

**Tube-to-wear – A shaped garment template for 2-bed flat machines  
achieved by jacquard knitting**

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Keywords: Jacquard knitting, shaping, whole garment, sew free

**Backgrounds and objective**

Knitting describes “*the technique of constructing textile structures by forming a continuous length of yarn into columns of vertically intermeshed loops*” (Spencer, 2001, p. 7). Hand knitting originated in ancient Egypt in the 5th century AD (Ross, 2017). In 1589, William Lee of Calverton invented the first mechanical knitting machine, the stocking hand frame, which laid the foundations for today’s weft and warp knitting machines (Spencer, 2001). Over the years, with the development of manufacturing skills, knitting machines have evolved to be finer, more precise, easier to use, and more versatile. In today’s weft knitting industry, a machine can be classified as a straight bar, flat, or circular type based on its frame design and needle bed arrangements. The flat machine allows the movement of loops between needles and beds, making it possible to knit shaped pieces. Therefore, the flat machine is the largest class of weft knitting machine in today’s market, and the v-bed machine is the most widely used flat machine type (Spencer, 2001). Invented by Pastor Isaac W. Lamb in the 1860s (Lamb Knittime Machine Corporation, 2023), the v-bed knitting machine got its name from the diagonally-approaching needle beds, usually set at an angle between 90 and 104 degrees. Modern v-bed knitting machines are equipped with electronics to control needle, yarn, and carrier movements.

A typical v-bed knitting machine has two beds and is used primarily to produce shaped sweater pieces, collars, rib trims, etc. Manual seaming is usually required to produce garment products. Unlike sewing woven or cut knitted fabrics, sewing integrally knitted pieces requires links-links machines that chain loops together to produce narrow, flat seams. Not only does the gauge of the links-links machine have to match the gauge of the knitting machines, but the linking process also requires a skilled operator, increasing the cost of production. Shima Seiki introduced a seamless knitting solution in 1995 by doubling the number of knitting beds from two to four to allow multiple pieces to be knitted and connected on the same machine (Shima Seiki MFG., 2023; Spencer, 2001). Seamless or whole-garment knitting advantages include higher productivity and less labor cost (Choi & Powell, 2007). However, it also increases the capital investment and makes it more complex to maintain the machines. An alternative seamless solution is to use half-gauge knitting on a 2-bed machine. However, it sacrifices the loop density of the knitted products.

Seamless v-bed knitting has been growing worldwide (Choi & Powell, 2007). Unlike manufacturers’ efforts on technological innovations in developing seamless machines, the project aims to achieve the goal from the design perspective. The objective of this project is to design a template that serves as a design solution for a 2-bed flat knitting machine to knit a shaped garment on full gauge needles. The solution should not be limited to a specific product type. It should contain enough room for style, size, silhouette, and aesthetic design flexibility.

### Technical inspiration and execution

The four basic elements of fashion design are shape/silhouette, line, color, and texture (Gbetodeme et al., 2016). One way of controlling color in knitting is to supply different colored yarn on different loops. Horizontal striping, intarsia, plating, and jacquard stitch selection are the four techniques that may be used to produce designs in colored stitches, and jacquard is the most versatile method for design variations (Spencer, 2001). The type of jacquard knitting is based on how the idle yarns (yarns in colors not showing on the front) are hidden on the back. The two-color rib jacquard (also called double jersey and tubular jacquard) caught the author's attention because (1) the two-color combination balances the front and back structures and



Figure 1 Tubular Shape Sample

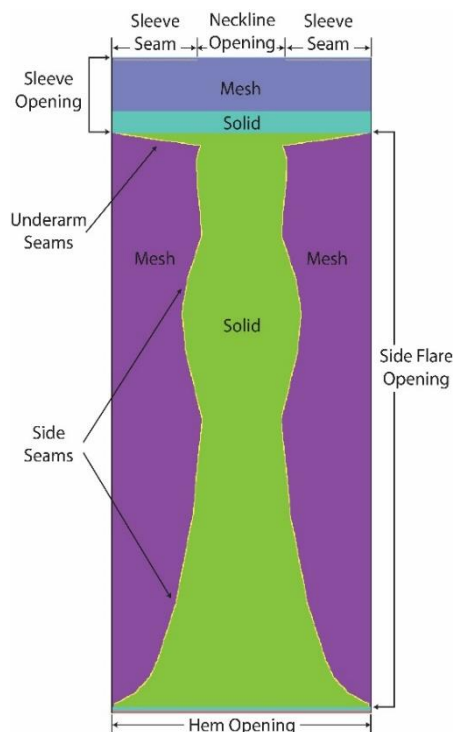


Figure 2 Design's Knit Pattern

makes the backside the reversed look of the front view, and (2) the front and back layer intertwined with each other only when color changes, making it possible to implement seams into the color pattern. Aside from the advantages of 2-color jacquard, there are also limitations of the structure that need to be considered when knitting in full gauge, including (1) only jersey stitches can be used when knitting both front and back layers; (2) transfer stitches can only be used on the edge of the design with carefully arrangement of needle and loop movement; (3) unless float jacquard is added, color changes will connect front and back layers and therefore, cannot be assigned to the region in the body areas where two separate layers are required. Another important feature to achieve is to allow the template to at least open at hem, neckline, and sleeve locations.

Considering all the features of using jacquard to achieve the goal of shaped knitting on 2-bed flat machines, a tubular pattern is used as the base of the design. A sample of the knitted shape is given in Figure 1, where the tube is knitted with jersey stitches all around, and the top of the tube is bound off, requiring no additional sewing to finish. The jersey stitches resulted in curls on the top and bottom of the edges, which cannot be avoided. The sleeve opening can be achieved by arranging the jacquard color patterns to be disconnected on the side edges. The finalized garment pattern is given in Figure 2, where the underarm and side seams are formed with the color changes of the jacquard design. The various fabric formats, labeled as mesh and solid, were achieved by plating and yarn selection for different regions. The garment was knitted on a 14G Shima Seiki SSR-112 machine.

### Aesthetical inspiration and execution

Aligning with the template's theme of being flexible, the garment's aesthetic is inspired by jellyfish for its spirit of beauty, being in the flow, regeneration, and immortality. As illustrated in the sample images on the next page, lightweight grey polyester yarn was used on the side and neck for flares to represent being in the flow. Medium-weight silk green yarns are used in the body part to provide light reflection with tailored side seams for the beauty of feminism. The natural curly of the fabric became part of the design to show a three-dimensional texture effect and represent the determination and strength of modern females. The same color yarns were used on both the front and back sides to make the look consistent.

### Conclusion

In summary, this project designed a template of a full garment that can be knitted on a 2-bed flat knitting machine by creatively using a jacquard design on a tubular shape. The template allows size, silhouette, and color variations and can become a new classic style. A dress inspired by jellyfish is presented to show the capability of the template.

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