

Optimization of Approach Flow for Better GSM Control

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ABSTRACT

Approach flow piping modification and process optimization is being discussed to ensure better GSM control both in machine direction and in cross direction. Process parameters optimization, e.g. machine chest consistency and holey roll speed optimization and flowsheeting optimization, e.g. entrained air removal, centricleaner piping rerouting etc. have been found to be very advantageous and significant improvement in GSM control has been achieved.

INTRODUCTION

In the paper machine section, GSM is the main important quality objective. Many a times substance variations occur due to approach flow and often these cannot be easily controlled by conventional methods. To solve the problem, the common tools such as consistency control and flow control are employed. In case the problem continues, O-shall scanners with DCS system is installed but satisfactory results may not be obtained. Quite often, the variations arising due to approach flow area are neglected or it is assumed that these variations could be due to inherent error of the controls system employed. Before going into the details we should first have a look on different type of variations that may appear in paper.

EXPERIMENTAL

Consistency and Stock Flow Variation

These are the most commonly known sources of substance variation. For any system, the substance may be indicated as a function of stock flow and consistency in the following way-

$$\text{GSM} = \frac{(\text{Flow} * \text{Consistency}) * (100\% \text{ losses})}{(100 * \text{Deckle} * \text{Machine Speed})}$$

The losses include wire trim losses, centricleaner losses, pressure screen losses etc., all expressed in percentage.

If we consider any system, we would observe that the stock flow remains constant if the other flow conditions are kept constant. This means having constant head by means of a SR Box, stable fan pump operating conditions, the flow through the basis weight valve will

change only when basis weight valve opening is altered.

Similarly, the machine chest consistency will remain the same for a particular batch provided no stock is coming into it. On slow speed machines, when the machine chest capacities could be of more than an hour, consistency control is easier and can be done manually without any difficulty. But on the high speed machines, the machine chest capacity is limited to a few minutes, due to which, it becomes necessary to improve consistency control by installation of consistency controller. In the following example, we will see how minor process changes can be used to improve consistency control in a small mill.

The machine chest capacity is 6 cu.m. and a consistency of 2.8-2.9% is maintained in this chest. The machine chest overflow is taken to receiving chest of the same capacity, the level of which is kept at 50% on an average. The pump upstream to receiving chest is of nearly double capacity than that of machine requirement and hence, it is operated only 50% of time available. Here, we see that the effective machine chest capacity is 90 cu.m. which at 2.8% consistency yields 2.5 tonnes almost two hour production of the machine in this typical case. The average roll weight at the machine is 1 tonne, and hence, operator gets hourly GSM report. Now, when a new batch is transferred to the receiving chest which is at 50% level, at initial, suppose, the consistency maintained is 2.8%, and a stock of 3% consistency enters into receiving chest, after mixing, the consistency in the machine chest rises to 2.86% only. In this way, a bigger chest is helpful in maintaining consistency by reducing variation by more than 60%.

To proceed further, it was observed that earlier the operators had a habit of maintaining a consistency of 3.2% in the machine chest. With the manual system,

nobody can expect a very good control and it was observed that the 90% confidence limits were $\pm 0.04\%$. These figures may be considered excellent for a manual control system, where the consistency is being judged by mere looking at the flow pattern of stock in the chest.

Pulsation

Pulsation is most commonly known reason for substance variation that appears within a short span of time. Most pulsations come from pressure screen or fan pump, and can be detected easily the measurement of frequency of pulsation and comparing the same with the equipment frequency. On most slow speed machines, pulsation from fan pump and pressure screen causes less problems. An example would reveal how these can be detected easily on slow speed machines-

Machine speed	175 rpm
Pressure screen speed	350 rpm
Number of vanes in Pressure Screen	2
Pulse frequency generated	700 rpm
Pulse width	$175/700 = 0.25$ m

Just looking from underneath of paper at the dry end would reveal such type of pulsation, as the substance due to this pulsation varies within every 25 centimetre of paper run. Further, the pulse frequency i.e. 700 rpm, or approx. 12 Hz can be easily detected by naked eye as our

eye can detect pulsations less than 24 Hz. This also means that 24 Hz, or 1440 rpm, the pulsation becomes difficult to detect by naked eye, and hence suitable automation is a must to detect this. From the above example, we may also observe that if the machine speed is increased, the pulse width will increase, and testing of gsm using a template of 125x20 cm will not be very reliable.

Another source of pulsation is the head box holey roll. On slow speed machine, with open headboxes, holey rolls are commonly used to create turbulence, so that better formation and stock distribution is achieved. On a particular paper machine with open head box and two holey rolls, the following trial was conducted to determine the magnitude of pulsation. A reel made as cut on a simplex cutter alone and the different sheets were extracted for testing. The sheets were tested for dimensional accuracy, and having assured that all the sheets were of correct size, the weight of these was taken on a digital balance after conditioning. The substance was calculated by dividing the sheet weight by sheet area, and was plotted against the sheet number. This indicated the holey roll pulsations to the tune of ± 0.3 gsm, at a frequency equal to that of holey roll. Later, the holey roll rpm were changed from 11 rpm earlier to 20 rpm, and it was observed that this difference went up to ± 0.5 gsm. The profile instability was then computed for a number of rolls and it was observed that the instability was more for table roll rpm of 20. As obvious, the holey

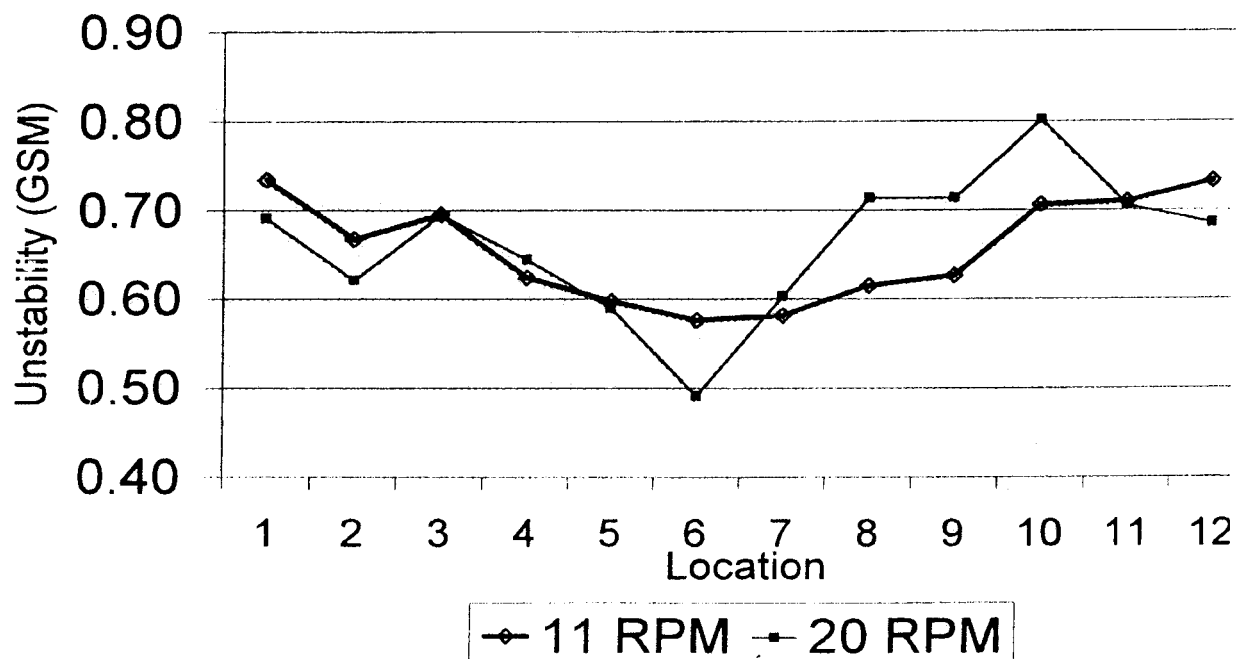


Fig. 1 Effect of Holey Roll RPM on Profile Unstability

roll rpm were reduced back. It is further planned to reduce again to 7 rpm.

Other Variations

Consistency and flow variations as well as pulsations are very easy to study and necessary corrective action can be taken for these without much difficulty. But, other variations also take place in the approach flow area. Most of these are chaotic, random and of varying magnitude. These may appear in either cyclic or in temporary form.

Approach Cyclic Variations

Approach cyclic variations are those which appear due to inherent nature of approach flow area. These result in frequent increase and decrease of gsm by a marginal value even if consistency and flow rate from the basis weight valve is constant. In most of the cases, it can be observed if there is a profile instability, present and it is very difficult to control gsm even for a short while. The existence of these can also be seen by the example that in case there is a roll rejected due to high CD profile variation. In some mills, the common is to tear off some of the sheets from that particular roll and recheck the profile. Most of the time, the profile obtained is acceptable. The above example is adequate to show why it happens.

To give a better idea of the process, we may have a look on following equations-

$$GSM = f(HBflow, HBCy, FPR, OF, RECIR, MCS)$$

$$BW = f(HBflow, HBCy, FPR, OF, RECIR, CCCy)$$

$$HB = f(PSICy, RRsol, RRflow, PSIfow)$$

$$PSI = f(EPflow, FPcy, CCRflow, CCRcy)$$

$$FP = f(STKflow, STKcy, SCCflow, SCCcy, BWflow, BWCy, RECIR, OF)$$

Nomenclature

HB=Head box parameters; OF= Overflow from head box; RECIR=Recirculation rate from head box; MCS=Machine speed; FPR= First pass retention; BW=Back water parameters, CC=Centricleaner parameters; Cy=Consistency; flow=flow rate; PSI=Pressure screen inlet; RR=pressure screen reject rate; Sol=Solids flow rate; FP-Fan pump; CCR-Centricleaner reject; STK=Stock; SSC=Secondary centricleaner.

From the above equations, we can see that the different parameters make a circular relationship, i.e. they are interlinked in a closed loop as given below-

- Start Loop
- High head box consistency
- Higher retention
- Low backwater consistency

- Higher gsm
- Low head box consistency
- Lower retention
- High backwater consistency
- Lower gsm
- Go to start loop

In this way, the gsm keeps on changing continuously from lower to higher and vice versa. If we study the dynamics of this process, we can see that this cycle time is of the order of a couple of minutes. This can be calculated by dividing total approach area volume by flow rate through approach flow. Normally, this effect is more severe on single layer wire, more fine stock, where the first pass retention is low. If the first pass retention is higher, this effect will be lesser and there would be negligible fluctuation in gsm. With such variations, is often difficult to check and correct basis weight in real time. This is because these fluctuations disable the measuring system to get the real value of gsm instantaneously. Of more importance is the fact that the normally available control loops, e.g. consistency and stock flow loops are unable to counter this effect even when they are running with gsm feedback cascade mode. The reason behind is that the process time in such control is fairly large, and is of the order of the same time as that of such fluctuations. The process time in a fully controlled system with DCS and QCS is the sum of scanning time needed for one pass of scanner plus time for a full circulation of stock in approach flow area. As a result, most of these fluctuations remain present in the system and very accurate gsm control is not possible.

Auto Tuning

As it appears, the problem does not remain in the system for long. The available piping designs try to reduce these variations slowly and slowly. But, whenever any change in operating condition appears, they restart oscillating for some time. In the conventional system, the stock from the fan pump flows to centricleaner and then to pressure screen and finally head box.

In centricleaner section, there is normally one or more headers, to which centricleaner bottles are connected directly. The stock enters the header from one end, and enters the first centricleaner bottle. The remaining stock approaches forward at the same velocity if the header is tapered, or even at a smaller velocity if the header is straight. Whatever the case may be, there is a significant time gap between entry of stock to first and last centricleaner bottle. The similar happens to accept side to centricleaner also. This means sudden change at outlet consistency. A study at some different centricleaners installations revealed that this time gap

could be even of the order or 20-40 seconds. Similarly, in pressure screen section, the inlet to pressure screen is mixed with the stock contained in the screen housing. Here again a change in inlet consistency results with a slow change in outlet consistency, the time being in the 5-15 seconds range. The following equation can be given for effective inlet consistency at screen basket-

$$C_t = C' C_{in} e^{-(Q/V)t}$$

where, C_t is consistency after time t , C_{in} is initial consistency at which screen is running, Q is the flow rate through the screen, V is the volume of pressure screen and C' is the final consistency at which screen would operate. In this way, we see that any sudden change at fan pump will reflect in slow change at head box. Furthermore, the similar things happen in head box also. The changed stock enters the head box at different CD locations at different times. Of course, this results in CD profile instability, to a certain extent, yet, the major fluctuations described earlier are damped by this phenomena.

Further Actions Possible

Retention improvement

As indicated earlier, the easiest solution lies in improving first pass retention to the highest possible. If the retention

is good, there would be less chances of back water consistency fluctuation, and hence grammage fluctuation. The practical application was made on a paper machine running at 200 mpm, producing 36 gsm poster paper. The CD profile variation was recorded at an interval of 0.7 seconds for a total time of 30 seconds. The results obtained were very interesting. The CD profile variation tested upto 0.2 gsm accuracy, showed a variation of 1.6 to 3.6, with an average of 2.5 and a 90% confidence value of 0.7. This means, we may get a CD profile variation of 1.8 to 3.2 for the same roll at the (almost) same time. If that is due to pulsations, the MD GSM variation may appear but not the CD profile variation. The existence of such profile variation is a strong evidence of head box consistency fluctuation.

In a particular case, such variations could be reduced to half, only by increasing the headbox consistency from 0.68% running earlier to 0.78%. Surprisingly, no noticeable change in formation was detected. In addition to reduced load electrical load on fan pump, overall retention was improved improving the overall yield. Simultaneously, reduced fines content of machine backwater also resulted in reduced rosin and alum consumption. Severe foaming problem in the approach flow area was also cured automatically, and defoamer consumption was reduced

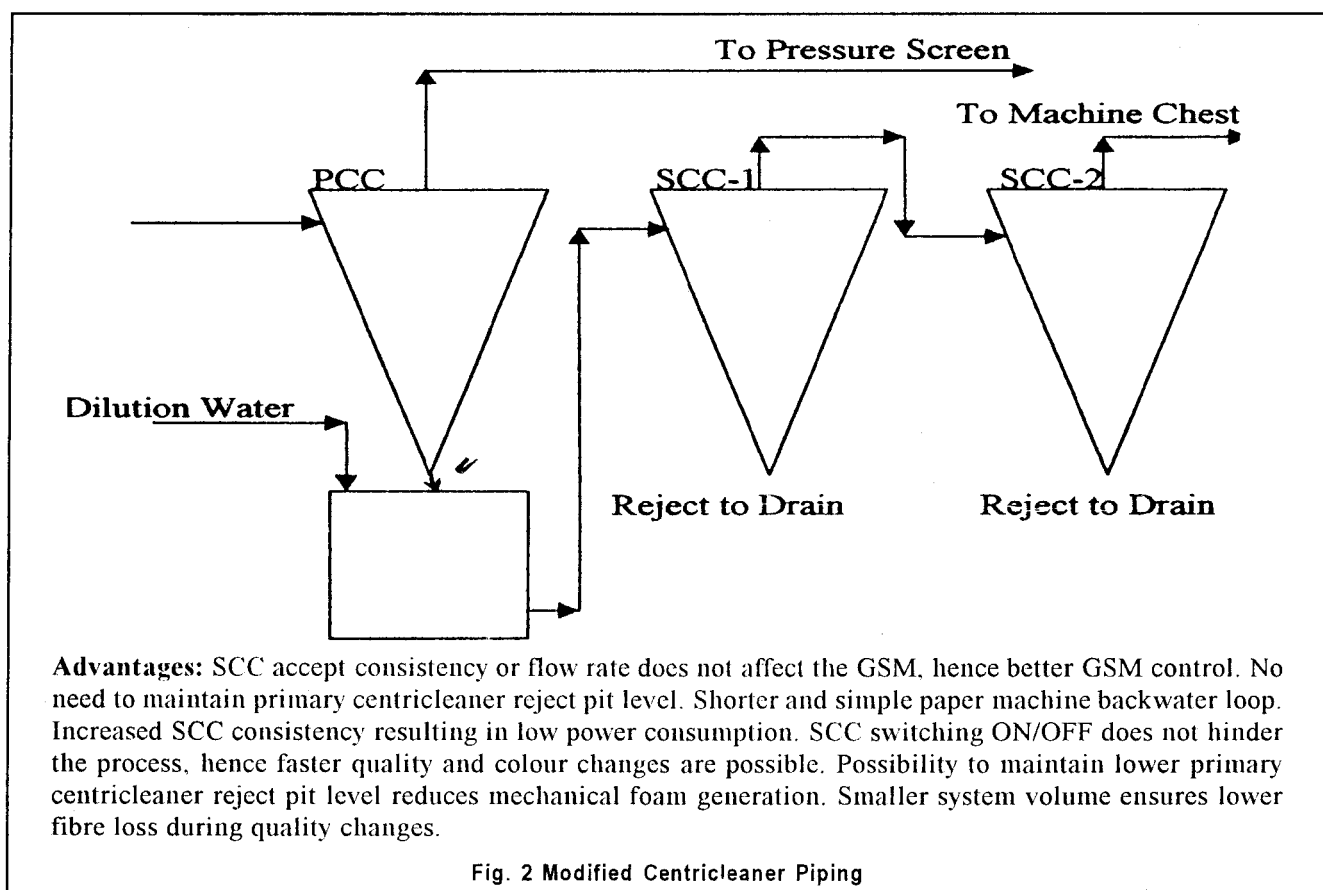


Fig. 2 Modified Centricleaner Piping

to only one tenth of the original one. Probably, this was due to higher amounts of entrained air due to high fines content in the backwater when the consistency in the head box was 0.68%.

Consistency Control

As a common practice, the consistency control is supposed to be only for machine chest but a lot of things happen in the approach flow area. Three or more streams with different consistencies and flow meet at the fan pump, resulting in some other consistency. Centricleaner pits, which are of significant size in most of the small paper mills create consistency variations at the pump suction, resulting in frequent consistency variations etc. From the example below, we may see how a centricleaner pit works to increase substance variation.

Machine capacity	30 tpd
Primary centricleaner loading	40 tpd
Centricleaner inlet consistency	0.8%
Flow through primary centricleaner	3472 lpm
Number of primary centricleaner bottles	6
Flow rate per centricleaner bottles	580 lpm
Centricleaner reject flow rate (Solid)	1.5 tpd
Centricleaner reject consistency	2.4%
Backwater consistency	0.2%
Secondary centricleaner feed flow rate	600 lpm
(Only one bottle in operation)	
Secondary centricleaner feed consistency	0.36%
Accept flow rate through sec. C.C accept	3 tpd

Here, we may see that the secondary centricleaner is being operated at a much lower consistency. In such a case, huge backwater is required to makeup the level in centricleaner pits, which contains mainly fines, and hence significant amounts of entrained air. As a result, this pit acts as a small DAF (Dissolved Air Flotation) unit, where, the fines, along with some fibres float on the top of the pit. After a certain time of say 5-7 minutes, air gets released to atmosphere, and these flocks settle down due to gravity, thereby increasing consistency at the secondary centricleaner which goes to fan pump suction after cleaning, and thus head box consistency increases, and so the basis weight. As we may see, the flow through secondary centricleaner accounts for around 8% of dry stock flow through fan pump, and a variation of its consistency in the range 0.25%-0.5% may result in even upto 3-5 gsm variation in paper or even more also. This

behaviour is extremely chaotic in nature, and hence exact measurement of its frequency and magnitude is not possible. Eventhen, its existence could be proved by the elimination of frequent gsm fluctuations when the secondary centricleaner accept was diverted elsewhere from fan pump suction, as shown in Fig. 2.

Doing as above, it was found that the grammage variations reduced significantly. Use of smaller pit size can also be beneficial to reduce grammage variations.

Entrained Air

Entrained air generates due to high turbulence in the wire part, particularly near to head box, where the drainage is relatively fast, and consistency on the wire is low. The backwater containing more fines usually contains more air. This air passes through centricleaners, and particularly on slow speed ground floor machines, wherever the piping elevation is more than the head box level, accumulates in the pipeline. When the quantity of air is more than a hold limits, it escapes towards head box, and get removed, but simultaneously disturbing the flow pattern and cross direction profile. On most slow speed machines installation of deculator is not economically viable. The effect of entrained air is more severe at the cross direction location near to inlet of head box. On the paper machines where a tapered manifold is installed, the grammage fluctuation towards the stock entry is a clear indication of the same. In a typical such case, it was found that grammage unstability was significantly high where the stock entered the head box.

To solve this problem some air vents were provided in the approach piping, and it was found that the machine runnability improved significantly. The profile unstability was reduced, and cross direction profile variation reduced to 60% of earlier one.

CONCLUSION

As the above changes were incorporated in a particular plant, the gsm and profile unstability could be reduced significantly. With increase in gsm stability, machine runnability was also improved, and it was observed that web breaks due to grammage were reduced to even less than 10% of the original. It also made it possible to increase the machine speed by nearly 5%, without any other modification.

REFERENCES

1. Singhal, D.K., "Cross Direction Profile Unstability: Evaluation & Correction," IPPTA. 14 (1) 35, (2002).