Simple Matimatical Technique in Laser Cavity Design and Manufacturing.

AKRAM, N. MOHAMMED * **FAIK H. ANTER ****

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Abstract:
In this research we studied the mathematical and practical methods in laser cavity design and manufacturing. We present a new and easy mathematical model which have a good agreement with experimental results.

Introduction:
In many chemical laser designs, the shapes of cavity is cylindrical [1].
The tube is surrounded by helical distribution of electrical electrodes, one helix is for positive , another for negative electrodes Fig.(1) .

There are two problems in that design. The first one is in calculating the helix length exactly; The second one is in drawing that helical shape on the tube surface.
All calculus books(1,2,3,4) give an equation may be derived to.

$$R=(a\cos wt)\,i + (a\sin wt)\,j + (bt)\,k \text{ -------(1)}$$

Where R: distance from the origin of the circle to the moving point (p) which drawing the helix, a, b & w are positive constants represent a circular helix of fig (2).

The length of the circular helix (L) may be given as:-

$$L=\int_a^b V dt \quad \text{------(2)}$$

Where $V = \frac{dL}{dt}$ velocity of point (p) on the helix Curve.

Generally, equation (2) doesn't gives practical and simple method to calculate the circular helix length. Besides that, all calculus books didn't give us any manufacturing method for drawing that helix. Fig (3) represents an orthogonal triangle If we bend the line BC Circularly until the point B coincides on the point C, we get the shape shown In Fig-(3b) in which (r) represent the radius of circular base. From fig.(3a) & Fig .(3b) we have:

$BC=L_1=2\,\Pi\,r.$

In the same time the line (AC) will represent one helical ring of length L_2 , where :

$$Ac = l_2 = \left[(BC)^2 + (AB)^2\right]^{\frac{1}{2}}$$

$$\therefore L_2 = \left[(2\pi \quad r)^2 + h^2\right]^{\frac{1}{2}} \quad \text{------(3)}$$

where h represent one helical ring height (one step as we shall see later). If we add N orthogonal triangles One over each other, we shall obtain a circular helix of length (L) and height (H), where:

* Dr, Applied Science department, University of technology, BAGHDAD-IRAG
** Asst.prof.Dr, Physics department, college of education.An bar university, An bar, Iraq

$$L = Nl^2 = N\left[(AB)^2 + (BC)^2\right]^{\frac{1}{2}}$$
$$= \left[N^2(AB)^2 + N^2(BC)^2\right]^{\frac{1}{2}}$$

from equation (3), we have:

$$L = \left[N^2(2\pi\ r)^2 + H^2\right]^{\frac{1}{2}} \quad --- (4)$$

Now if we put θ=2 п N, we get:-

$$L = \left[\theta^2 r^2 + H^2\right]^{\frac{1}{2}} \quad --- (5)$$

θ may be any angle in radians depending upon the angular velrcity □ as we shall see.

Results and Calculcetions:

We used two tubes of different lengths and different radii, and a silk of thickness ≈0.1mm for measuring the helical length with N turn. We obtained the results listed in table (1) were the theotrical results from equation (5) are also recorded.

Table(1)

Tube radius (r) cm	Tube light (H) cm	Experimental length cm	Theoretical length cm
4.028	65	337.0	335.50
2.42	85	274.0	272-20

Discussion

From table (1) we see that the experimental and theatrical results are nearly equal. The small difference is due to the thickness of the wire which surrounds a cylinder of radius (r). at zero thickness the experimental length is equal to the theoretical length exactly. This may be explained as follows if we consider a wire of length (L) surround a cylinder of radius r, then the internal wire's side Fig. (4) Will be squeezed, its length will be. L_1=2п r, and will be shortest than (L) while, the outer side will be elongated to be (L_2) where L_2=2 п (r + dr), and will be taller than (L). The real length of the wire will be the average (the dotted circular). So the measured wire length will be longer than the internal length (L). Which is equal the circular helix length.

In order to manufacture the needed helical length, put the cylindrical tube in the turner machine after replacing the metal cutter by a magic pen.

By controlling the horizontal pen movement to make one step height (h) for each one complete revolution of the turner machine it is possible to draw the helical length on the tube. If we have a certain tube length (H) and radius (r), then for any needed step length (h), we can find the corresponding helix length (L) or oppositely if we need certain helical length (L) for tube of length (H), we can find (h), or (N) from equation (5).

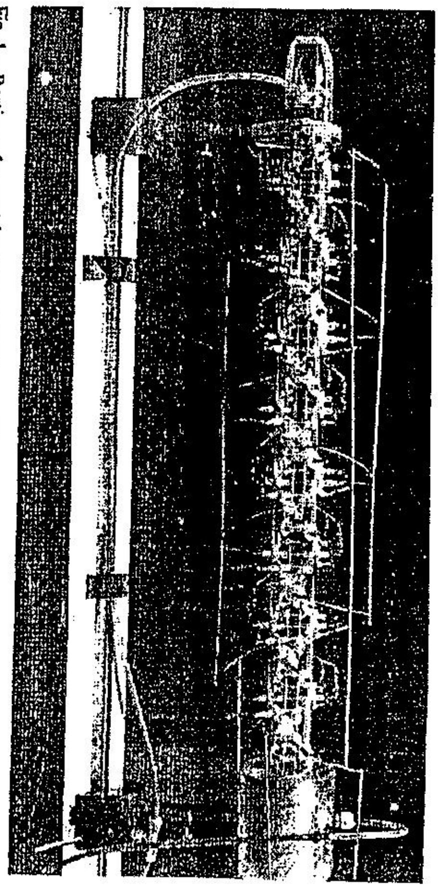

Fig. 1 . Portion of a multiple-pin pulsed laser. Pins are arranged on a spiral geometry to give better uniformity. Each pin is individually ballasted.

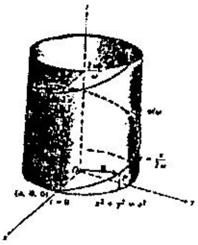

Fig. 2. The helix traced by
R= (a cos wt)i^ + (a sin wt)j^ + (bt)k^.
b > 0. spirals up from the xy – plane as t increases from zero.

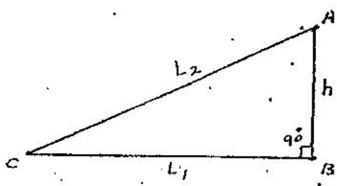

Fig. 3a: An orthogonal triangle.

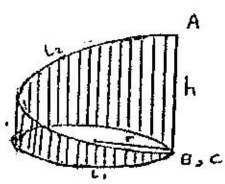

Fig. 3b. The binded triangle with circular base.

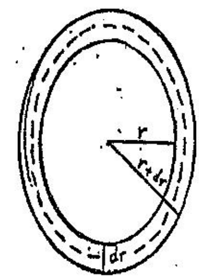

Fig. 4. Schematic shape of wire surrounded a cylinder of radius (r).

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تقنية رياضية بسيطة لتصميم وتصنيع فجوة ليزرية

فائق حماد عنتر * اكرم نوري محمد **

* قسم انفيزياء / كلية التربية/ جامعة الانبار
** قسم العلوم التطبيقية/ الجامعة التكنولوجية

الخلاصة:

في هذا البحث تمت معالجة تصميم فجوة الليزر حسابيا وعمليا باستخدام نموذج رياضي بسيط وجديد ، وقد وجدنا بان هناك تطابق جيد في النتائج العملية والنظرية.