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STUDY OF BEAM ANGLES FOR DIFFERENT POSITIONS OF COLLIMATOR JAWS IN RADIOTHERAPY TREATMENT.

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Abstract — *Linear Accelerator Used for External-beam Radiation Therapy. Many types of external-beam radiation therapy are delivered using a machine called a linear accelerator (also called a LINAC). A LINAC uses electricity to form a stream of fast-moving subatomic particles. This creates high-energy radiation that may be used to treat cancer. Collimators (beam limiting devices) are used in linear accelerators for radiotherapy treatments. They help to shape the beam of radiation emerging from the machine and can limit the maximum field size of a beam.*
The secondary collimators are situated after the primary collimator and consist of two pair of tungsten blocks (jaws), upper jaws and lower jaws that restricts the radiation emerging from the head to determine square or rectangular field. The secondary collimators are calibrated so that the collimator reading will give the corresponding field size at 100cm FSD. Due to beam divergence the field size any other distance will be different and will be calculated by using similar triangles method. For designing collimator jaws, the different beam angles were calculated for various field sizes.

Keyword – *Asymmetric, Collimator, Jaw, LINAC, Field size, Beam.*

I. INTRODUCTION

Collimators (beam limiting devices) are used in linear accelerators for radiotherapy treatments. They help to shape the beam of radiation emerging from the machine and can limit the maximum field size of a beam. The linear accelerator has at least two set of collimators namely Primary and Secondary Collimator.

1.1. Primary Collimator

The treatment beam is first collimated by a fixed primary collimator located close to the target so as to reduce its size. The primary collimator is circular and defines the maximum angle of the existing beam.

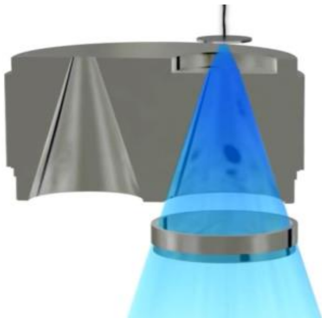

Figure *1 Primary Collimator*

1.2. Secondary Collimators

The beam is further collimated by continuously movable x-ray collimators. The secondary collimators are situated after the primary collimator and consist of two pair of of lead of tungsten blocks (jaws), upper jaws and lower jaws that restrict the radiation emerging from the head to determine square or rectangular field size ranging from approximately 4cm² up to 40cm² at 100cm FSD.
The secondary collimators are calibrated so that the collimator reading will give the corresponding field size at 100cm FSD. Due to beam divergence the field size any other distance will be different and will be calculated by using similar triangles method.
Secondary collimator can be move either symmetrically around the central axis of beam or asymmetrically. Where one of the collimators coincides with the central axis that one side of the field has no beam divergence.
A further collimator can be positioned below the secondary collimator. This collimator consists of a number of leaves of tungsten and it is called as multi-leaf collimators (MLCs).

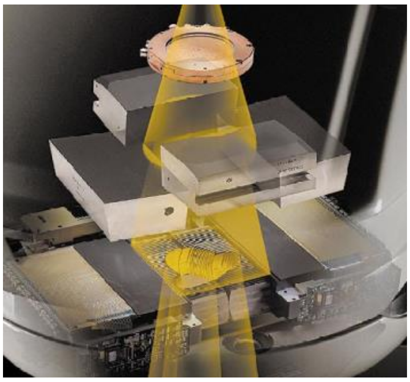

Figure 2 Secondary Collimators

The function of all the collimators mentioned is to define the beam, which they do by attenuating the part of the beam that is not required. The collimator material needs to have a high density because the major interaction process at these energies is the Compton interaction.

II. THE MATERIAL USED FOR JAW AND ITS PROPERTIES

- Jaw Material: Tungsten
- Atomic Symbol and number: W and 74
- Element Category: Transition Metal
- Density: 19.24g/cm^3
- Melting Point: It has the highest melting point- 6192°F (3422°C)
- Boiling Point: 10031°F (5555°C)
- It has lowest vapour pressure (at temperatures above 1650 °C, 3000 °F), and the highest tensile strength.
- Tungsten has the highest melting point and lowest vapor pressure of all metals, and at temperatures over 1650°C has the highest tensile strength.
- It has excellent corrosion resistance and is attacked only slightly by most mineral acids.
- Tungsten has the lowest coefficient of thermal expansion of any pure metal.

III. GENERAL LAYOUT OF TREATMENT HEAD IN RADIOTHERAPY CONCEPT

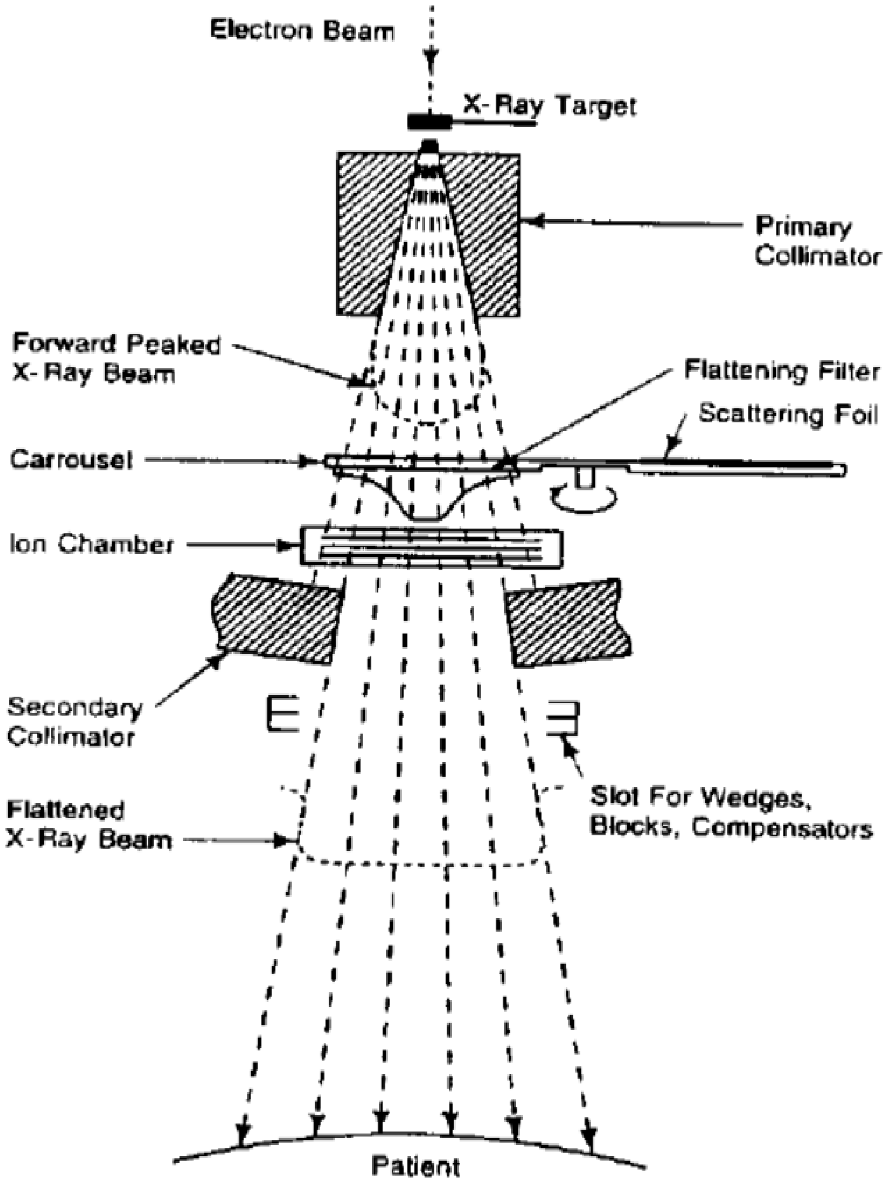

Figure 3

3.1. From the Collimator Study, the Cone Angle and Distance from X-Ray Target to Secondary Collimator is Shown in Figure Below

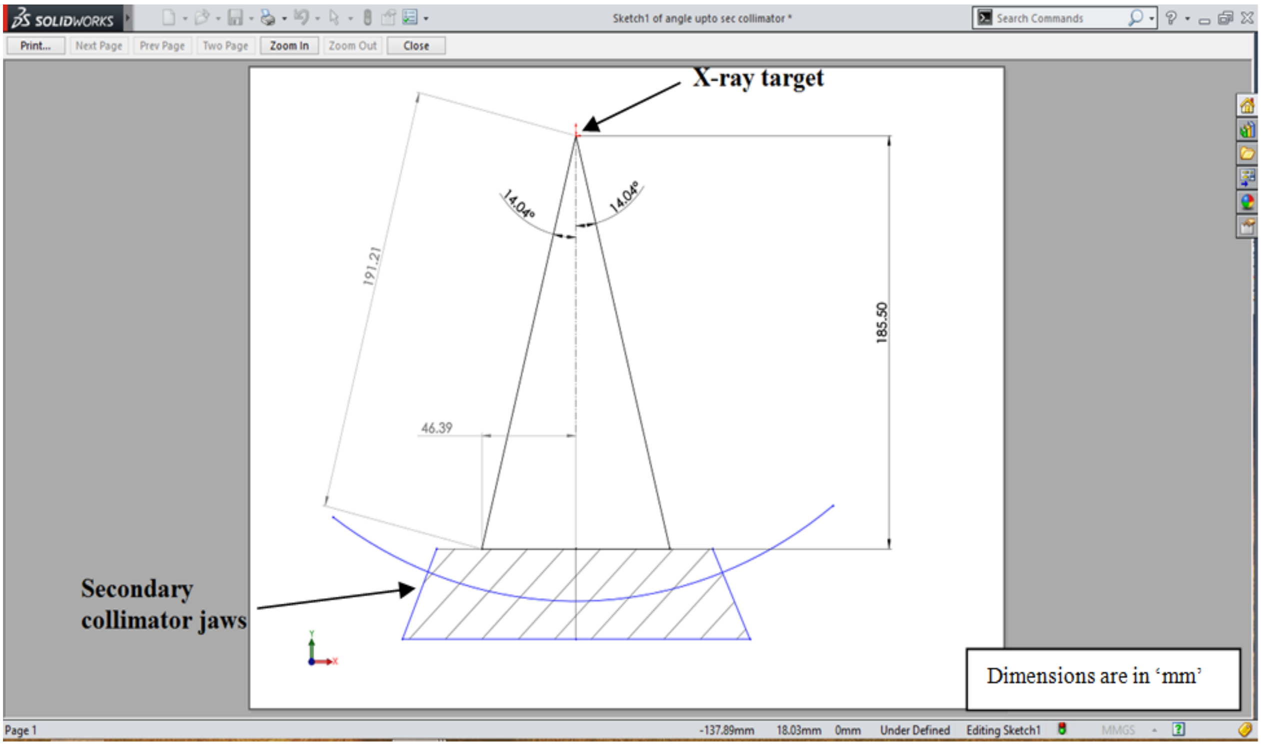

Figure 4

From the above figure, the cone angle is 28.08º and distance from x-ray target to secondary collimator is 185.50 mm which is used to design the shape and size of jaws of secondary collimator.

3.2. Calculations of beam angles at different positions of jaws for defining different x-ray field size

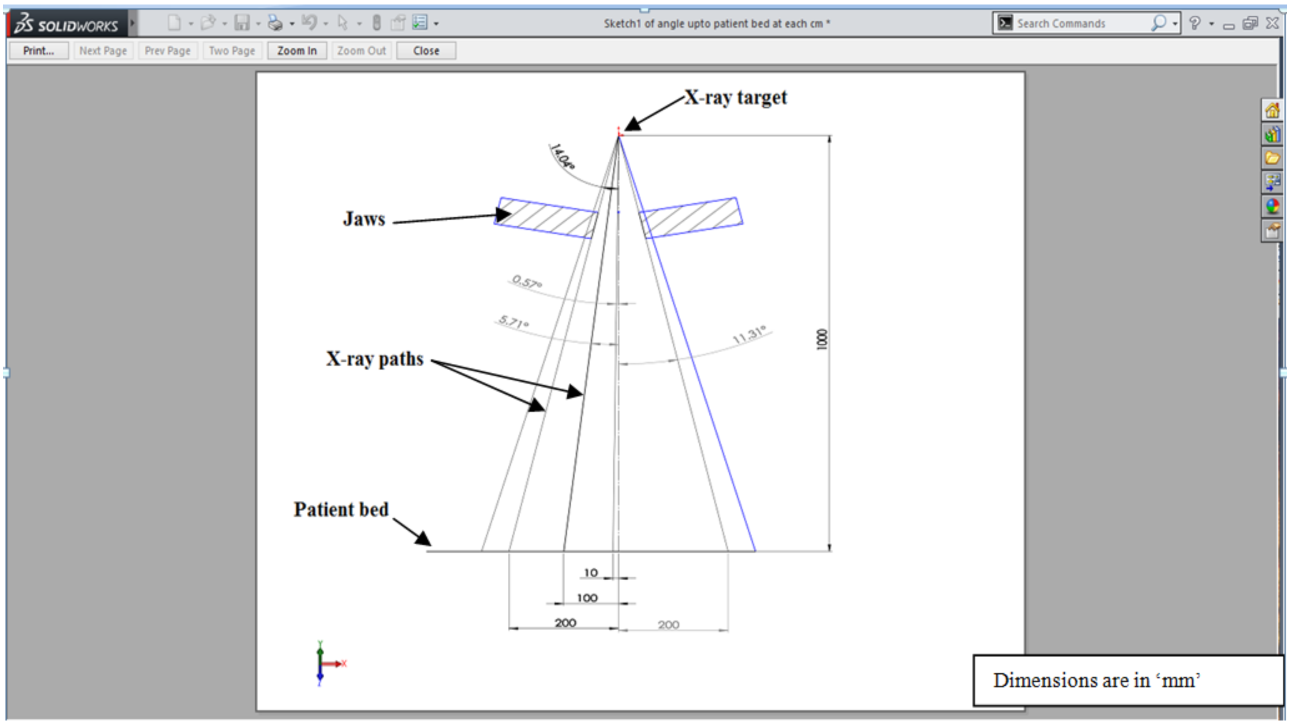

Figure 5

From above figure, the beam angles required to determine the various x-ray field at 1m from target are shown in below

Table 1

X-ray field size on patient bed from central axis (in cm)	Beam angles from central axis (in degree)
1	0.57º
2	1.15º
3	1.72º
4	2.29º
5	2.86º
6	3.43º
7	4.00º
8	4.57º
9	5.14º
10	5.71º

3.3. Opening and closed positions of jaws

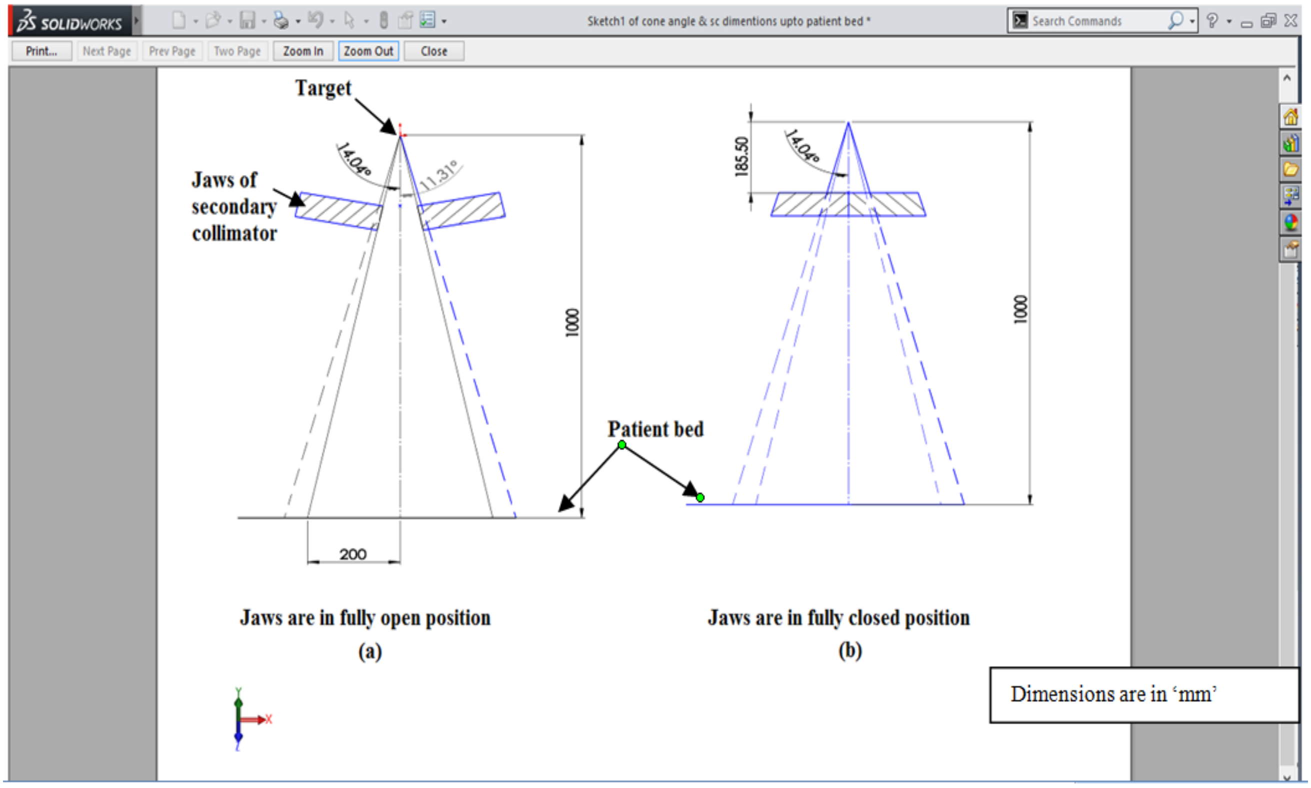

Figure 6

Figure 6(a), shows the maximum opening positions of jaws and figure 6(b), shows the closed position of jaws.

IV. CONCLUSION

1) From the above figure. 4, the cone angle is 28.08º and distance from x-ray target to secondary collimator is 185.50 mm which is used to design the shape and size of jaws of secondary collimator

2) By using triangle method, we have calculate the different beam angles for various x-ray field size at a distance of 1m from the source as shown in above table 1.

3) The maximum x-ray field size of $40cm^2$ on patient bed at a distance of 1m from target is achieved by an opening of jaws at a beam angle of 11.31º from central axis is shown in figure 6a. Since the maximum rectangular field size of $40cm^2$ limited, the x-ray beam at an angle more than 11.31º from central axis are blocked by the tungsten jaws which are not allows the beam to strike on patient coach as shown by hidden line in figure 6a.The closed position of jaws which restricts the entire x-ray beam passing from target. And due to these no radiation takes place at patient bed as shown in figure 6b.

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