Using the Basic Math and the Drawing Software for Calculating the Length of Tube for a Cane of Personalized Dimensions

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Abstract

A walking stick is an external help to maintain balance and maintain mobility during the walk of a person who is recovering from an injury to one of his legs. In this paper the analytical method is described for determining the length of pipe needed for the manufacture of a cane custom design, using basic math such as calculating perimeters and trigonometry, as a training exercise for students of mechanical engineering who take the course theoretical and practical manufacturing process because they start the course with deficiencies in basic math. It also briefly describes the use of Autocad software for this purpose. To design the stick, geometry and material commercial canes were considered, and anthropometric measurements of the palm of hand and height to the stick were taken. For a stick 830 mm height and 90 mm grip, a length of 967.14 mm tube is required.

Keywords: Trigonometry, Drawing software, Length of Tube, Walking Stick, Personalized Dimensions.

Introduction

In the courses of Manufacturing Processes I and Workshop Manufacturing Processes I for students of mechanical engineering, is studied and applied the process of bending sheet and pipe, and for enabling the material in this process, it is necessary to use basic math such as calculating perimeters and trigonometry, or the use of engineering software such as Autocad.

Because students who start these courses have gaps in knowledge of basic mathematics, this paper is intended that students see the practical use of basic math, or use Autocad if students already handle it, to determine the tube length required for manufacturing a cane custom dimensions.

Function and correct use of a cane

A cane (Fig. 1) is an external aid for balance and maintain mobility while driving when a person is recovering from an injury to one of his legs. The cane is lighter walking aid, which part of the body weight is transferred, wrist support him; a cane can not and should not hold most of the body weight [1].

The cane should be held with the hand that is on the same side of the functional leg: if the left leg is injured, then the stick must be held with the right hand, and vice versa (Fig 2). When step with the injured leg is given, you must move the stick forward at the same time, supporting part of the body weight on the leg but on his cane.

Method

For custom design cane is considered in principle the design and material of rods available commercially.

Material Selection

The material of commercial canes is aluminum tube of outer diameter 22.2 mm. This material is commercially available as extruded tube and calibrated tube, the tube length is 6.10 m and the wall thickness of 1.24 mm [2]. The extruded tube was suitable for the bending process, as the calibrated tube fractured to start bending.

Figure 1. Forearm position recommended for use cane

Figure 2. Support on the pole on the right side, left foot injury.

Design parameters

Bending angles. The geometric contour of a commercial cane has five segments (Fig. 3); the internal angle between segments *a* and *c* is 60 ° and between the segments c and *f* is 150 ° (Fig. 3.a). For the initial design of cane, internal angles of 45° and 13° between the segments *a* and c, and between the segments *c* and *f* respectively, were considered (Figure 3.b). But with these angles about 2% over tube length is required (Fig. 3.c).

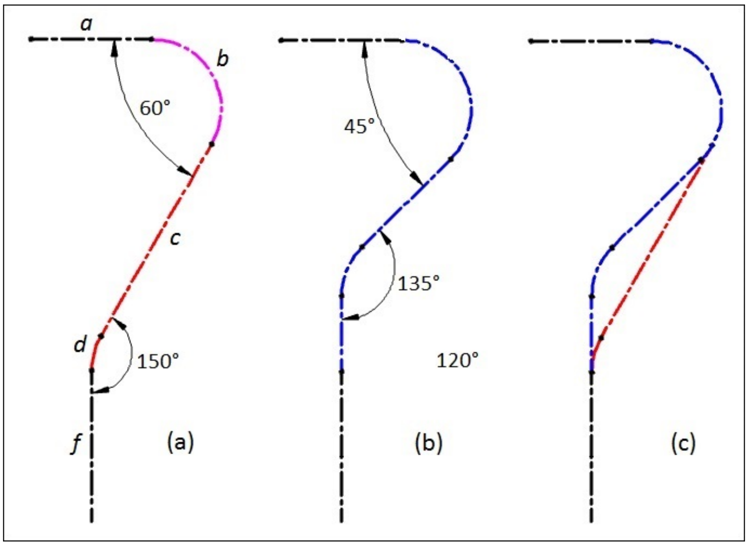

Figure 3. Outline of a stick: a) commercial design and custom design, b) design initially considered, c) Overlapping designs.

Therefore, to our final design the bending angles of commercial sticks were considered (Fig. 3.a). The segment *a* is the segment in which the stick is held, and its length depends on the size of the hand palm of the person (Fig. 4).

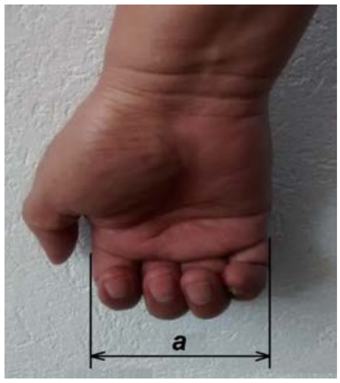

Figure 4. Width of the hand palm.

Bending radii. The internal radius *R* of bending of the two segments *b* and *d* was considered 46.2 mm (Fig. 5), which is the radius having the disk to bend tube 22.2 mm diameter, disk of the manual bender [3] with which practices account for students Manufacturing Process Workshop I.

Cane height H. To determine the appropriate height *H* of the cane, the person standing still with your arms at his sides, to hold the stick (Fig. 1) forearm must be flexed between 15° and 20 ° to the vertical [1] so that the support on the stick to be effective.

Dimension A. For the calculation of the dimension A (Fig. 5), the length of the straight segment *a*, the radius *R* of arc *b* and the diameter ***F*** of the tube, are considered. Therefore, using vector algebra [ ], we have (Fig. 6):

$$\boldsymbol{A} = \boldsymbol{a} + \boldsymbol{R} + \boldsymbol{F} \qquad (1)$$

Four dimensions are considered for segment ***a***, according to hand measurements: 69.6, 79.6, 89.6 and 99.6 mm. ***R*** = 46.2 mm and ***F*** = 22.2 mm.

Dimensions *H* and *A* can be checked after the manufacture of the cane.

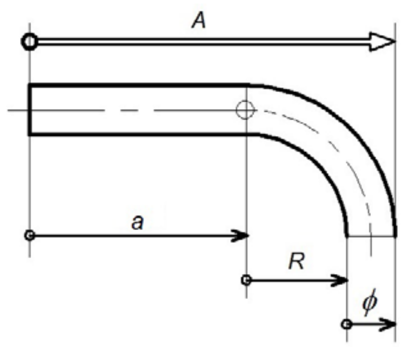

Figure 5. Dimension string for the vector calculation of *A*.

Dimension B. If one considers that the supporting force of the person (*0.5P*) is applied to the center of *a*, the line of action of the force must coincide with the longitudinal axis of the straight segment ***f*** to avoid unnecessary bending moments.

To ensure the above, the dimension *B* must be checked after the manufacture of the cane.

Therefore, using vector algebra (Fig. 6), we have:

$$\boldsymbol{B = 0.5\ (a - F)} \qquad (2)$$

Substituting values, we have (Fig. 7):

B = 23.7, 28.7, 33.7 and 38.7 mm

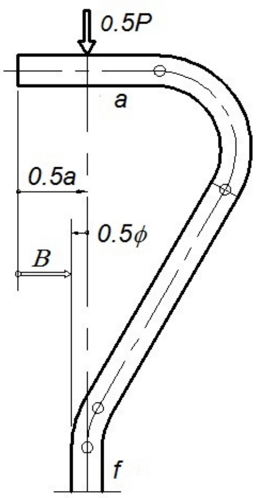

Figure 6. Dimension string for the vector calculation of *B*.

Calculation of the tube length

For the calculation of the tube length, the analytical method or drawing software (Autocad) can be used.

Analytical method

This method involves applying basic math: trigo-nometry, calculus of perimeters, and vector algebra.

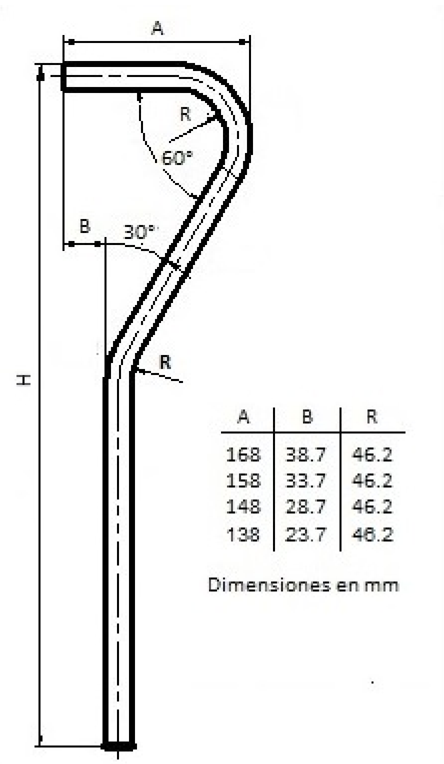

Fig. 7. Custom dimensions for the cane.

Fig. 8 shows the identification of the cane segments, considering the neutral axis of the tube (where no have any effort), to calculate the tube length *L* necessary for the manufacture of cane, given by Eq. (3):

$$\boldsymbol{L} = a + b + c + d + f \qquad (3)$$

$$a = \text{data}$$

Calculation of the segment b:

According to the calculation perimeters:

$$\boldsymbol{b} = 2\,\pi.c3\,/\,3 \qquad (4)$$

$$c3 = (R + 0.5\mathrm{F}) \qquad (5)$$

Calculation of the segment c:

First the length of its horizontal projection ***Ch*** is determined using vector algebra [4], the dimension string to calculate Ch is (Fig.8):

$$\boldsymbol{Ch} = (\boldsymbol{a} - \boldsymbol{c2}) + (\boldsymbol{c3} - \boldsymbol{c4} - \boldsymbol{c1}) \qquad (6)$$

$$\boldsymbol{c2} = B + 0.5\,\boldsymbol{F} \qquad (7)$$

Using vector algebra, Fig. 9 shows that:

$$\boldsymbol{c4} = \boldsymbol{c3} - \boldsymbol{c5} \qquad (8)$$

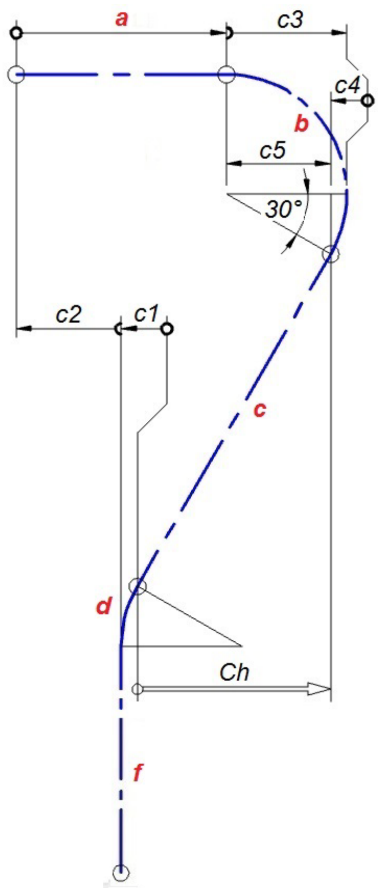

Fig. 8. Minimum dimension string *Ch* to calculate the cane segment *c*.

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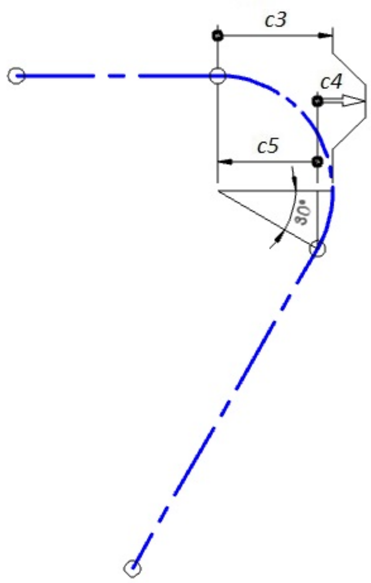

Fig. 9. Dimension string *c4*.

By trigonometry , Figs. 8 and 9 show that:

$$\boldsymbol{c5} = c3.\cos 30° \qquad (9)$$

Fig. 8 shows that:

$$\boldsymbol{c1 = c4} \qquad (10)$$

The value of the parameters *c1*, *c3*, *c4* and *c5* is constant for any size stick.

Finally, also by trigonometry we have:

$$\boldsymbol{c} = Ch / \cos 60° \qquad (11)$$

Calculation of the segment d:

According to the calculation perimeters:

$$\boldsymbol{d} = 2\,\pi.c3 / 12 \qquad (12)$$

Calculation of the segment f:

Using vector algebra, Fig. 10 shows that:

$$\boldsymbol{f = h - c7} \qquad (13)$$

where ***h*** is the height of cane considering the position of the neutral axis thereof:

$$\boldsymbol{h = H - 0.5F} \qquad (14)$$

Fig. 11 shows that:

$$\boldsymbol{c7 = c6 + Cv + c6 + c3} \qquad (15)$$

By trigonometry (Fig. 11):

$$c6 = c3.\ \mathrm{Sen}30° \qquad (16)$$

Observing Figs. 8 and 11:

$$Cv = Ch.\tan 60° \qquad .\ (17)$$

Substituting Eq. 14 and c7 values in Eq. 13, the segment f have values dependent height H of the stick.

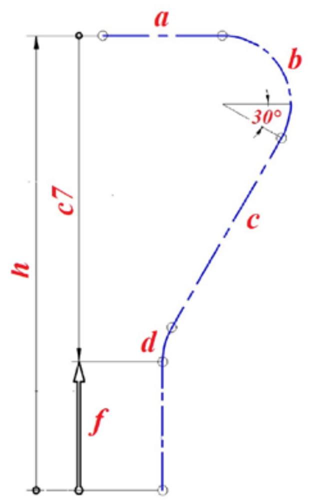

Fig. 10. Dimension string *f*.

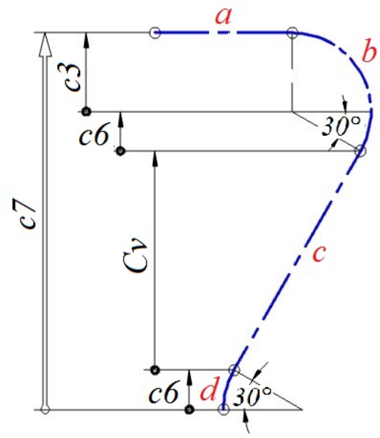

Fig. 11. Dimension string *c7*.

Autocad method

Initially drawing stick to scale 1 is prepared (Fig. 12), with the measures corresponding to the palm (*a*) and height (*H*) of the stick, and the *LIST* command is used pointing each segments to display the value thereof, and having displayed the value of the length of each of the segments, the values are added and the tube length L necessary for the manufacture of the stick is obtained. They may also bind all segments to form a single identity and then applies *LIST*.

Each student makes calculation for his cane, which will serve for one of their relatives.

Results

Analytical method

As an example, for a = 89.6 mm and H = 830 mm, the tube lenght L is 967.14 mm. See Table 1, that shows the value of each segment and the general dimensions of cane.

Table 2 has been prepared to quickly verify that student calculations are correct.

Table 1. Calculation example: tube length *L* for *a* = 79.6 mm and *H* = 830 mm.

Segment	Value (mm)	Calculated with Equation
A	158	1
B	33.7	2
b	120	5, 4
c	173.49	9, 8, 10, 7, 6, and 11
d	30	12
f	554	17, 16, 15, 14 and 13
L	967.14	3

Table 2. Tube length *L*, dimensions for the cane, and values of each segment.

Dimension or segment, and tube length (mm)	Dimension *a* (mm)			
	69.6	79.6	89.6	99.6 mm
A	138	148	158	168
B	23.7	28.7	33.7	38.7
b	120.00			
c	153.49	163.49	173.49	183.49
d	30.00			
f	H – 258.63	H – 267.29	*H* – 275.95	*H* – 284.61
L	*L* = H + 114.5	H + 125.8	*L* = *H* + 137.14	*L* = *H* + 148.48

Autocad method

For the above analytical example, Fig. 12 shows the baston drawing scale and the Autocad text window, where the application of the LIST command can be observed, to display the value of segment *c*. As expected, the above value is the same as that obtained analytically.

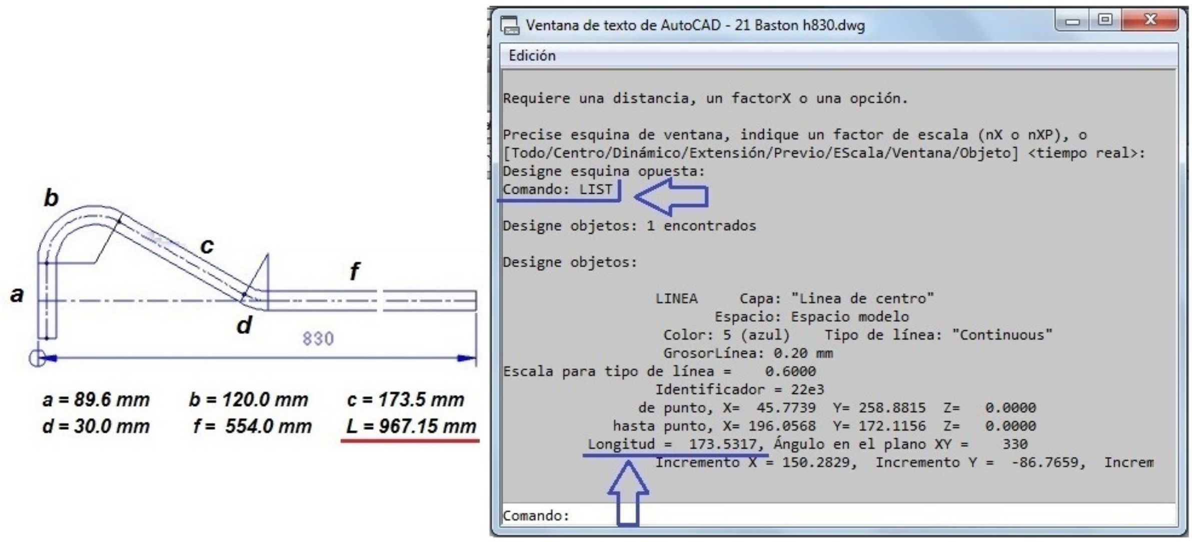

Fig. 12. Autocad text window showing the value of segment *c* of the cane.

Conclusions

This paper presented two methods for calculating the length of pipe required for the manufacture of a cane custom dimensions. For the analytical method, equations have been deduced for calculating dimensions *A* and *B* of the cane, which can be verified after manufacture, and the height *H* depends on the stature of the person. Dimension *a* depends on the width of the palm of the person who will use the cane.

The student must measure both the width of the palm as the appropriate cane height according to the stature of the person who will use the cane, and using this data, the student must establish the corresponding equations to calculate the value of each segment, applying the calculation of perimeters, trigonometry and vector algebra.

Therefore, the analytical method is useful to the student to remember basic math, and with these, calculate the length of tube required to manufacture his own cane.

References

1. Cómo usar correctamente el bastón. http://es.wikihow.com/usar-un-bast%C3%B3n-correctamente. (consultation October 30, 2015):
2. Catálogo de Metales Diaz S.A. de C.V. (2015). Ave. Dr. Gustavo Baz No. 224, Col. Bella Vista, Tlalnepantla de Baz, Estado de México, México. C.P. 54080. Tel. 0155-5360-3545. www.metalesdiaz.com.mx
3. Villanueva-Pruneda Sergio *et al*. Manual de fichas técnicas. Máquinas-herramienta. Taller Mecánico. 1a Edición 2013. Comité editorial de la División de Ciencias Básicas e Ingeniería. UAM-A. ISBN: 978-607-28-0207-0
4. Mendez-Hinojosa A. Matemáticas I enfoque por competencias DGB. Editorial Santillana. ISBN: 978-607-012-5638X