MODIFICATION OF SHUTTLE LOOM FOR PRODUCING THREE DIMENSIONAL SHAPED FABRICS

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SUMMARY

Fabrics woven on a loom are usually 2 dimensional (2D) which are converted in to 3D shape mostly by making-up (cutting & tailoring). Certain disadvantages are associated with making-up. Therefore, it is desirable if weaving machines are developed those can produce desired 3D shapes directly on loom. The aim of this work was to bring about modifications on a shuttle loom to produce seamless woven 3D shapes. Chapter 1 contains introduction of the entire work.

Beginning from limitations of making-up and reasons for need for a weaving machine to produce 3D shapes directly on loom, Chapter 2, describes the review of literature. Initial developments to produce desired 3D shapes took place on shuttle loom in which 3D shapes are woven in folded form by progressive elimination of ends which are cut subsequently. The main limitation of this method is need to cut eliminated ends subsequently and irregularity produced at the places where ends are eliminated.

Around 1990's developments began to develop rapier weaving machines those can produce desired seamless 3D shapes directly without elimination of ends and subsequent thread cutting. Abstract of various patent literatures regarding this as well as subsequent developments on shuttle loom for various possible practical applications on this base is the major content of literature review.

Chapter 3 contains stage wise details of the entire experimental work carried out for modification of shuttle loom to produce seamless 3D woven shapes. Total work progressed through several stages those

include developing a suitable technique to weave desired 3D shape on a hand loom that is adoptable on a shuttle loom, designing and fabricating modifications in shuttle loom one after the other, experiencing some hurdles and failures, finding solutions, critically observing several aspects of weaving 3D shapes etc.

Initial work was begun on handloom. Technique of weaving 3D shape in folded form by using reed with shaped dent wires, suitable selection of interlacement that assist in shape formation and retention by employing jacquard shedding, and a take up motion that can take up ends across the width at differential rate on successive picks, was found adoptable on shuttle loom. Mathematical tools were developed those can generate curves of shape of dent wires for hemispherical and pyramidal shapes on computer. Modifications necessary for weaving 3D shapes were identified. These modifications were designed, developed and fabricated stage wise and employed on shuttle loom one by one.

Firstly, a shuttle loom was procured. A warp feeding creel was designed and developed. Method of fabricating reeds with shaped dent wires was developed. A mechanical reed position control was developed and weaving was carried out with dobby shedding for initial trial. A special fell control mechanism with combs was designed, developed and fabricated and 3D shapes were woven. Several problems were noticed while weaving and attempts were made to find their solutions. Subsequently a programmable stepper motor drive with pulley and cord mechanism was designed and developed. Later stepper motor control through a computer was developed. Jacquard shedding was employed. Other developments were a fell control mechanism using spiked rollers across width, conical roller for shuttle flight control etc. 3D shapes were woven with this set up. Difficulties observed and limitations of the method were noticed. Thus Chapter 3 contains entire account of experimental work.

Chapter 4 deals with results and discussions of the experimental work. A pyramidal shape was first woven manually. Subsequently, pyramidal and hemispherical shapes were woven on handloom using shaped slotted fins. This method was not adoptable on a power loom but it enabled understanding of 3D woven shapes that inspired further work. It was found that in a 3D shape spacing of ends and picks change depending upon profile of 3D shape. Therefore, to produce a 3D shape, suitable arrangements should be provided to change spacing of ends and picks depending upon shape profile. It was also found that weaving a 3D shape in folded form would be more convenient from weaving point of view. Method of changing spacing of ends by using reed with shaped dent wires that is displaced vertically was evolved. End and pick spacing is also influenced by interlacement. Pyramidal and hemispherical shapes were woven on handloom using reed with shaped dent wires. Pyramidal shape woven with suitable interlacement that assists in shape formation gives better shape formation. Of course this necessitates jacquard shedding. Mathematical tools developed facilitated generation of curves of shapes of dent wires for pyramidal and hemispherical shapes using computer that helped in fabricating reed. Same technique was adopted on power loom. Conditions of weaving were quite different from that on a usual shuttle loom, like a reed with shaped curved dent wires with large height that is displaced vertically during weaving; needle bar instead of reed for shuttle guidance, warp supply from creel, changing width of fabric at cloth fell etc. Some elements were redesigned/ modified. Several difficulties were observed during weaving and suitable solutions were attempted. It was doubtful whether it would be possible to run across the shed or not under these unusual conditions of weaving. However it became possible to run shuttle across the shed and weave 3D shapes.

Following results and discussions, Chapter 5 contains conclusions. A 3D shape can be fundamentally produced by two ways. One is by shifting planes of cross over points and the other is by changing spacing of ends and picks depending upon shape profile. Method producing 3D shape by changing spacing of ends and picks is comparatively easier to adopt on a shuttle loom. End spacing can be changed by using reed with shaped dent wires. It is convenient to weave 3D shapes in folded form. However weaving 3D shape in folded form is suitable for symmetrical shapes only. Interlacement between ends and picks also influence their spacing. Pick spacing depend upon rate of take up. To change spacing of picks, ideally, each end should be taken up at different rate on successive picks depending upon shape profile. Therefore, to produce a desired 3D shape, firstly the profile of 3D shape must be analyzed and changes in spacing of ends and picks through out shaped region must be found. Reed with shaped dent wires, take up and interlacement between ends and picks must be managed in such a way that spacing of ends and picks is changed exactly as per shape profile and there by exact desired shape is produced. Thus principle of producing desired 3D shape is understood in principle. However there are difficulties in satisfying all these requirements in practice. For example, while determining curves of shapes of dent wires, width wise contraction has to be determined which is very difficult practically. It is difficult to exercise proper control on cloth formation as conditions of weaving are different. However, major modifications on shuttle loom consisting of reed with shaped dent wires and its mounting bracket, mechanisms for displacing reed vertically to change line of beat up, mechanism for controlling fabric at cloth fell, individual warp feeding from creel, developing weaves those would assist in shape development, conical roller for shuttle flight control etc. were brought about on loom successfully and 3D shapes were woven. However, mechanism that gives differential take up to individual ends on successive picks could not be developed. Therefore 3D shapes to exact desired dimensions could not be produced.

This work has been able to focus on fundamental requirements for producing desire 3D shape and has identified necessary modifications on shuttle loom for the same. Accordingly elements on loom are modified. However, there is a scope for further work, which is described in chapter 6.

Chapter 6 is followed by appendix which describes application of geometric transform for obtaining curve shapes of dent wires. Bibliography is contained at the end of the thesis.