BOND GRAPH MODELING OF CAN-SPRING MECHANISM USED FOR SLIVER STORAGE

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Abstract: *Helical compression springs are extensively used for the combed cotton sliver handling system in spinning preparatory sections in the textile industry. Storage can-spring stiffness decreases with time due to prolonged fatigue loading. It is found that the older storage can-spring of reduced spring stiffness deform non-uniformly during combed sliver deposition and withdrawal. In order to produce consistent quality of an intermediate delicate product like combed sliver, sliver stresses should be monitored meticulously at the time of sliver deposition and withdrawal from storage cans. Present work is an attempt to study the can-spring mechanism used for storage can through bond graph modeling technique. The present paper records the first stage of the work, which is concerned with establishing the relationship between spring stiffness and sliver tension. Bond graph modeling of the can-spring mechanism is one among best-suited technique to study present research problem due to its characteristic features.*

Keywords: *combed cotton sliver, can-spring stiffness, storage can-spring, bong graph*

1. Introduction

Helical compression springs are extensively used for the combed cotton sliver handling system in spinning preparatory sections in a textile industry. In order to produce consistent quality of an intermediate product like combed sliver, sliver stresses should be precisely monitor at the time of sliver deposition and withdrawal from storage cans [1-3]. Present work is an attempt to study the can-spring mechanism used for storage can through bond graph modeling technique. The present paper records the first stage of the work, which is concerned with establishing the relationship between spring stiffness and sliver tension. According to Mukherjee et al and Borutzky [4-5] bond graph modeling of can-spring mechanism is one among best suited technique to study present research problem due to its characteristic features in order to understand the dynamics involved in current problem.

Sliver can-springs are subjected to repeated reversals of loading over a prolonged period of time resulting in their degradation due to fatigue; consequently, with the passage of time, their stiffness's reduce. According to Singh et al [6], an older can-spring will deflect more in comparison to a newer can-spring made of the same material, against the same applied load. In case of low can-spring stiffness, there are chances of sliver stretching due to its own weight in the unsupported region as shown in Figure 1(a). Non-uniform deformation of a can-spring may influence sliver quality severely at the time of deposition and withdrawal of sliver on subsequent machine passages. According to Kothari et al [7] storage can-spring stiffness should be chosen meticulously for smoother sliver deposition and withdrawal. Higher sliver withdrawal speed at speed-frame machine will also contribute in improving combed sliver tension investigated by Miao et al [8].

Modeling the dynamics of the can-spring sliver deposition/withdrawal system is necessary to develop an understanding of the system and to study the effects of variation of can-spring stiffness, rate of deposition and withdrawal of sliver, etc. on quality of sliver and yarn. The variation of mass on the top plate due to deposition or withdrawal of sliver makes the task of developing the model quite challenging. In this paper, a bond graph model for the can-spring sliver deposition/withdrawal system is developed systematically from first principles. The model explains the transactions of power and understanding of cause-effect relationships between interacting sub-systems. The model facilitates the study of the effect of sliver can-spring stiffness and rate of sliver deposition or withdrawal on product quality through analysis and simulations.

2. Theoretical modeling of can-spring mechanism using bond graph technique

An attempt has been made to study the dynamics of can-spring mechanism used at finisher draw-frame stage for sliver storage. It has been presumed that the sliver deposited over the top plate has uniform linear density or fineness and the weight of sliver deposited per second over the top plate remains constant. For accurate prediction of can-spring mechanism real values of the independent variables based on industrial experience were considered for evaluation. Also, in depth study of sliver quality characteristics has been conducted while selecting sliver linear density, inter-fiber cohesion and lengthwise sliver uniformity.

The following nomenclature has been adopted.

M = Initial mass of top plate before sliver deposition takes place.

Δm = Increment in mass of deposited sliver on the top plate in the time duration Δt .

u = Velocity of the top plate at time *t*.

v = flow velocity of sliver at time *t*, before depositing on the top plate.

$q(t)$ =Deformation in can-spring due to applied load of deposited sliver.

The formulation of dynamics for the can-spring system yields to equation (1).

$$\frac{d}{dt}\left[\left(M+\int^{t}\dot{m}\cdot d\tau\right)\cdot u\right]=-\left[M+\int^{t}\dot{m}\cdot d\tau\right].g-F_K(q)-F_R(u)+\dot{m}v(t) \tag{1}$$

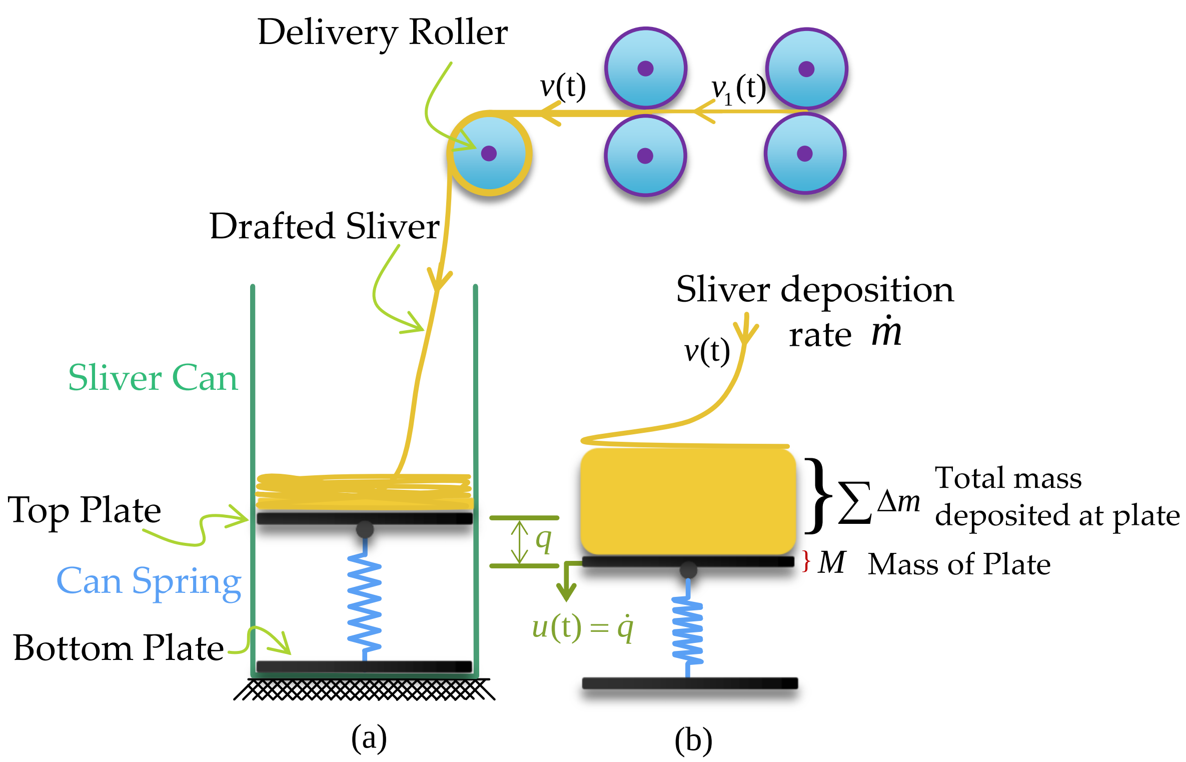

Figure1: (a) Sliver storage at draw-frame delivery, (b) Can-spring mechanisms at draw-frame

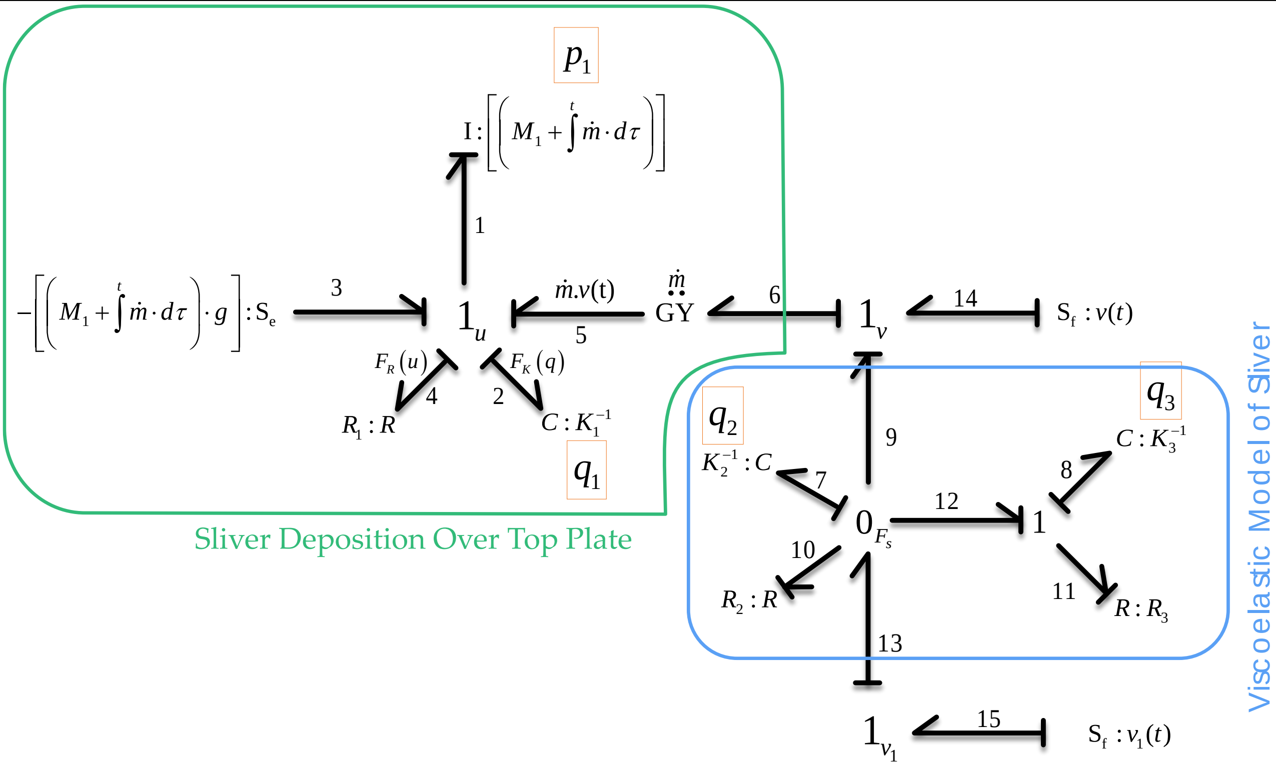

Figure 2: Bond-Graph model of sliver deposition at draw-frame delivery

2.1 Visco-elastic representation of sliver

For the purpose of modelling Kelvin-Voigt model, Maxwell model and Standard model has been studied initially. Based on the observations, with some modification in the most recent and widely accepted standard model has been used for further consideration as shown in figure 3.

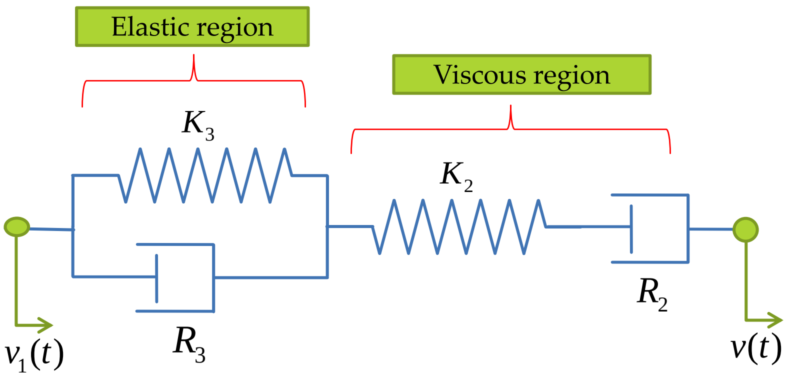

Figure 1: Representation of the visco-elastic behavior of sliver

3. Simulation Results

The linear momentum and displacement of the top plate build-up with time and direction is considered as negative due to energy build up in storage spring through compression as shown in figure 4. Similarly, it has been observed that after sudden initial impact of sliver on the top plate, velocity of top plate almost remains constant with a small decrease with passage of time. Also, the mass deposited over the top plate increases with time depending on the sliver deposition rate as shown in figure 4.

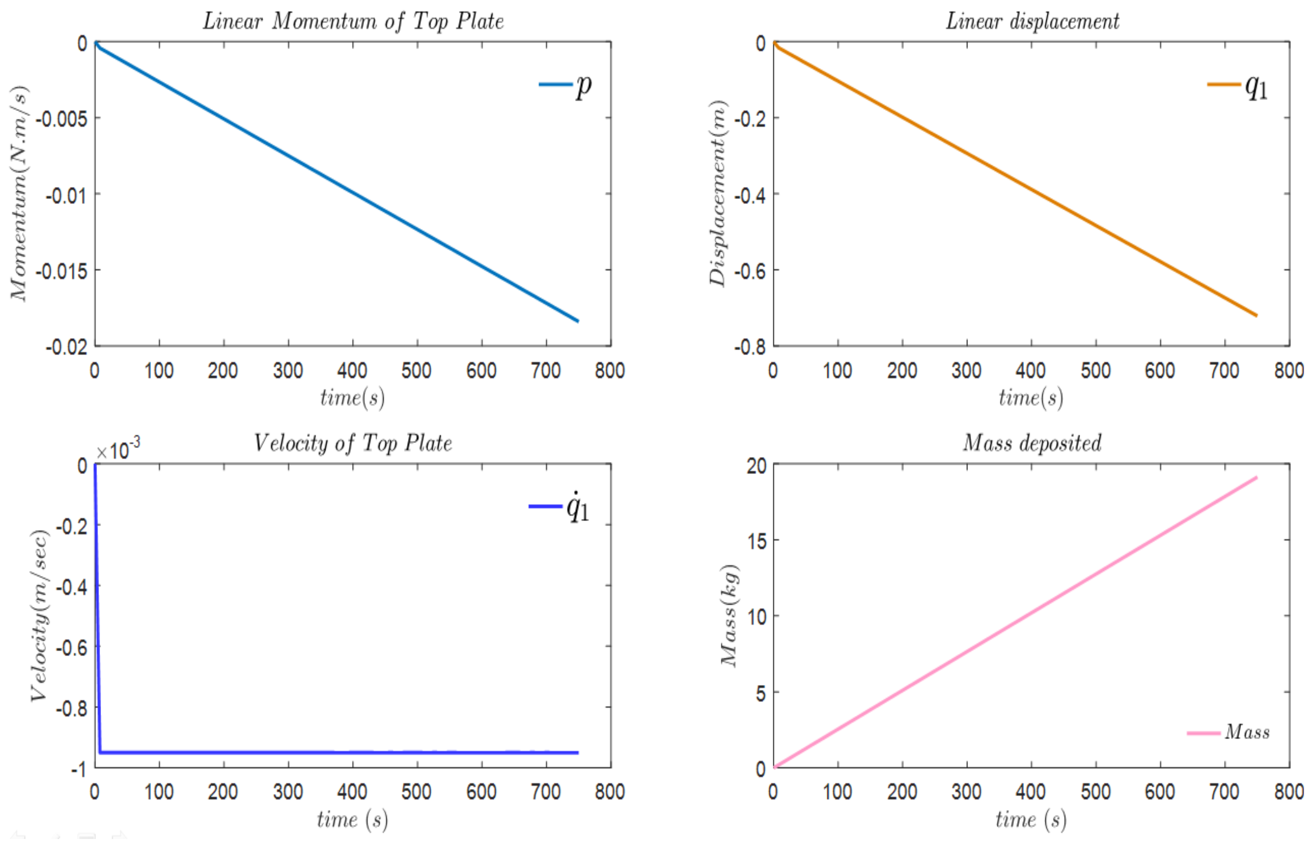

Figure 4: Linear momentum, displacement, velocity and mass deposited over top plate

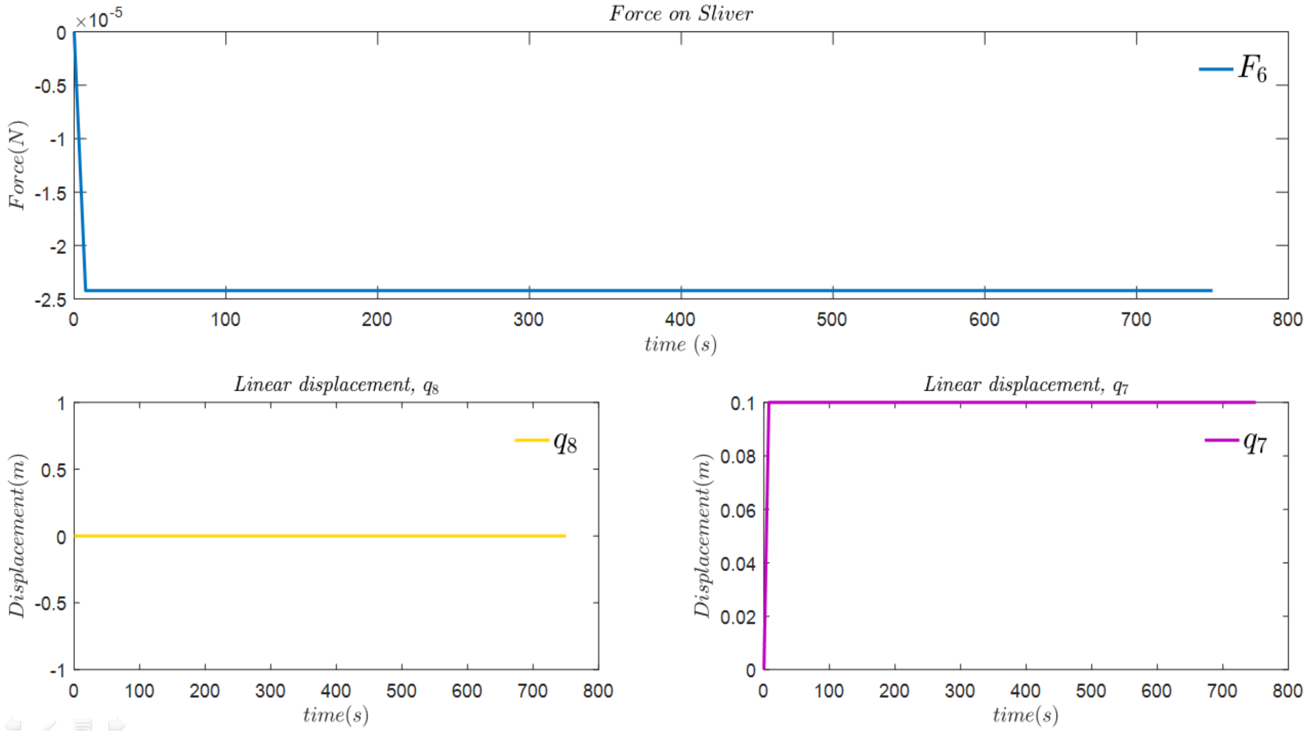

Figure 5: Force on sliver and responses linear displacement with time

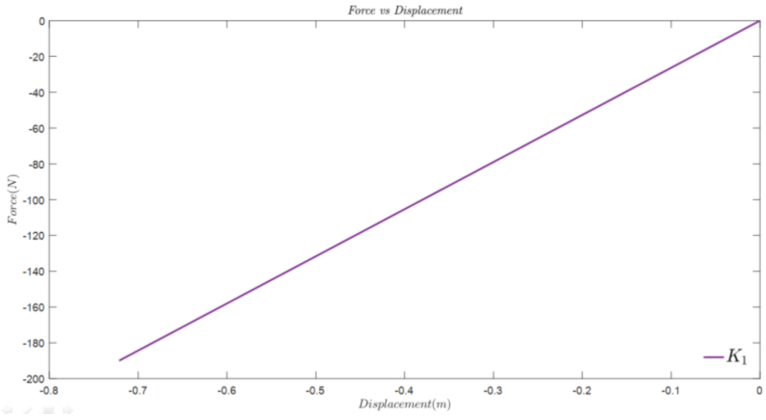

Figure 6: Force experienced by storage-spring versus displacement

Tension experienced by the sliver, in terms of force including gravitational force is too low as expected. This is due to sliver characteristics features and contribution of the role of sliver deposition rate over the top plate. The linear displacement of the responses q7 is almost remains unchanged with passage of time and the linear displacement of the responses q8 experience a sudden increase within a short span of time and after that remains constant as shown in figure 5. Also, the force experienced by the can-spring increase with increase in displacement as shown in figure 6.

4. Conclusion

In order to study the dynamics of can-spring mechanism, the bond graph modelling of the system has been studied. The simulation results have shown that the force experienced by the sliver is too low which in turn vindicating that a small undesirable deflection can deteriorate the sliver structure and can alter sliver configuration. It is found that the linear momentum of the top plate increase in negative direction with passage of time depending on sliver linear density and sliver deposition rate. However, more rigorous study is required to study the accurate dynamics of such precise systems because the force and the stresses experienced by the sliver are too low due to very low inter-fiber cohesion.

5. References

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