Some Considerations In Designing Autolevelling System For Conventional Drawframes (Textile Machinery)

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Abstract:
Uniformity in the mass per unit length of sliver is of utmost importance to produce quality yarn. Conventional drawframes are used for the purpose using ‘doubling’ technique and hence the process has inherent incapability to correct long-term and periodic mass variation and limited capacity for short-term correction. Modern drawframes with autolevelling systems are therefore used for wider range of correction using servo-controlled drafting system. A drawframe autolevelling system can be designed as retrofit to conventional drawframe to improve its correction range; subsequently higher quality yarn can be produced with some additional investment. Presently no such system is available in the market, though engineers had made attempts. This paper discusses existing drawframes with autolevelling system, some design consideration of retrofit autolevelling system and proposes a kinematics of the mechanical drive for it.

Key words: slivers, mass variation, drawframe, doubling, draft, autolevelling, open-loop & closed-loop control, sensing rollers, retrofit.

Introduction: 1, 2
The textile spinning process comprises various sub-processes and accomplished in various sections. The lumped or compressed mass of fibers is opened in ‘blowroom’, converted in to sliver by ‘carding’, fibers are made unidirectional in combing, degree of mass variation per unit length of sliver is reduced in ‘drawing’, converted to roving by ‘speedframe’ and finally spun in to yarn by ‘ringframe’.

The drawing process is carried out in drawframes by ‘doubling’ number of slivers from different ‘cards’ or ‘combers’. Its major influence is to improve uniformity or regularity in weight per unit length over a considerable length of sliver. The evenness in output sliver is achieved by natural averaging or even out. Drawframe is a very important machine because it has major impact on the quality (evenness) of yarn and drawing is the final process of quality improvement in the spinning mill.
The conventional drawframe, which only use ‘doubling’, cannot correct long-term and periodic variations and also has limited capability for short-term correction. The uniformity of sliver can be further improved only by use of autolevelling system. There are many spinning mills in India and each has number of conventional drawframes. If a successful and cost effective autolevelling system is designed and manufactured to use as retrofit for conventional drawframes, the mills can produced superior quality of yarn.

**Drawframes with Autolevelling systems:**

Autolevelling system has sensing system, which measures mass variation of input or output sliver to the drawframe, and accordingly the servo-controlled drafting system corrects it by changing draft of the drafting system.

Early autolevelling systems were using ‘closed-loop’ control, i.e. measurement of sliver at the drawframe output with pneumatic sensor and regulation of the main draft at drawframe input. For the fixed delivery speed, the rotational speeds of the delivery side roller are kept fixed and varied for the other two pairs simultaneously by servomotor and differential as per correction required. The speed ratio between these rollers is fixed for constant break draft. The correction length depends on the distance between the measuring sensor and the point of regulation as well as actual draft. Therefore they were capable of ‘medium-term’ autolevelling only. Figure 1 shows schematics of such system.

Modern drawframe is equipped with autolevelling systems having ‘open-loop’ control. Here the mass variation in sliver is measured with spring loaded ‘tongue & grooved rollers’ before it enters in to drafting rollers and the correction made in main drafting zone. The delivery-
side drafting rollers assume fixed speed and the speeds of remaining rollers will vary according the correction draft required. This is done by planetary differential gearing system attached with main motor and a servomotor will control output speed of which. Figure 2 shows schematics for it.

![Figure 2 Drawframe with open loop controlled autolevelling system](image)

The incoming slivers are squeezed between sensing rollers such that the actual mass at that point can be sensed. The variation in mass will cause one of the rollers to move and as it is mounted on a bell-crank lever, it will oscillate about its fulcrum. At the other end of the lever a secondary electrical transducer, LVDT (Linear Variable Differential Transformer) is mounted, so the final output of sensing system is electrical and processed further with electronics and digital computer. The computer will generate command signal for the servomotor to vary its speed, which will in turn change the speed of drafting rollers to apply the correction. Correction length here mainly depends on the inertia of the measuring system and response of the servo-system. Such systems are capable of achieving 'short-term' autolevelling.

**Autolevelling system for retrofit:**

The quality of output sliver of a conventional drawframes can also be improved if an add-on autolevelling system can be fitted with it. The basic desired features of such retrofit may be as follows;

1. Easy to adapt for existing conventional drawframe with as less as possible additional space requirement.
2. Ease of operation along with main machine.
3. Long-term stability with easy and reproducible settings.
4. Wide range of control or correcting capacity in terms of irregularities.
5. High reliability and in worst case of malfunction of autolevelling system, drawframe should be able to run as 'normal' machine.
6. The cost and payback period for the retrofit.

Early attempts were made in Europe for retrofit using 'closed-loop' control system. A technique in which mass variation in all the input slivers are sensed but only about half of the total number of slivers to be corrected in an auxiliary-drafting zone. Figure 3 explains it schematically.

![Figure 3 Closed-loop controlled retrofit autolevelling system](image)

It can correct only 'long-term' mass variation; here the correction length is even longer than drawframe with 'closed-loop' controlled autolevelling system as the distance between the point of measurement and point of correction has further increased. Such systems were unsuccessful. Actually author has studied one non-working machine of this kind.

Using 'open-loop' control and with a different approach, a retrofit autolevelling system is proposed schematically as shown in the figure 4.
The first pair of drafting rollers of the auxiliary drafting zone will be driven by main drive (Use of the ‘creel’ drive shaft will be an excellent choice.) with only tension-draft between it and the last pairs of drafting rollers of main machine. The second pair will be driven by servomotor with appropriate speed reduction such that the nominal draft exists in the auxiliary drafting zone. Sensing and feed rollers will also have the same peripheral speed that of the second pair of drafting roller with very small difference to have tension-draft. The pair of bevel gear will drive sensing rollers, as their axis has to be perpendicular to sliver path or axis of rotation of other rollers and motor. Figure 5 shows pictorial view of possible kinematics of proposed retrofit autolevelling system.
The auxiliary drafting zone will accomplish autolevelling by changing speed of last drafting roller with the help of servo-motor directly as per the mass variation sensed by electro-mechanical sensing device (tongue – groove roller and secondary electrical transducer, LVDT).

**Designing system, modules and components:**

Following considerations were made for the selection and design and of components:

1. Only ‘timing belt-pulley systems are to be used to have flexible yet stiff and backlash free drive is required for good control. The pitch and the width of the timing belt decide the stiffness. Tooth profile, pitch of the belt and no. of teeth on the pulleys are standard, available in market hence width only can be decided.

2. The inertia of the rotating components such as sensing rollers, feed rollers, pulleys etc., should be as low as possible so that servomotor’s response is not hampered.

3. The natural frequency of oscillation of spring loaded sensing roller should be sufficient for good ‘amplitude’ response of the mechanical sensing. This will be decided by the inertia of moving roller (tongue) and the spring mass and the stiffness of the tension spring which in turn should be enough to apply desired load with ‘safe’ deflection.  

4. The load on the sensing rollers should be right enough that slivers not over squeezed so that individualization of fibers is spoiled and not under squeezed for wrong information on the mass variation is sensed.
5. The fluted metallic bottom rollers and top rollers with rubber cot are of standard size. The top rollers will be loaded on bottom rollers by compression spring.

6. The bevel gear pair has to be good in terms of backlash or some anti-backlash design idea will have to be applied.

7. A combination of open and cross belt drive is used for rotating sensing rollers in opposite direction.

8. A special trumpet has to be design, mainly on geometrical and manufacturing criteria to converge the slivers into sensing rollers.

9. The relative locations of the drive components can be decided on the basis of sliver path of the existing machine, distance required for converging the slivers in to sensing rollers without much friction on the sliver guides and standard lengths of timing belts.

10. The frame structure for mounting drive, electronics and computer and connecting it with main machine accurately and rigidly.


12. The loading mechanisms for top rollers and sensing rollers should be simple and can be operated with comfortable force.

**Conclusion and further scope of work:**

Drawframes with ‘open-loop’ controlled autoleveller system are running successfully worldwide; hence the idea of retrofit autolevelling system should work without any doubt.

To go for prototyping, following considerations has to be addressed:

1. Auxiliary draft zone converts two-zone drafting to three-zone drafting. Though there were drawframes with three-zone drafting, here the auxiliary or controlled-draft zone is the break draft zone; this should not result in deterioration of uniformity.

2. The sensing system should accurate information of sliver mass variation.

3. There should not be any ingress of error due to mechanical drive components.

4. Verification of estimated v/s actual capability of correction.

Above can be evaluated by designing prototype with a fixed drive system for auxiliary draft zone, minimum possible intermediate draft. Also optimum nominal draft for controlled-draft zone can be evaluated. Actually conventional drawframes has ‘double-delivery’ but for evaluation, only one delivery should be manufactured.

Measuring and testing on individual component or module for desired v/s actual parameters for estimating correction capacity of the system. These could be from dimension, geometry & inertia of moving parts, stiffness of belt & springs, response of servomotor, correctness of
the output information from sensing system etc. Each of this parameter is important for the desired performance of the machine.

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