

Chapter 1

INTRODUCTION

Back from the beginning of the 20th century, developments began to develop a weaving machine that can produce desired three dimensional (3D) shapes directly on loom as this becomes advantageous technically as well as economically. However earlier developments produced 3D shapes in which some warp threads would protrude out from shape which were to be cut subsequently. The objective of the present study is to bring about *modifications on shuttle loom to produce three dimensional shaped fabrics* which are *seamless* and without any threads protruding out from shaped region. This chapter contains introduction of the entire work.

Woven fabrics produced are mostly 2 dimensional (2D). In their actual application they are often required to be in a three dimensional (3D) shape. To obtain 3D shape from a 2D woven fabric, most usual method is cutting 2D woven fabric in several specific shapes and then tailoring them together, called making-up. This method is very flexible in creating shape, allows combination of different materials and product change but has draw backs of high manual labour requirement, presence of seams at the joints which causes irregularities in the structure, possibility of occurrence of quality deficiency of visual and technical nature, lack of reproducibility, difficulty in producing certain shapes, wastage of material while cutting etc (01).

Automation of making-up is an option that can reduce labour cost and improve reproducibility of shape. However seam related problems can not be eliminated.

To overcome drawbacks associated with making-up, possible solutions can be thermal moulding of 2D woven fabrics or developing a weaving machine that can produce desired 3D shape directly on loom without any need for making-up. Thermal moulding is not versatile and is applicable to certain materials only. Therefore development of a weaving machine that can produce desired woven 3D shapes directly on loom is a better option.

Back in the beginning of 20th century, desired 3D shapes were woven in folded form on shuttle loom. In this method, weaving begins on double cloth principle in tubular form. Using jacquard shedding, certain warp threads are eliminated gradually from weaving by stopping their lifting. This elimination generally propagates from either ends towards centre following a particular curve. Thus effective tube diameter keeps on changing. On unfolding this woven structure, 3D shape is generated. Several prototypes on this principle were developed. However main drawback of this method is this that it becomes necessary to cut the ends at the periphery which are eliminated. Also this method is suitable only for shuttle weaving.

It is worth mentioning that most of the efforts for weaving 3D shapes directly on loom were for catering need of technical applications rather than for apparels.

At the beginning of the 1990s development of a rapier weaving machine began at the Aachen University in Germany to produce 3D hollow shells (01). This development was distinct from earlier works in the sense that 3D hollow shells were to be woven without seams and without the need for thread cutting. This technique of producing seamless 3D shapes is known as “Shape Weaving”.

The system since then has been under constant development. Various applications of 3D woven shapes developed are in aeronautical engineering, automotive engineering, apparel industry etc. A free form fabric, e.g. a motor cycle seat is also produced. For composite manufacture a finished 3D woven perform can be produced within a matter of minutes and is exactly reproducible. It would be worth mentioning that rapier loom developed for shape weaving is quite complex in operation as well as expensive.

In the present study suitable *modifications were to be made on a shuttle loom to produce desired seamless three dimensional shapes without any need for thread cutting*. Development began from weaving a 3D hemisphere manually. After passing through several stages of development, ultimately stage of weaving 3D shape on a power loom could be reached.

After producing a hemispherical shape manually, various techniques were attempted on hand loom to produce desired 3D shape. Technique of weaving 3D shapes using shaped slotted fins could produce hemispherical and pyramidal shapes of smaller dimensions. This technique was not adoptable on power loom but it gave fundamental understanding of 3D woven shapes.

Analysis of these 3D shapes revealed the principle changes required for producing 3D shapes. One possible method is of shifting planes of cross over points according to shape profile. Other possible method is providing arrangements on loom those can change spacing of ends and picks as per 3D profile of shape.

Method of producing 3D shape by changing spacing of ends and picks and weaving 3D shapes in folded form, was found suitable. End spacing is influenced mainly by space between successive dent wires of reed and interlacement. Pick spacing is mainly influenced by rate of take up and interlacement. Weaving process should be modified in such a way that spacing of ends and picks is changed according to profile of 3D shape.

Principle of changing spacing of ends by using shaped dent wires was developed. Shapes of curves of dent wires depend upon shape profile. Mathematical tools were developed for finding curve shapes of dent wires for pyramidal and hemispherical shapes of desired dimensions. Reeds with shaped dent wires were fabricated. This reed is to be displaced vertically to change line of beat up to change spacing ends. Pyramidal and hemispherical shapes were woven on handloom. Suitable manipulation of weave assists in shape generation. Shape produced with assistance gave better results. Of course this requires jacquard shedding, so that interlacement order of threads can be individually selected for assistance in shape generation.

After weaving 3D shapes on hand loom, modifications necessary to weave the same on power loom were identified. A power loom was

procured. As length of individual ends in 3D shape is different from one another, a warp feeding creel was designed and developed. Suitable method was developed for reed fabrication. Initially a mechanical reed position control mechanism was developed and later a programmable stepper motor drive with pulley and cord mechanism to drive the reed was developed to change reed position vertically. Mechanisms for controlling fabric at cloth fell, guiding shuttle, jacquard shedding etc., which are necessary because of different conditions of weaving of 3D shapes, were designed and developed.

Weaving of 3D shapes was begun. Most of the conditions, identified for producing 3D shapes during weaving on hand loom, were satisfied. One of the requirements is providing a mechanism that can take up individual ends with differential rate of take up across width and on successive picks to change spacing of picks. The principle of this mechanism is understood in principle but could not be developed. Therefore exact desired shapes could not be produced.