate separation of process zone and personnel zone environments, as seen in Figure 4. A movable collector C is rotatably positioned to operate near the shed and behind or in front of the harness. This collector captures a high volumetric flow rate of air. Also seen in Figure 5 are two blow-off nozzles, B1 and B2, which, together with the capture flow(s) and unshown source flow diffuser(s) comprise a Modular Environmental Control Apparatus, MECA.

The partial separation of Figure 5 radically changes process zone air flow patterns and results in the following advantageous features:

1. Most of the emissions EM are captured. Dust and fly are deposited on the concave filter surface(s) which may be manually or automatically cleaned. Loom and other equipment heat, ions, gases, etc. pass through the filter for further downstream conditioning. Noise can be suppressed by addition of absorbing panels.

2. The air captured by the collector and sourced by the blow-off nozzles or general diffuser can be driven and conditioned (cooled, humidified, ionized, etc.) by a modular environmental control apparatus mounted on each loom. Such modular apparatus thus provides both capture and source flows ("return" and "supply" flows in HVAC jargon).

3. The modular environmental control apparatus can both source or supply conditioned gas to the process and personnel zones and capture or return emissions-laden gas from these zones on a machine-by-machine basis. It follows that such designs can completely eliminate the central A/C system in some cases and, in most cases, greatly reduce the demands on it.

4. It further follows that one or more process zone(s) of each machine can be independently controlled with modular environmental control apparatus.

5. Under loom returns can be eliminated since their air capture functions are handled by the capture flow into the collector. This enables maximum flexibility; MECAs can be removed from old looms and installed on new looms with different foot-prints into existing weave rooms, with or without in-floor returns.

6. In retrofits where an existing central A/C is retained and MECA capture or return features primarily are exploited, conditioned air from the central A/C supply grills is brought into quicker and more intimate contact with the shed or process zone.

7. Local humidification can be applied above the shed to supplement (or eliminate) humidification of central A/C supply air.

8. Traveling cleaners, which serve any one loom less than about 5% of the time, can be eliminated in favor of 100% dedicated blow-off cleaning in a “push-pull” mode.

9. Air exchange is obviously localized to small effective volumes. Exchange rates of 100s of changes per hour in the process zone are readily achieved. Compare this to ~25/hour for central systems or to 1000s/hour for the perfect separation suggested by the envelope in Figure 4. (This point can be greatly expanded.)

10. Precise, accurate and rapid controls of process zone environmental conditions (which can be different from employee zone conditions!) are possible.

11. Large savings in air conditioning costs (capital and operating) can result from even partial separation of process and personnel zones.

Figure 6 shows how the movable collector automatically rotates from operate position to retract position when the loom stops. When the loom runs again, after the weaver has repaired the stop, the collector automatically rotates from retract to operate.

V. Conclusions

As ModuFil has begun to carefully introduce products embodying these new concepts to the market place, reactions have understandably ranged from skepticism to enthusiasm. This audience of textile peers can recall and appreciate similar reactions to PCAMs introduced by ppm in 1980, to ModuFils and Lint Traps introduced by ModuFil in 1982, or to MTM and AFIS introduced by Schaffner Technologies in 1983 and 1986 and now in the capable hands of Zellweger Uster. It is our hope and expectation that ModuFil folks can tell similar success stories about MECA in the near future. If this happy outcome materializes, it will be with the much-appreciated support of some of the same cooperative Customers that supported our earlier new concepts.

Enthusiasm has been sufficiently positive that five real-world trials have been run or are in progress. For time and business reasons, we will not present detailed results now. We can confirm that the concepts are valid, especially that of separating the process and personnel zones. You may expect the second, results-oriented paper within one year.

It is interesting to extend the above-disclosed concepts, noting the practical first step of partially separating process and personnel zones with the modular environmental control apparatus (MECA) design. Such inventive deliberations lead to further practical embodiments and beneficial results of PZEC thereby effected.

It is easy to enthusiastically hypothesize that weaving machine performance can be improved, that weaving personnel performance, comfort, health, and safety can be improved, and that these improvements can be at lower capital and operating costs. And it is easier to be skeptical. Confirming these hypotheses with real world data is hard. Skeptics and enthusiasts will find plenty to interest them in paper II.

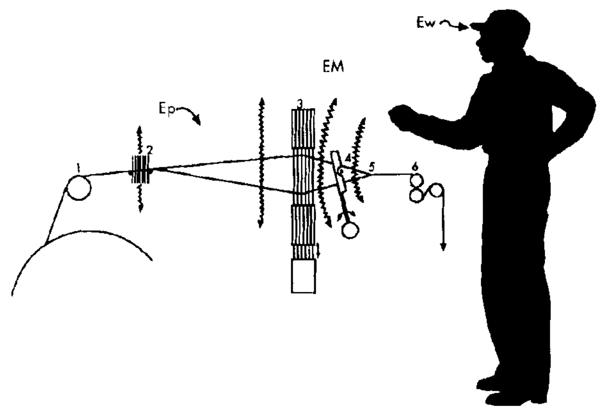

FIG. 1 Process Zone and Personnel Zone

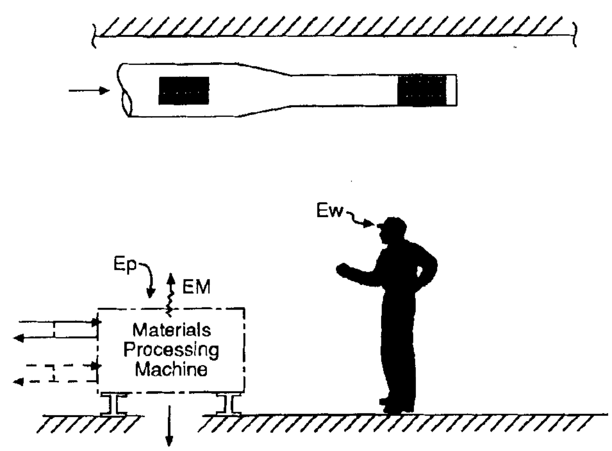

FIG. 2 Generic Process and Personnel Zones

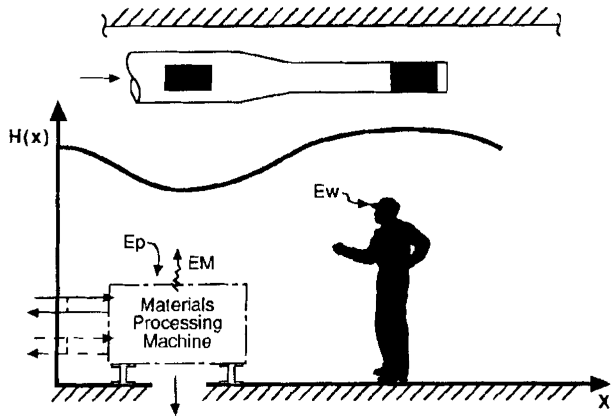

FIG. 3 Common Environment for Process and Personnel Zones

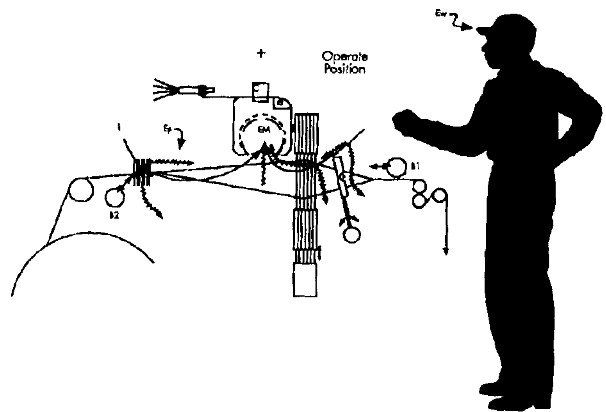

FIG. 5 Collector in Operate Position

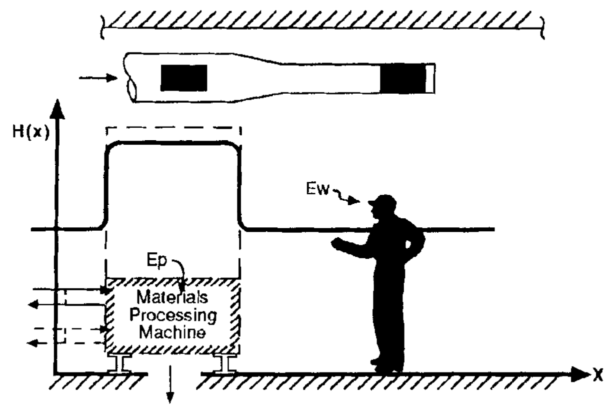

FIG. 4 Separate Environments for Process and Personnel Zones

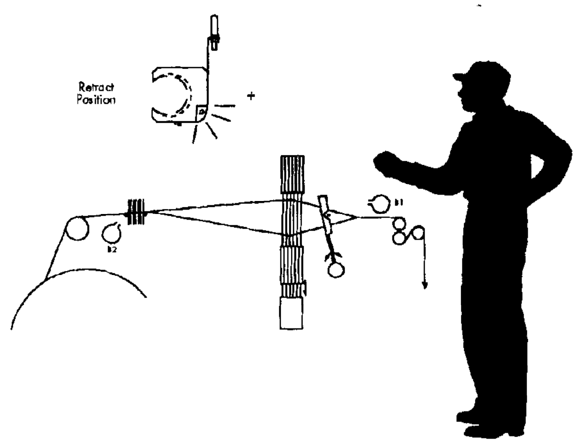

FIG. 6 Collector in Retract Position