

ANALYSIS AND SYNTHESIS OF SHUTTLE  
PROPULSION AND RETARDATION

by

MRINAL KANTI TALUKIAR  
DEPARTMENT OF TEXTILE TECHNOLOGY

A Thesis

Submitted in fulfillment of the requirements of the  
degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

July, 1980

TO MY BELOVED PARENTS

ABSTRACT

Unconventional weaving machines - quite deservedly - are now being widely introduced in the developed countries but in India, these machines are not economically viable unless they are used for manufacturing high priced fabrics. Conventional slow speed looms (both automatic and non-automatic) are used in large numbers to cater the need of the country and clearly, it will be a long time, if ever, before these looms are entirely replaced. If the speeds of these looms are improved to some extent, it will be of large economic advantage to the Textile Industry of India. Since the propulsion and retardation are the major barriers in achieving higher loom speed, the object of this work was to develop a new mechanism, for propelling and retarding the shuttle, that would overcome the disadvantages of existing mechanisms and could be incorporated on the existing loom. A CIMMCO automatic loom having side lever underpick was chosen for this project.

Since there was a paucity of literature available on this type of loom, it was essential to analyse the existing mechanisms. The following parameters were measured by varying the loom speed, swell pressure, swell

ii)

spring stiffness etc. :

- i) ~~movement of shuttle inside~~ the shuttle-box during picking and checking;
- ii) strain on picking stick;
- iii) ~~transient response~~ of picker;
- iv) ~~displacement of swell~~;
- v) relative noise level; and
- vi) power consumption.

A simple inexpensive technique was developed to measure the movement of shuttle for a large number of picks in succession.

Results indicated about the ineffectiveness of the existing uncontrolled pivoted swell since the speed of the shuttle checked by the swell alone was only 11-19% and maximum retardation took place when the shuttle struck against the picker and this resulted in a high retardation value which increased with the increase in loom speed. The increase in swell pressure had proven to be useless because it acted almost perpendicular to the line of movement of shuttle.

A jump phenomenon, which caused unwanted vibration of the picking stick and picker, was observed. Impact between picking stick and buffer was found to be considerable.

A theoretical analysis was made for the displacement of swell and experiments were conducted to confirm the validity of the theory.

With the conventional system of checking almost all the kinetic energy of the shuttle as it entered the shuttle-box was wasted and this energy was spent in doing harm in the form of heat generation, wear and tear of the shuttle, picker and producing noise and vibration.

Keeping the drawbacks of the existing picking and checking mechanisms in mind, a new mechanism was developed in which movement of picker during propulsion and retardation would be controlled by a four bar plane mechanism connected in series with a four bar two revolute two spheric-pair (RGGR) mechanism and the dwells at the extreme two ends would be controlled by segment gears. The basic features of the new mechanism were to propel the shuttle and after propulsion, the picking stick was brought to rest without any impact against the buffer and was kept at its inward position. On the return journey the shuttle was checked by the picker which was moving in the same direction as that of approaching shuttle and when they met, the shuttle would be decelerated according to the type of motion by means of multi impacts. Experimental results conducted with the new mechanism showed that peak

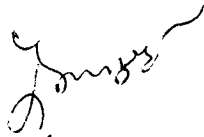
iv)

retardation value was considerably reduced and shuttle was brought to rest by multi impacts. The violent impact between picking stick and buffer was conspicuously absent and the power consumption was less.

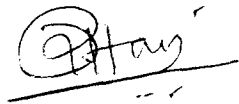
CERTIFICATE

This is to certify that the Thesis entitled "Analysis and Synthesis of Shuttle Propulsion and Retardation" being submitted by Mr. Mrinal Kanti Talukdar to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy in Textile Technology, is a record of bonafide research work carried out by him. He has worked under our supervision and has fulfilled the requirements for the submission of this Thesis, which has reached the requisite standard.

The results contained in this Thesis have not been submitted in part or in full, to any other University or Institute for the award of any degree or diploma.



(K.N. Gupta)  
Assistant Professor,  
Mechanical Engineering Department  
Indian Institute of Technology,  
Delhi.



(P.K. Hari)  
Assistant Professor,  
Textile Technology Deptt.  
Indian Instt. of Technology,  
Delhi.

ACKNOWLEDGEMENTS

The author wishes to express his profound gratitude to Dr. P.K. Hari of Textile Technology Department and Dr. K.N. Gupta of Mechanical Engineering Department for their keen interest, valuable guidance and sustained encouragement throughout the work.

He also wishes to thank Prof. V.B. Gupta, Head of Textile Technology Department for providing facilities to carry out this work.

He is indebted to Mr. S.K. Sud of Instrument Design Development Centre for his kind cooperation in completing this work.

Thanks are due to all the laboratory staff, particularly M/s K.N. Saxena and B.S. Chawla for their assistance during the course of work.

The financial support for the present work provided by the Ministry of Education, Government of India is gratefully acknowledged.

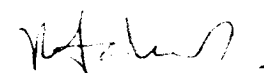
The author is thankful to the Principal, Victoria Jubilee Technical Institute, Bombay for sanctioning study leave.

The author appreciates co-operation rendered by M/s Sumanta Bhattacharya and Susil Kumar Saha.

He wishes to thank Mr. J.S. Bedi for the neat and accurate typing and Mr. K.G. Padam for tracing the figures.

Finally, the author offers his heartfelt thanks to his family members for patiently enduring certain unavoidable difficulties which resulted from his preoccupation with present work.

July, 1980



M.K. TALUKDAR

CONTENTS

	<u>Page</u>
ABSTRACT	i)
CERTIFICATE	v)
ACKNOWLEDGEMENTS	vi)
CONTENTS	viii)
LIST OF FIGURES	xii)
KEY TO SYMBOLS	xviii)
CHAPTER 1	GENERAL INTRODUCTION
	1
CHAPTER 2	REVIEW OF LITERATURE
	9
2.1	Introduction
	9
2.2	Review of Methods for Measuring Shuttle Movement
	9
2.3	Review of Methods of Propulsion and Retardation of Conventional Shuttle
	17
2.3.1	Propulsion
	18
2.3.2	Retardation
	26
2.4	Review of Previous Work on Propulsion and Retardation of Conventional Shuttle
	36
2.4.1	Propulsion
	36
2.4.2	Retardation
	47
2.5	Conclusion
	61
CHAPTER 3	EXPERIMENTAL WORK
	62
3.1	Introduction
	62
3.2	Loom particulars
	62
3.3	Variable parameters
	64
3.3.1	Swell pressure
	64
3.3.2	Position of shuttle at rest
	66
3.4	Evaluation of Performance of Loom
	67
3.5	Measurement Techniques and Instrumentation
	67
3.5.1	Movement of shuttle in the shuttle-box
	69
3.5.2	Strain in the picking stick
	75

3.5.3	Transient response of picker	78
3.5.4	Displacement of swell	85
3.5.5	Average power consumption	87
3.5.6	Relative noise level	87
3.5.7	Position of crank shaft	89
3.5.8	Determination of jumping action of picking plate	92
3.5.9	Determination of damping ratio	94
CHAPTER 4	ANALYSIS OF EXISTING MECHANISMS FOR SHUTTLE PROPULSION AND RETARDATION	96
4.1	Introduction	96
4.2	Movement of shuttle in the shuttle-box	101
4.2.1	General Discussion	101
4.2.2	Effect of loom speed	117
4.2.3	Effect of swell pressure and stiffness of swell spring	121
4.2.4	Effect of mass of swell	129
4.3	Strain on Picking Stick	133
4.3.1	General Discussion	133
4.3.2	Effect of loom speed	137
4.3.3	Effect of swell pressure and stiffness of swell spring	142
4.3.4	Effect of shuttle mass	143
4.4	Transient Response of Picker	143
4.4.1	General discussion	143
4.4.2	Effect of loom speed	161
4.4.3	Effect of swell pressure and stiffness of swell spring	164
4.4.4	Effect of shuttle mass	164
4.5	Displacement of swell	167
4.5.1	General discussion	167
4.5.2	Assumptions made for proposed theory	167
4.5.3	Theoretical model	169
4.5.4	Determination of damping ratio	176
4.5.5	Force acting on swell	178
4.5.6	Static displacement of swell	180
4.5.7	Dynamic displacement of swell	184
4.5.8	Actual displacement of swell	185
4.5.9	Results and Discussion	189
4.6	Power Consumption	199
4.6.1	General discussion	199
4.6.2	Effect of loom speed	200
4.6.3	Effect of swell pressure	204
4.6.4	Effect of mass of swell	204
4.6.5	Effect of nominal displacement of picker	206

4.7	Relative Noise Level	206
4.7.1	General discussion	206
4.7.2	Effect of loom speed	210
4.7.3	Effect of swell pressure	214
4.7.4	Effect of mass of shuttle	214
4.7.5	Effect of nominal displacement of picker	214
CHAPTER 5	SYNTHESIS OF PROPOSED PICKING AND CHECKING MECHANISM	215
5.1	Introduction	215
5.2	Principle of Working of Proposed Mechanism	216
5.3	Selection of Mechanism	217
5.4	Choice of Follower Motion During Propulsion and Retardation	219
5.4.1	Kinematic characteristic of different motion	219
5.5	Type and Number Synthesis	229
5.6	Dimensional Synthesis	231
5.6.1	Optimisation of Link Dimensions	233
5.7	Conclusion	247
✓ CHAPTER 6	KINEMATIC ANALYSIS OF PROPOSED MECHANISM	248
6.1	Introduction	248
6.2	Chace Solution to the Kinematic Analysis	248
6.2.1	Plane Mechanism	248
6.2.2	Spatial Mechanism	252
6.3	Computation	256
6.4	Results and Discussion	263
6.4.1	Impact between shuttle and picker during retardation	264
6.5	Conclusion	265
CHAPTER 7	EXPERIMENTAL STUDIES WITH NEW MECHANISM	266
7.1	Introduction	266
7.2	Description of New Mechanism	271
7.2.1	Linkage mechanism	271
7.2.2	Intermittent Gear	273
7.2.3	Stopping Mechanism	275

7.3	Analysis of Mechanical Error	276
7.4	Provision for Altering Shuttle Velocity	280
7.5	Results and Discussion	282
7.5.1	Movement of shuttle during Propulsion and Retardation	282
7.5.2	Bending of picking stick	286
7.5.3	Transient response of picker	289
7.5.4	Power consumption	290
7.5.5	Relative noise level	291
CHAPTER 8	SUMMARY AND CONCLUSION	294
8.1	Introduction	294
8.2	Summary and Conclusion	294
8.3	Suggestions for Future Work	301
REFERENCES		303
APPENDIX		307
LIST OF PUBLICATIONS		321
BIO-DATA		322