

# Development of indigenous design and fabrication of manually operated sock knitting machine

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**Abstract:** Currently Africa has a great plan to produce and export textile products to improve regional economy and foreign exchange rate. To carry out this plan cotton cultivation expansion and establishment of textile mills is drastically changing from time to time in Africa especially in Ethiopia. However, the owners of the cotton processing mills are the well-to-do families. This is unachievable for the rest of the people. Importing machineries is beyond the economy of low-income people. Currently, for example the simplest to latest circular sock knitting machine costs from 60 thousand to 1 million Ethiopian birr. In this paper low cost manually operated sock knitting machine was designed and fabricated in Ethiopia. Except needles all parts were designed and fabricated in Ethiopia. The machine can produce one pair of socks in twenty minutes. The machine costs about 22,000 Ethiopian birr. A machine can return on its investment within five to eight months. Socks are some of the largely consumable textile products that many people can invest on it. The local people can easily use cotton yarn to process it. It is therefore, very useful to invest on the newly developed machine. This is the right investment for lower economy people.

**Keywords:** sock, circular knitting machine, cylinder, cam shell, bevel-gear

## 1. INTRODUCTION

All over the world, the majority of knitted fabrics are manufactured on circular knitting machines. The high performance level of these machines, the different materials and the range of yarn counts that they are able to process; the wide variety of designs and stitches are some of the reasons which have granted circular machines the market leadership in the knitting sector (Spencer, 2001; Ajgaonkar, 1998; Ajgaonkar, 1998; Carmine & Paola, 2002; Chandrasekhar et al., 1995). The variety of knit fabrics that can be manufactured with these machines can meet

the needs of a very large end user market; from the traditional outdoor and underwear sectors to hosiery, household and car interiors, without forgetting technical textile applications (Spencer, 2001; Aldrich, 1992; Roy, 1993).

During the 1870s, the patents granted to Henry Griswold virtually perfected the hand-powered sock machine (Spencer, 2001). This world-famous small-diameter latch needle machine has a single rotating cam-system (and yarn feed) that can be oscillated (reciprocated) for heel and toe pouch knitting, and an attachable dial needle holder for knitting the integral rib

tops at the start of the sock (Spencer, 2001; Kerms, 1992).

Mechanically-controlled double-cylinder machines of the Bentley Komet type used to dominate the manufacture of socks but, with the encroachment of microprocessor controls, the simpler and cheaper single-cylinder machines now account for two thirds of new machinery sales (Spencer, 2001). Bogan Harmony Auto Knitter, American Family Knitting Machine, Bickford Family Knitting Machine and Ainslie Auto Knitter Knitting Machine are some of the most commonly used manually operated sock knitting machine. The cost of these machines is elevated due to many reasons. Cost of the metal modification, salary of the workers in the metal workshops, retailers benefit and the reduction in demand of production of manually operated machine as high-performance automatic machines are produced in western countries.

In this paper low cost manually operated sock knitting machine was designed and fabricated in Ethiopia. Except needles all parts were designed and fabricated in Ethiopia. The machine can produce one pair of socks in twenty minutes. The machine costs about 22,000 Ethiopian birr. A machine can return on its investment within five to eight months. Socks are some of the largely consumable textile products that many people can invest on it. The local people can easily use cotton yarn to process it. It is therefore, very useful to invest on the newly developed machine. This is the right investment for lower economy people.

## **2. MATERIAL AND METHODS**

### **2.1. Materials selections**

All parts of manually operated circular sock knitting machines were made of medium grade iron. However, bronze can also be used for fabrication of the machine.

### **2.2. Computer Aided Design and preparation of engineering drawings Selection of needles**

The needle selection is made based on type of socks to be produced. Most of the places in Ethiopia are hot, and does not need to use too heavy socks. Therefore; for most common use E-8.5-gauge needle type is selected and dimension requirements were set as given in Table 1.

The cylinder is made of medium grade iron. The cylinder height is found from cam slot height, bellow slot of the cam shell, butt to needle hook height and the needle excess out. While cam slot height is the sum of butt height, setting height, and needle reciprocating height.

### **2.3. Bolt holes**

Two bolt holes at the opposite ends of the cross-section edge of the cylinder, on the same diameter. Hole to hole distance = 98.6mm and hole diameter of 3mm, with appropriate bolt. The bolt hole needs to have a stainless steel insertion to increase life of the cylinder.

**Table 1 Dimension requirements for needle selection**

Requirements for needle design	Dimension
The needle thickness	1mm
Slot depth	4mm
E gauge	8.5
Slot width	1.5mm
Teeth width	1.5mm
Total mm/needle	3mm
Slot height	100mm
Working height	30mm
Needle excess out on cylinder during knitting time	24mm
The reciprocating height of the needle for 6mm loop length	27mm

**Table 2 The relation between sock size and needles**

Sock size	Number of needles on the cylinder
Heavy socks	60 and bellow
Medium socks	60 to 100
Finer socks	More than 100

Finer socks, for fixed diameter of the cylinder 4.75 inch, the number of needles can be greater than or equal to 100, as the standard given in table 2. For 115 needles

cylinder 8.5 E gauge needles are used. For the 110mm diameter cylinder, Fig. 1, if  $N = 115$  needles then the English gauge,  $E = 8.5$ . The number of needles means the number of cylinder slots. Therefore, the cylinder has 115 external slots.

The slot size is defined based on the needle type and slot size varies below the spring slot and above the spring slot. The slot size for 24-gauge needle type is as follows;

a. Below the spring slot

Slot size 2mm x 4mm x 67mm

Tooth size 1.14mm x 4mm x 67mm

b. Above the spring slot (for placing the needle in to the slot)

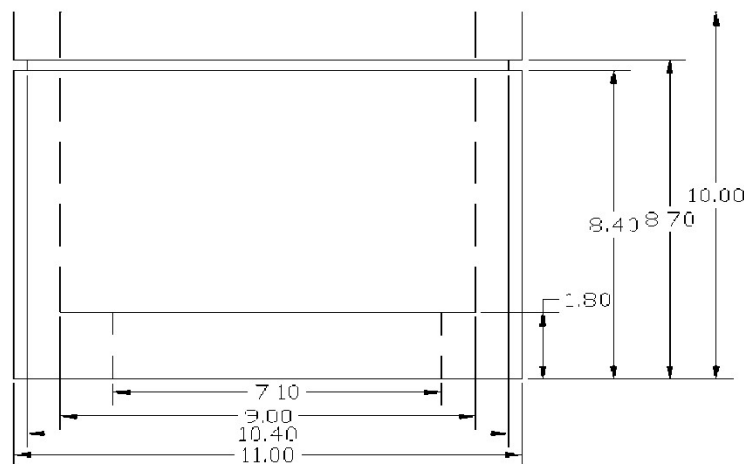
Slot size 2.5mm x 4mm x 33mm

Tooth size 0.64mm x 4mm x 33mm

### 3. RESULTS AND DISCUSSIONS

#### 3.1. Cylinder

The cylinder is made of medium grade iron. The cylinder height is found from cam slot

**Figure 1 cylinder design**

### 3.2. Cam shell

The external diameter of the cam shell is 136mm, internal diameter of 110.5mm and total height of 78mm as shown in table 3. Within the cam shell the cylinder is inserted where the cylinder is fixed and the cam shell is rotating around. The camshell has a triangular curved bore where cam is fixed. The cam is used to raise and lower the needle to knit yarn. Camshell has a circumferential groove on the inside diameter almost at mid position of the camshell height. It also has a cut on one side at the middle of which is cam bearing fixed bullet. Cam shell provides various functions during knitting process. The camshell rotates while the cylinder is fixed at a position. The butts of needles placed in the cylinder slots are supported by the camshell groove while the fixed bullet holds the knitting cam. The up and down movement of the needle is made by angular knitting cam.

Table 3 Dimensions of cam shell

Dimensions of Cam shell	Dimension length, mm
Inside diameter	110.5
Bore diameter	122
Outside diameter	136
Cam shell height	78
Needle step height	53
Cam bore height	15
Cam bore width	108

### 3.3. Bevel gears

Bevel gears are used when it is necessary to transmit power from one shaft to another where the communication shaft is located at an angle, with their axial lines

intersecting. Bevel gears are not restricted to shafts at right angles. There are right angle bevel gears and angular bevel gears. In cases where the ration of a pair of bevel gears is 1:1, both gears being the same size and having the same number of teeth, they are known as miter gears, shown in equation, 1, 2 and 3. These gears permit the driving of one shaft at right angles to the other. In a bevel gear the teeth are cut on a conical cone. A pair of gears is used to transmit power from one shaft to another, and share the two shafts have their extended axial lines intersecting at some angle other than 90°. The gears are called angular bevel gears. Based on the calculation of bevel gear parameters, the number of gear, equation 1 and 2, shaft angle, equation 3 and 4 were calculated. The number of teeth on both the gears is equal, equation 5, as per the principle of miter gears.

$$Z_{v1} = \frac{2\pi_{b1}}{P} = \frac{Z_1}{\cos \gamma_1} \quad (1)$$

$$Z_{v2} = \frac{2\pi_{b2}}{P} = \frac{Z_2}{\cos \gamma_2} \quad (2)$$

Where

$Z_{v2}$  Virtual number of teeth

$R_b$  Back cone radius

$P$  Circular pitch of the bevel gear

$Z_1$  Number of teeth on the pinion

$Z_2$  Number of teeth on the gear

$\gamma_1$  Pitch cone angle of pinion

$\gamma_2$  Pitch cone angle of teeth

### 3.4. The base

The base carries the cylinder, the camshell, gear ring and yarn mast. On one side of the base, flattened surface helps the crank shaft to fit the gear ring. The base carries all these loads including the cranking force during knitting. On the base of the machine the cylinder, cam shell and the pinion gear are fixed on the steps formed, as shown in fig. 2. The rotating gear is fixed 90 degrees to the horizontal pinion so that

they mesh and rotate as operated by handle on the initiating gear. Four stands are welded together with the base to make better operation position.

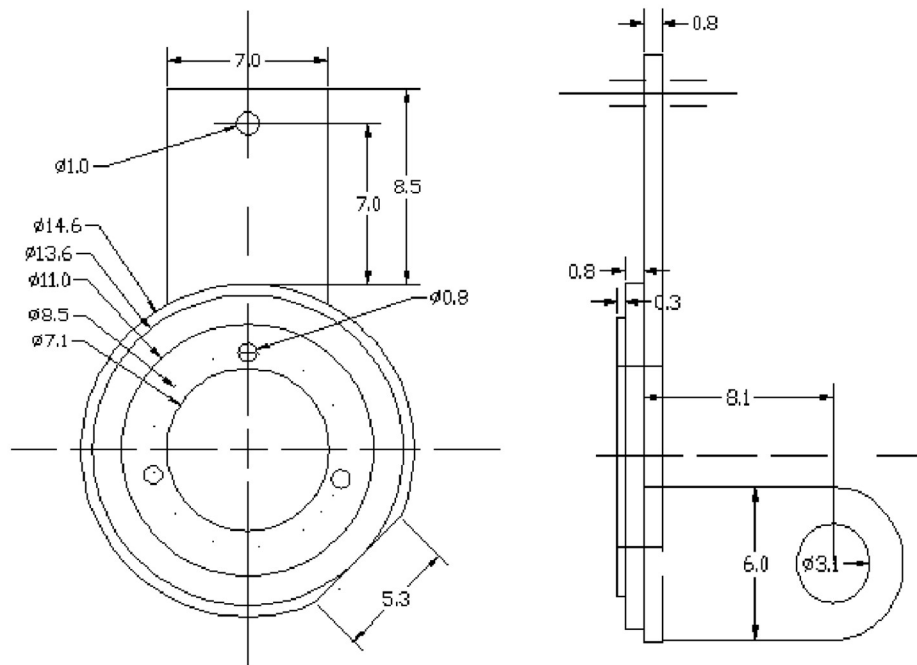


Figure 2 The base of the machine

### 3.5. Assembly of the Machine and Knitting Trial

The cylinder, the camshell, and the gear ring were assembled on the seat. Needles were placed in their slots. After assembling all parts, knitting was made on the new developed machine. The machine was partially gauged; half of the

needles were inserted by jumping one. The sock produced was good.

## 4. CONCLUSION

In this project manually operated circular sock knitting machine was designed and produced in Ethiopia. Previously, this machine was not available in the country.

All the parts of the machine are produced in the country except the needles. Needles for one machine cost not more than two hundred fifty Ethiopian birr.

The use of the machine has various advantages. It can be designed and produced by fifteen to twenty thousand Ethiopian birr. Lower economic class people can purchase the machine, operate it, produce socks using local yarn, enjoy in its profit, and distribute the product to their own people at low price. Therefore, it is the right investment for lower economic class people. Development and utilization of the machine can substitute machines and socks imports. The machine is simple to apply and efficient to produce but needs an appropriate needle for higher quality and productivity. The needles can be imported at lower costs. The machine is very simple to operate that women can use and generate their income. Being designed well, from an appropriate metal, the machine can work for long time under normal operations.

The future scope of this study is more important than what is given here. The small diameter circular knitting machine (sock knitting machine) developed in this project can be improved to larger diameter circular knitting machine. This is because knitting mechanisms are similar except few modifications. Developing a mechanism to perform in a given operation is more difficult than automating it. Possibly some gear systems, motor, stop motions, traducers and controllers are required to automate those manual machines. Therefore, I say that there are few years we have to stop

importing of those machines (knitting machines) purchased at tens million levels, by producing them at 50 to 70% reduction in cost.

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