Design and Development of Flower Stringing Machine

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Abstract : India is well known for its cultural, traditions and influenced on crafts. Flower garlanding is one such skill that is developed over centuries. Flowers are used in every occasion and has its own demand in day in day out. Flower garlanding business depends on the supply and demand. There are lot of factors like flower delicacy, transportation, occupational ergonomics, influences the reduced productivity in flower stringing and results in lower profits. Hence there is a need of a low-cost Flower Stringing Machine, that can help a labor class family to sell more and earn more to afford today's costly life. In present work, instead of reinventing a new method or mechanism to string the flowers, exiting sewing machine is considered as bench mark and studied in detail to understand the multiple types of cloth stitches and respective machine mechanisms. The flower stringing machine is conceptualized based on the existing cloth sewing machine and added multiple kinematic mechanisms to drive the flower feeding and stringing. Current stringing machine needs operating skills like machine speed control, adjusting thread tension, needle and bobbin mounting. These factors are considered and designed the flower stringing machine components specifications and are derived using standard machine design calculations. Finally, the machine is fabricated and evaluated for its functionality and analyzed for quality of strung flowers, process time and compared against the current manual method of flower stringing.

IndexTerms - **Flower Stringing, Flower Garlanding, Flower knotting, Cloth Sewing Machine, Gear Transmission Mechanism**

INTRODUCTION

India, have a huge tradition in every festival, every religion idols, are decorated with garlands made from different fragrant flowers and non-fragrant flowers (often jasmine) and leaves. Both fragrant and non-fragrant flowers, religious plant / tree leaves are used to make garlands to worship religion deities. Some of those flowers are champaka, jasmine, lilies, ashoka, oleander, roses, hibiscus, manoranjini etc. These flowers not only sensitive, but also costlier. Stringing these flowers without damaging and make it sustain for a longer duration till it's get sold by a business man and serve the purpose under the different environmental conditions, creates a challenge to develop a machine that handles and ties flowers together [8]. Flowers are usually tied in several steps, as string is taken around two roses placed one 180 degrees away from the other with the string at the bottom going around the stems of the flowers and a loop being formed [6]. In similar manner a cloth sewing machine, is also involves similar feed mechanism that is the basic motion of needles, loopers and bobbins, to sew the materials. Feed dog makes the sewing product move per stitch, can change amount to move and forms stitches suitable for the sewing product and stretches stitching or gathering stitching can be performed by means of feed mechanism, and prevention of puckering, gathering, etc. can be performed [1].

Analyzing Sewing Machine

To ensure the quality of stitch, it is important to know:

- The interaction between the components of the sewing machine and the sewing thread
- The influence of the sewing machine parameters and the thread properties on thread tension.

To obtain understanding into the movements, velocities and accelerations of these two elements, they were modelled, and their movements simulated using the ADAMS software package.

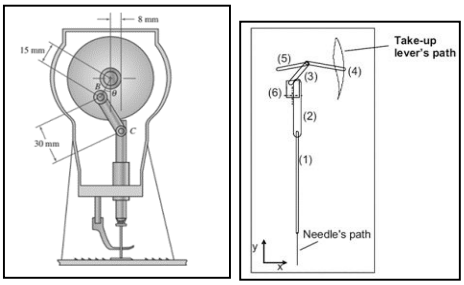

Fig 1: ADAMS modelling of sewing machine needle assembly [7]

The result of the modelling and simulation of a needle bar mechanism and the take up lever are as follows: When the needle moves, the initial displacement is 31 mm; its upper position is defined at 0° and its lower position at 180° of the sewing machine's main shaft turn. Common movement of the take up lever displacement is 58.14 mm. The upper position in the y direction is reached at 66° of the main shaft turn, and the lower position at 302°. The rotation angle is calculated using the time needed for one turn of the sewing machine's main shaft.

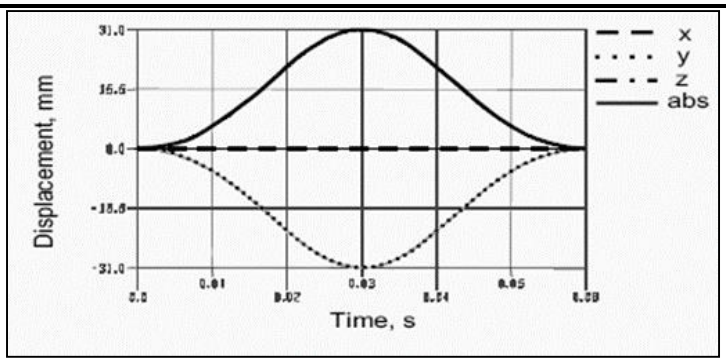

Fig 2: Needle movement

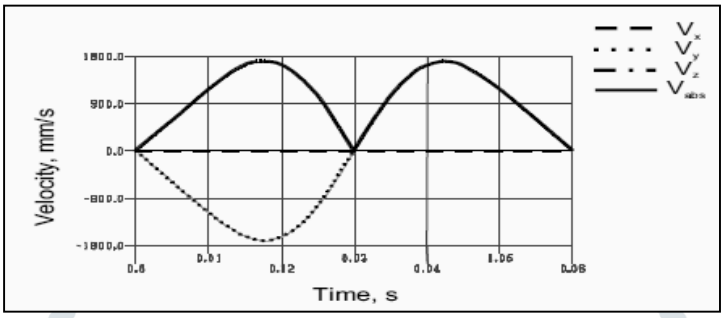

Fig 3: Needle velocity

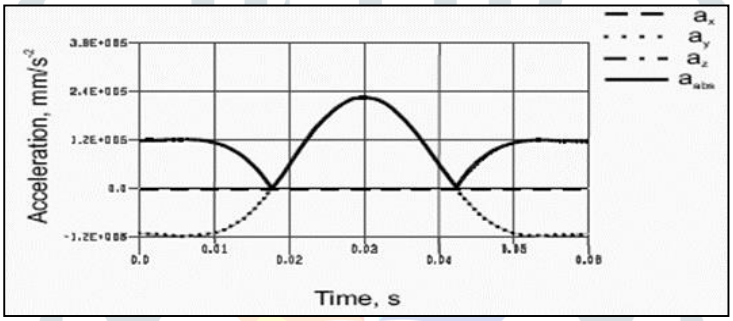

Fig 4: Needle acceleration

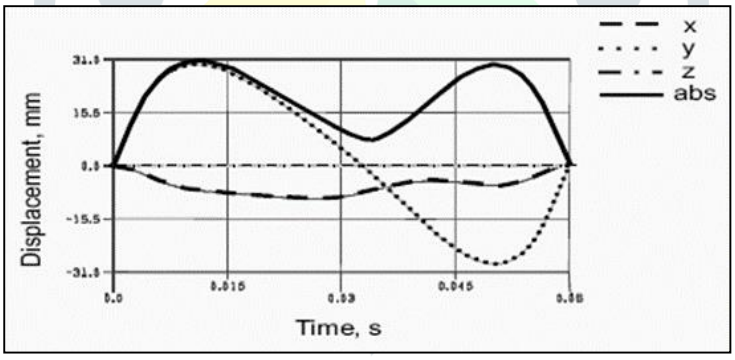

Fig 5: Take up lever eye movement

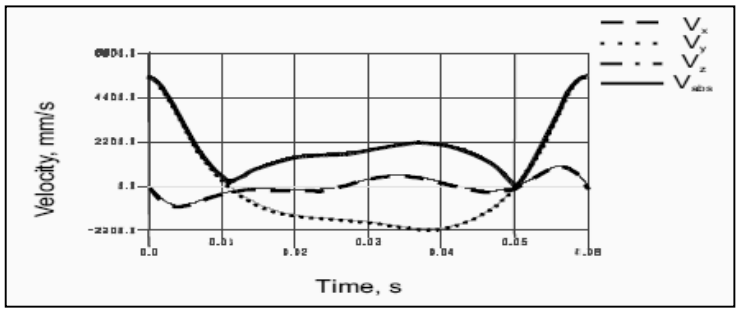

Fig 6: Take up lever eye velocity

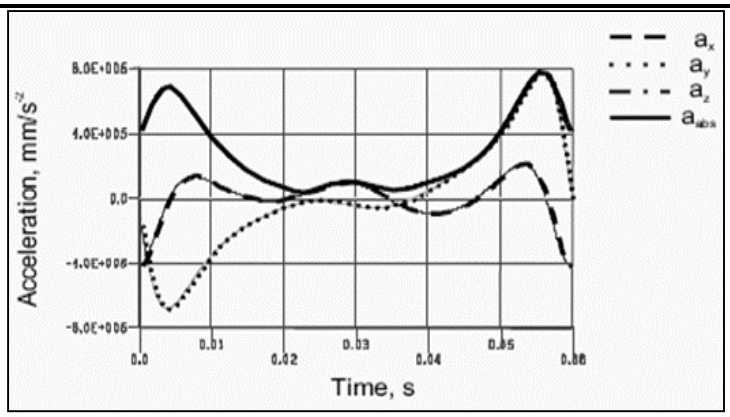

Fig 7: Take up lever eye acceleration

The results of needle eye movement depending on the sewing machine's main shaft turn at stitch velocity of 1000 rpm is presented in Figures 9 to 11. The results of the take up lever movement analyses are presented in Figures 12 to 14. In the diagrams the paths, velocities and accelerations in the x, y and z directions (the directions x, y and z are shown in Figure 8) are given for the points defined on the take up lever eye.

Sewing Machine Parameters

A detailed study of multiple types of cloth stitching and respective machines are analyzed and experimented to suit the need of flower stringing that does not damage the delicate flowers with a good quality of stringing. A Single Thread Chain Stitch is the type of stitch selected for the application of flower stringing.

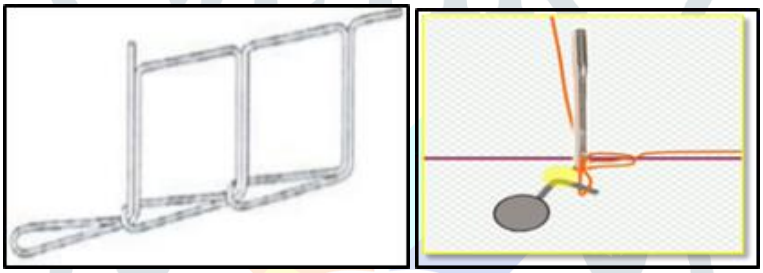

Fig 8: Single thread chain stitch [1]

Sewing machine needle moves up and down in simple harmonic motion with an amplitude of 30 mm and a frequency of 2.55 Hz [1].

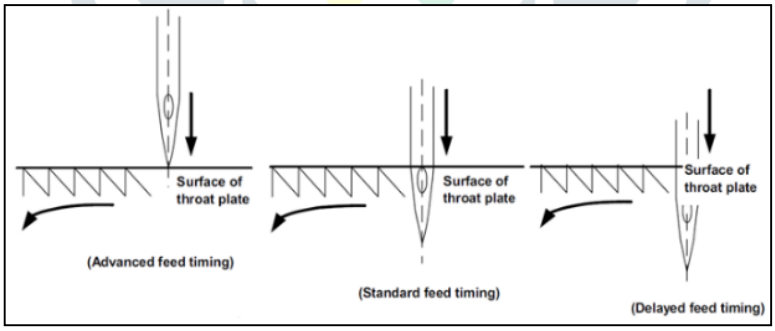

Fig 9: Feed Timing [1]

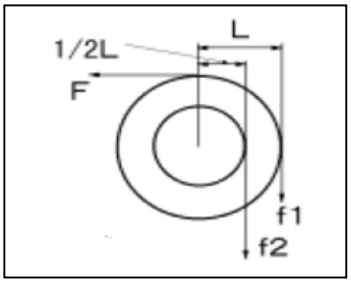

Fig 10: Bobbin thread length [1]

F = Force the bobbin thread comes out
f1, f2 = Force bobbin thread desires to stay there
L = Distance from the centre bobbin thread is fully wound
To get Thread tension of Jasmine flower stem without damage, Compression strength ≈1 N (100 g) [4]
Substitute F > f1 x L = f2 x 1/2 L F > f1 x L = f2 x 1/2 L, i.e. 100g > 50g > 12.5g [1]
As per sewing machine standard B3129-012-A00 table [3], 3-turns tightening position of tension nut should be set, so that flower stem is not damaged.

Design Concepts

Design concepts were modelled using Commercial software CREO. Conceptualization is based on adding different kinematic mechanisms to existing sewing machine to transmit the forces driven by a single DC motor.
Concept I, consists of sewing machine, and belt drive mechanism. Both are driven by a single motor. Drawback of this concept was, sewing machine and feeder belt drive speed could not able to be varied.

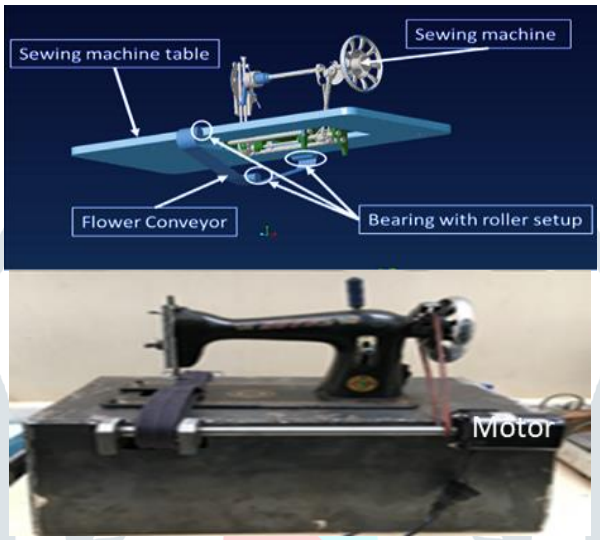

Fig 11: Concept I with flower conveyor

In Concept II, complete feed dog mechanism was re-modelled. Drawback of this model was redesigning existing sewing machine, which was not cost and time effective.

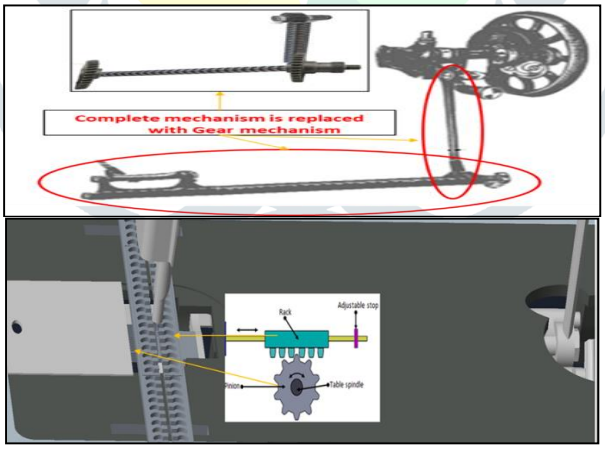

Fig 12: Concept II modified feed dog mechanism

Concept III, is a combination of concept I and II. The motor power is transmitted to sewing machine through chain drive and in turn the force is transmitted to feeder belt mechanism through gear bevel and spur mechanism.

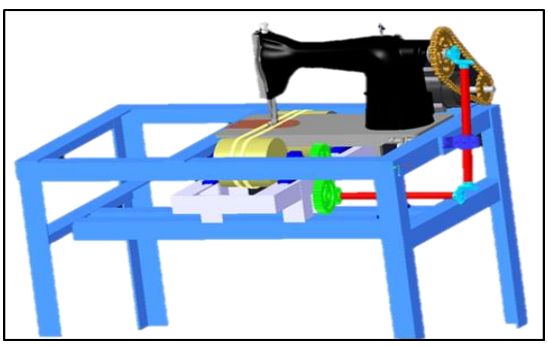

Fig 13: Design Concept III combination of gear and belt drive mechanisms

In Concept III, desired speed of sewing machine and feeder belt mechanism was achieved, using appropriate gear ratios.

Analytical Calculations

All the calculations are carried out based on Machine Design handbook [8].

Table 1. Design calculation data

CHAIN DRIVE		
Number of Teeth	N1	18
	N2	60
Pitch diameters	D1	72 mm
	D2	238 mm
Chain speed	ω	2262 rad/min
	Vc	270 mmpm
Actual centre distance	C	78 mm
BEVEL GEAR		
Pressure angle	ϕ	20^0
Input power	P	20 KW
Gear Material Strength	Sut	660 MPa
Gear module	m	4 mm
Bevel gears Angle	θ	90^0
SPUR GEAR		
Pressure angle	ϕ	20^0
Power required	P	2 kW
Pinion speed	np	1440 rpm
Speed ratio	i	0.5:1
Factor of safety	n	3
Gear Material Strength	Sut	410 MPa
Module	m	5 mm
SHAFT		
Bending moment	M	490 KN
Diameter	D	20 mm
Maximum Load	σ	2.500 GPa
JOURNAL BEARING		
Internal Diameter	d	25 mm
Pressure	P	0.017 MPa
	Pmax	0.04 MPa
Temperature	Tav	40C
	Ti	25C
Speed	N	36 rpm
BELT DRIVE		
AC electric motor power	P	2 kW
Motor rotational speed	n1	950 rpm
Output rotational speed	n2	36 rpm
Distance between axes of pulleys	A	480 mm
Transmission ratio factor	Ki	1.15
length of the belt	L	900 mm
Pulley Diameters	D1 = D2	60.47 mm
GEAR TRAIN		
Gear pitch diameters	D1	2.5 mm
	D2	15 mm
	D3	16 mm

Fabrication and Results

Fig 14: Flower Stringing Machine Fabrication

Fig 15: Strung Flowers

The objective was set to achieve, the stringing of flowers firmly without damaging. Figure 14 is the evidence for the strung flowers, holding firmly and without damaging. This was achieved by matching the needle speed with respect the feeding belt rotation. Compare to manual flower knot, sewing machine knots are very different and strong. This was controlled in the machine by handling the thread tension.

Time taken on flower stringing machine to string 0.5 meters of flowers is about 10-12 mins, whereas manual method takes about 20-25 mins. The machine is fast enough to save approximately 50% of the time and in-turn increases the productivity.

The quality of the strung flowers on machine were very cluttered compare to manual method, because of uncontrolled flower feeding time and not maintaining the space after each knot. Flower stringing machine consists of connected parts with the objective of transferring motion and force from a power source to an output i.e. flower feeder. Flowers are not locked and get misaligned due to vibrations created by the power transmission mechanisms. Different flowers will have different stem sizes. Current belt width is chosen only for Jasmine flower or equivalent stem size. Currently the thread / string pitch is locked to Jasmine / equivalent flowers sizes. To modify the same, one need to calculate and adjust the sewing machine parameters. To have a better quality of strung flowers, one need to program the speed of the machine to control the flower feed and the needle take up lever positions. As mentioned in sec 5.2, manual flower knot, sewing machine knots are very different, one can invent a new knotting mechanism dedicated to flower stringing, to ensure perfect garlanding.

CONCLUSION

To ensure a good quality of flower stringing, it is very much important to control the Interaction between sewing machine mechanisms, sewing thread, and the influence of sewing machine parameters to alter thread loading in the stitch formation. The designed machine has achieved the objectives set to string the flowers, with reduction of process time and increased efficiency, also lesser manual effort with reduced ergonomic problems, compare to existing hand knotting.

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