Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 15 Issue 3 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

A Physicist Description of Indigenous Telecobalt Machine Bhahbhatron-II TAW

By Athiyaman.M, Hemalatha Athiyaman, Neelakandan, Rajasekaran, Dr.H.S.Kumar & Dr. Ajay Sharma

Acharya Tulsi Regional Cancer treatment and Research Institute, India

Abstract- The newly designed indigenous Bhabhatron-II is installed in our institution. The Telecobalt machines were put into use for Radiotherapy after the possibility of producing High activity sources with smaller dimension which satisfies the ideal requirement of Teletherapy source. The Bhabhatron II head can accommodate nearly 250RMM source strength. Being a computer controlled machine the Bhabhatron machine differs from other conventional Telecobalt machines. This machine has advanced features such as asymmetric collimators, motorized wedge etc. This unit has keypad attached at both sides of the couch that also has digital display. The patient treatment is computer controlled. The plan parameters can be entered in the console computer and the exposure time can be programmed. This unit suits well for developing countries provided the cost of the source shall be maintained cheaper.

Keywords: *bhabhatron ii, asymmetric collimators, indigenous.*

GJSFR-A Classification : *FOR Code: 249999p*

Strictly as per the compliance and regulations of :

A Physicist Description of Indigenous Telecobalt Machine Bhahbhatron-II TAW

Athiyaman. M[α], Hemalatha Athiyaman[σ], Neelakandan[ρ], Rajasekaran[ω], Dr. H. S. Kumar[¥] & Dr. Ajay Sharma[§]

Abstract- **The newly designed indigenous Bhabhatron-II is installed in our institution. The Telecobalt machines were put into use for Radiotherapy after the possibility of producing High activity sources with smaller dimension which satisfies the ideal requirement of Teletherapy source. The Bhabhatron II head can accommodate nearly 250RMM source strength. Being a computer controlled machine the Bhabhatron machine differs from other conventional Telecobalt machines. This machine has advanced features such as asymmetric collimators, motorized wedge etc. This unit has keypad attached at both sides of the couch that also has digital display. The patient treatment is computer controlled. The plan parameters can be entered in the console computer and the exposure time can be programmed. This unit suits well for developing countries provided the cost of the source shall be maintained cheaper.**

Keywords: bhabhatron ii, asymmetric collimators, indigenous.

I. Introduction

In the era of advanced radiotherapy (RT) technology development, the telecobalt units (TCU) are still trying to compete with the linear accelerator (LINAC)[1] .The main reason for the suitability of Telecobalt source for treatment purpose is its high specific activity which can lead to achieve smaller dimension source, an ideal requirement of any Radioactive Source for clinical purpose and also to achieve desirable dose rate at larger distance .The other advantage of the Cobalt 60 source is high energy of 1.25 MeV which lies in the Mega Voltage region. The Megavoltage energy photons interact irrespective of the atomic number and depend only on electron density. Hence the main disadvantage of higher absorption in bone due to Kilovoltage Photons is quashed by introducing the Cobalt 60 source. Even though the Telecobalt units have the above advantage it yields poorer geometrical precision due to larger Penumbra and as a radioactive source it decays when time passes that leads to dose rate reduction. These disadvantages are felt insignificant and they are still preferred in countries where facilities of maintaining Linear Accelerator are so cumbersome.

Acharya Tulsi Regional Cancer Centre has a long history of providing Radiotherapy. At the mid of 1930s this institution is the only centre in North Western India which provided Radiotherapy facility by Radium Sources and Deep Therapy X Ray Units. Presently this institute handles 5000 annual patients every year and majority of the cases are treated in our earlier installed Telecobalt Machines namely 780-E & 780-C; The present Telecobalt Machines approximately handles 100 patients per day and our Varian Linac handles around 50 Patients. To manage this higher workload it was decided to procure a Telecobalt Machine.

It shall be emphasized here that many of the major techniques and advances in physics of External Beam Radiotherapy were developed from Telecobalt Units. Techniques such as Arc Therapy, Measurement of T.A.R and subsequent Scatter Air Ratio and the associated algorithms for treatment planning based on the separation of primary and secondary radiation has evolved from Telecobalt Machine. More recently, Poffenbarger and Podgorask in 1998 have investigated the possibility of using an isocentric unit for S.R.S . Warrington and Adams have shown that conformal Therapy and even IMRT could be adequately delivered with a Cobalt-60 unit except for Deep seated Tumors.

II. Materials and Methods

The general characteristics, mechanical characteristics and special features of Bhabhatron-II, are described here. The machine was installed by the regulatory board authorized service engineer of the vendor. All the mechanical quality assurance tests were performed and ensured the mechanical characteristics of the machine is in line with the regulatory board and IEC recommendations. The normal conventional Quality Assurance equipments which are available in our department are used for commissioning the unit. For the measurement of Absolute Dosimetry Farmer Chamber was used along with the water equivalent Phantom. The Victoreen Based Advanced Survey Meter and

Author α: Assistant Professor, Sr. Demonstrator (RSO) Department of Radiation Physics, Acharya Tulsi Regional Cancer treatment and Research Institute, Department of Radiation Physics, Bikaner, Rajasthan, India. e-mails: athi.roja87@gmail.com, hames_medphy@yahoo.co.in.

Author σ: Senior Demonstrator, Department of Radiation Physics, Acharya Tulsi Regional Cancer treatment and Research Institute, Sardar Patel Medical College & Associated Group of Hospitals, Bikaner, Rajasthan, India.

Author ρ ω ¥ §: Acharya Tulsi Regional Cancer treatment and Research Institute, Sardar Patel Medical College & Associated Group of Hospitals, Bikaner, Rajasthan, India.

Pressurized Ion Chamber are used for the Radiation Protection survey. Additionally we had obtained the Digital Pocket Dosimeters from Rosalina Medical Instruments for the purpose of Source Loading procedures which shall be worn by the personnel involved in source Transfer. The basic construction of the machine, the components of the Head, description of primary collimator and secondary collimator, symmetric and asymmetric properties of Jaws are described here. The machine properties vary significantly from other conventional telecobalt machines. The planning parameter related motions such as field size, collimator rotation and exposure time are programmable in the control console computer. Also we describe here about the computer control console and the facilities available in the console such as visible indicators for source on, transit and OFF position, pressure situation in the compressor, wedge details.

III. Basic Construction of Bhabhatron-II Taw Machine

a) Head

The basic mechanical construction of Bhabhatron-II is as similar to other commercial Telecobalt Machines. The Bhabhatron-II machine head can accommodate the maximum source strength of 250RMM[4]. The Source Head is made up of Tungsten to shield the source in the OFF position which differs from the other machines where the other commercial machine's head are made of Depleted Uranium Figure 1. The Tungsten shield in Bhabhatron-II TAW model forms a conical opening at the source fully exposed condition which forms the primary collimator. The source capsule is mounted in a cavity approximately 2.8cm in diameter and 1.2cm long with an end plug and clip. The source drawer is operated with the pneumatic pressure system with pressure range of 35 - 40 PSI to 60 - 65 PSI. The source drawer slides along a horizontal tube inside the head which places the source from Fully Exposed (ON) position to Fully Shielded (OFF) Position by the piston of air cylinder. The air cylinder is controlled by two air valves, which, under normal conditions, do not permit the source to remain in the fully exposed position when electrical power is removed from the unit. In this case, the valves will return the source to the fully shielded position or will depressurize the system so that the source can be returned manually. The valves are operated by the treatment control system (primary and secondary timers).

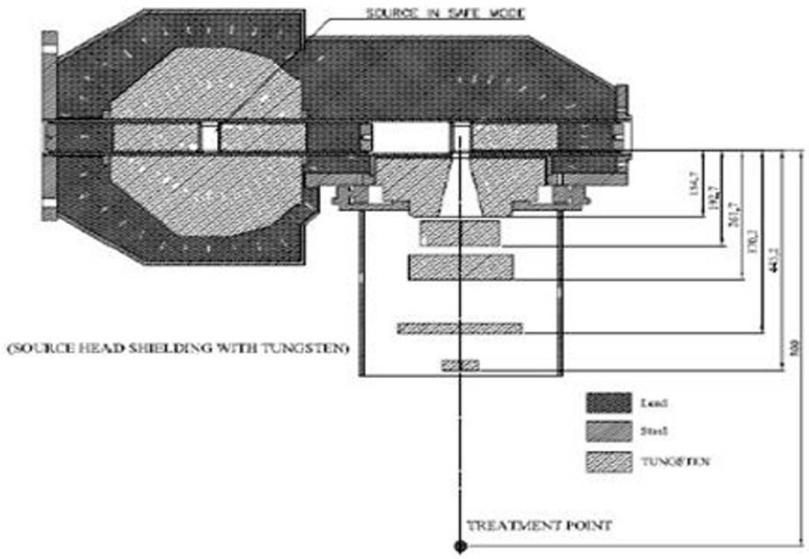


Fig. 1 : Head Characteristics of Bhabhatron-II TAW

The manufacturer of Bhabhatron Telecobalt Machine uses two materials i.e. Tungsten & Depleted Uranium for shielding the source in OFF condition. The models Bhabhatron-II, Bhabhatron-II-A, Bhabhatron-II-AW contain Depleted Uranium. The models Bhabhatron-II T, Bhabhatron-II-TW, Bhabhatron-II-TA, and Bhabhatron-II-TA contain Tungsten. The Suffixes T, A & W are used to identify the models of Bhabhatron. TAW represents Tungsten, Asymmetric & Motorized Wedges respectively.

Beam limiting devices are made of fixed primary collimator and two secondary collimators. The Y jaws are next to the primary collimator which is parallel and independent to each other as Y1 & Y2 Jaws. The secondary Y Jaws stops at a minimum level of approximately 2x2 cm^2. The minimum achievable field

size of 0x0 is achieved by the Y jaw Trimmers. Next to Y Jaws the X Jaws are placed which are symmetrical to each other. It shall also be noted that the Y Jaws can be operated in both the modes (Symmetrical & Asymmetrical mode) with the help of the dedicated switch attached in the Keypad.

Mechanical Parameters	Extension Level
Gantry	360 Degree
Couch Lateral	+/- 20 cm from the Isocentre
Couch Longitudinal	0 to 90cm Range
Couch Rotational	+/- 90 Degree Isocentric Rotation (IEC 61217)
Couch Vertical	60cm to 130cm(70cm Range)
Collimator Rotation	+/- 90 Degree Isocentric Rotation (IEC 61217)
X Jaw (Symmetrical)	0 x 0 cm2 to 35 x 35 cm2
Y Jaw (Symmetrical)	0 x 0 cm2 to 35 x 35 cm2
Y1 Jaw Asymmetrical	0 to -17.5 cm (as per IEC Scale 61217)
Y2 Jaw Asymmetrical	0 to +17.5 cm (as per IEC Scale 61217)

As described above are the functional limits of various parameters such as Couch, Gantry, Collimator & Jaws. Apart from the asymmetric feature of Y Jaws in basic construction wise the Bhahbhatron-II TAW almost matches with the other commercial Telecobalt Machines. The Gantry shall be rotated to 360 Degree as similar to other Telecobalt machines to support various beam angle treatments. The gantry rotation speed shall be varied by the speed regulatory switch which is provided in the Keypad attached in the couch. Enabling this speed switch shall make all the mechanical motions to happen faster which shall help the Technologist for faster patient setup. A counter weight is designed to take counter the weight of the Head & other parts such as Collimator, Jaws, and Trimmers etc. The posterior counter weight is specially filled with Lead material which weighs almost 2 Tone capacities. The Head also has the source indicator rod as similar to other Telecobalt machines. It is attached with the source drawer and moves with the source that indicates (Through CCTV and/or Mirror) Beam ON condition. The external T-ROD shall be fitted with this indicator rod incase of failure of Automatic source retracting system to push the source to the OFF condition.

b) Collimator

The implementation of Asymmetric Jaws highly differentiates this machine from other Telecobalt Machines. The Asymmetric Jaws will play a vital Role in the Head & Neck cases treatment plan where the Bilateral Field Isocentre will be matched with LAN field which is not possible in other Telecobalt Machines due to the absence of Asymmetric feature. Along with this the asymmetric Jaw feature shall be greatly used in Breast cases where the dependency of Breast Cone to block the rest half of the beam to shield the underlying Lung tissue shall be achieved by independent Y Jaws. The Technologists shall be freed from mounting the heavy Breast cone in the machine due to this asymmetric Y JAW feature of Bhabhatron-II TAW.

The movement of Asymmetric Jaws can be done by selecting the asymmetric switch provided in the Keypad thereafter the individual movements of Y1 & Y2 shall be controlled by their switches. The other keys to turn ON Lasers, ODI & Field light are also provided. The Emergency Switches are given on both Keypads.

IV. Advanced Features of Babhatron-II

a) Isowedge

The Isowedge is one of the important features of Bhabhatron model over other conventional Telecobalt machines. Motorized wedge is a single wedge (60^{o}) which could generate desired angle (0 to 60^{o}) with the combination of open and wedged beam[1-2&3]. Isowedge time calculated by the software depends on the Isowedge Angle, field size and treatment time[4].The isowedge is mounted permanently into the treatment head and are automatically driven into the radiation path through programming. By adjusting the proportion of the treatment time the wedge angle can be adjusted. The isowedge treatment time depends on the field size and required wedge angle. The required Isowedge angle shall be selected in the control console and the respective time shall be entered. The isowedge remain in the radiation path till the isowedge timer consumes the programmed time. The isowedge reaches its home position after remaining in the beam path for the programmed time. The motorized wedge shall be used with the help of the Treatment Planning System which helps in accurate calculation of the beam weightage for the wedged and non wedged beams to achieve the desired wedge angle[1]. The implementation of isowedge has created an advantage of delivering wedged beams without mounting any physical accessories also the reduced the Technologists entry into the Treatment room to mount the accessories in-between.

b) Couch and Keypad

The couch is made of carbon fibers which shall withstand the maximum weight of 150kg. In conventional machines the mechanical motions

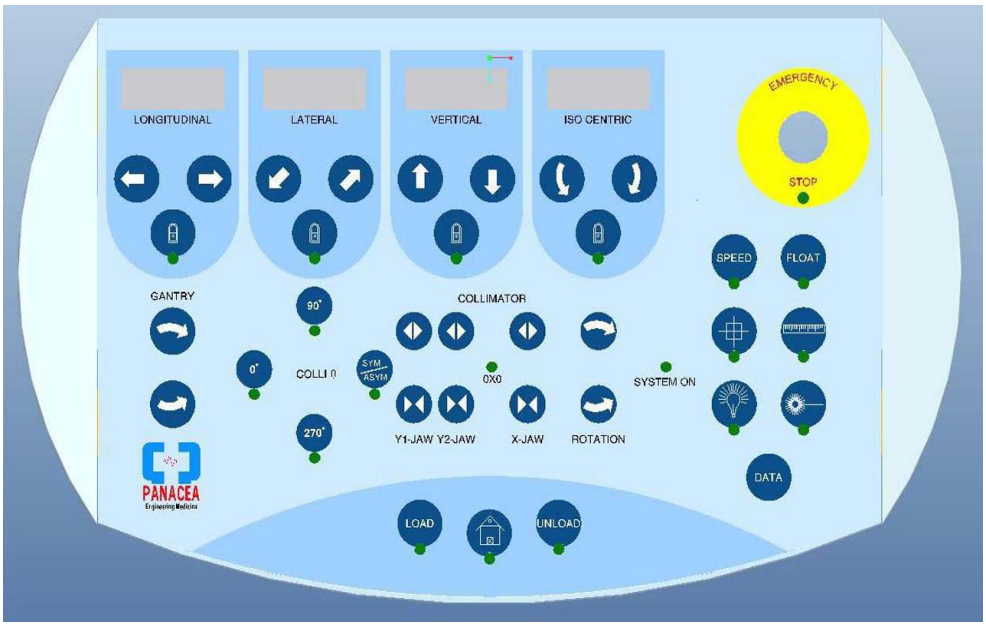
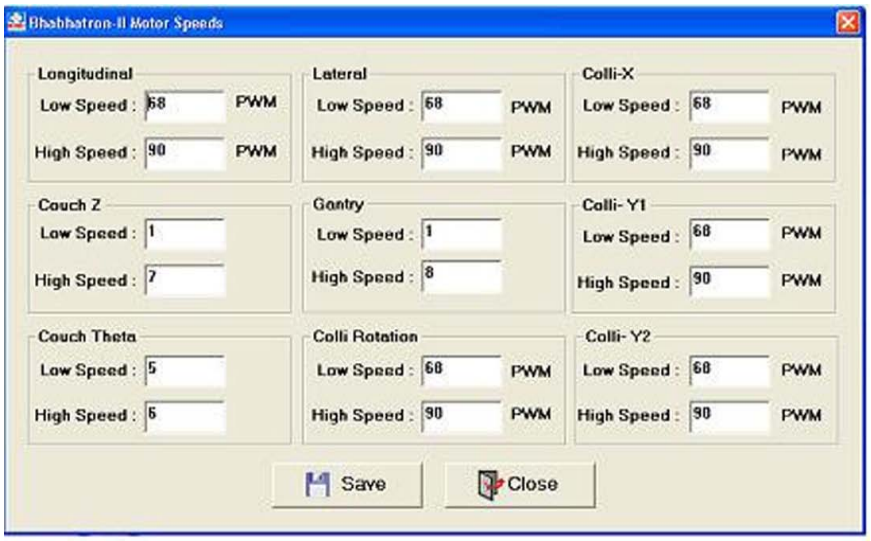


Fig. 2 : Key Pads attached in the Couch

are controlled by Hand Pendant whereas in Bhabhatron the mechanical motions are executed by keypads attached towards both sides of the couch. These Key pads have the digital display of Couch Values such as Longitudinal, Lateral, and Vertical & Isocentric Rotations. These pads control the collimator, Gantry & Couch motions. The first four key sets arranged in order is for controlling the Longitudinal, Lateral, Vertical and Isocentric rotation of the couch movement. Each key has a lock to fix the couch in the desired position which helps for accurate patient immobilization. It is not inevitable to use these motion keys every time since the motion enable key attached at both ends of the keypad restrict the motions of all the parameters unless enabled. Moving downwards there are keys provided for the Gantry rotation for clock and anticlockwise movements. Followed to that the keys for X and Y Jaw movement is provided. The movement of Couch, Gantry can be speeded up by the help of speed up switch provided in the key pad. The keys for field light, ODI scale, laser and room lights are provided in the keypad for easy patient setup.

c) Accessories velocity adjustment

The velocity i.e the speed of the mobile accessories, which are part of the machine such as couch, secondary collimator and Jaws, shall be programmed in the control software. The motor speed values shall be modified in the motor speed column by entering the desired PWM (pulse width modulation) values in the control console. As the mechanical accessories can be displaced in speed mode and normal mode with the help of enabling and disabling the speed switch the PWM values differ for these two modes. Providing the values as described in the figure will control the speed of the DC motors. The entered values will alter the duty cycle of the pulse to control the speed of the motors.



d) Control Console

The Control Console of Bhabhatron-II machine is computer controlled. The Beam On procedure happens through Mouse click which differs this machine a lot from other conventional machines. The treatment shall be given in two methods; they are namely Treatment Mode & Service Mode. The Treatment mode shall mainly be used for daily scheduled fractions. In this mode the patient treatment shall be programmed; The Collimator values (Field Size), Collimator, Gantry & Couch Rotation shall be entered through a valid id for every patient and be saved. The desired patient shall be opened for every fraction by entering the Valid ID number. The plan parameters will automatically be displayed.

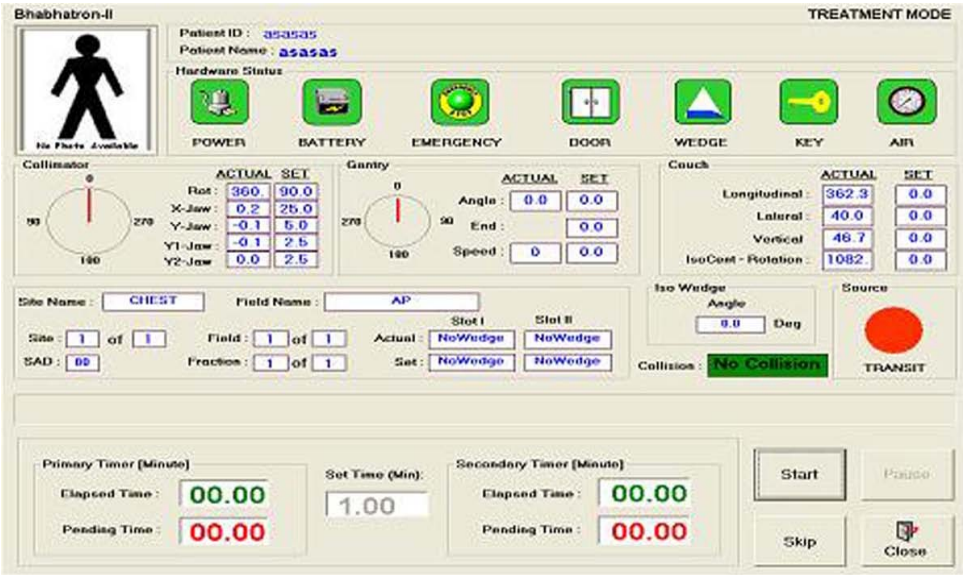


Fig. 3 : The console screen of Bhabhatron-II

The collimator values will automatically be set as entered in the Patient Record. The couch and Gantry shall be moved manually taking the display as reference. The Physicist shall enter all the parameters on the first fraction by creating a Record of individual patient. The patient details such as Name, ID No shall be provided for identification and for subsequent opening for daily fractions. The no of fractions to be delivered shall be entered in the next phase; then follows the plan parameter phase which demands the values of Filed size, Collimator Angle, Gantry Angle, Name of the Field, details of wedge etc. In case of executing the treatment through computerized 3D planning the couch values shall be entered after completing the CT Isocentre shift to the Treatment Isocenter. Another way of executing the treatment is through service mode. Executing treatment through computer controlled is a remarkable achievement in

Telecobalt Treatment which ensures the patient received proper treatment and manual errors are reduced considerably.

The service mode shall be used for unplanned fractions such as single fractions for palliative cases. There is no provision to enter the plan parameters in the service mode; The plan parameters shall be set in the machine through keyboard. The treatment time of the patient shall only be entered in the service mode and the Beam ON procedure shall be performed through mouse click. From the Treatment Console Screen we can get the details such as Power status of the machine, Battery Status, Door Status (Opened or Closed), placing of wedge, status of key, pressure status and mainly Source Status in color. Once all the parameters are set the treatment shall be executed through Mouse click. The source Transit is indicated in terms of RED color and the source ON position is indicated in terms of yellow color. The Primary timer and secondary timer will start displaying the elapsed time and pending time. The treated patient detail will be stored in the patient history. A detailed History of patients treated daily & weekly wise can be taken out as a printed copy.

V. Discussion & Conclusion

The Telecobalt units have disadvantages of penumbra & dose rate decay; But still these machines are preferred in developing countries due to less maintenance cost. For large countries like India based on the incident spectrum of malignancies prevailing, World Health Organization (WHO) recommended telecobalt machines as a simple effective equipment [5]. Dinshaw advocated the need to revisit the context of cost effectiveness, cost benefit, and cost-utility analysis in Indian perspective and to strike the right balance between the science of technology and the art of medicine, with special relevance to radiotherapy in cancer treatments[6] Though this machine has advanced features such as asymmetric collimator, motorized wedge etc it can never compete with the Linear Accelerator since fundamentally it is a Telecobalt unit with radioactive source which decays when time passes. This machine stands superior with among other Telecobalt units having the above mentioned features. The Theratron Equinox model has the same features such as asymmetric jaws, motorized wedge etc and stands at par with Bhabhatron. In today scenario the cost of the Telecobalt source has increased to a significant extent which made the Oncology community to rethink the purchase of Telecobalt units. The process of commissioning is always dependent on the availability of the source. This country faces acute shortage of Telecobalt source as so many institutions are waiting in long queue.

This machine shall be configured in the Treatment Planning System for accurate calculation and dose delivery. The 3D Planning will result in proper usage of asymmetric jaws and motorized wedges etc. The Head & Neck cancer patients shall receive effective lymp node irradiation due to the feasibility of LAN technique with the help of Y1 & Y2 Jaws. The Ca Breast patients will receive single Isocentre Treatment as the MT, LT fields & SCF fields will be treated with simultaneously with single isocentre. Also mounting the heavy Breast cone by the Technologists is eliminated due to the same asymmetric feature.

We conclude that the machine has advanced features from other conventional Telecobalt machines. The use of this machine shall be enhanced by commissioning this unit in the Treatment Planning System. The source cost and its availability still a disadvantage to its progress. Being an indigenous product this unit gives a pride to this Indian country and this country's dependency on foreign nation for radiotherapy units is reduced.

VI. Acknowledgement

The author would like to thank all the Radiation Oncologists in the Department of Radiation oncology and Radiotherapy Technologist, Acharya Tulsi Regional cancer treatment and Research Institute, Bikaner.

References Références Referencias

1. Characterizing and configuring motorized wedge for a new generation telecobalt machine in a treatment planning system, Rajesh A. Kinhikar, Smriti Sharma, Rituraj Upreti, Chandrashekhar M. Tambe, Deepak D. Deshpande Department of Medical Physics, Tata Memorial Hospital, Parel, Mumbai - 400012, India.
2. Dai J, Zhu Y, Ji Q. Optimizing beam weights and wedge filters with the concept of the super-omni wedge. Med Phys 2000;27:2757-62.
3. Van Dyk J, Barnett RB, Cygler JE, Shragge PC. Commissioning and quality assurance of treatment planning computers. Int J Radiat Oncol Biol Phys 1993;26:261-73.
4. Bhabhatron-II User Guide version 4.4, Panacea Medical Technologies.
5. Optimisation of radiotherapy treatment facilities. Technical Report Series 644, World Health Organization (WHO), Geneva, 1980.
6. Has the time come for doing away with Cobalt-60 teletherapy for cancer treatments, Editorial, Journal of Medical Physics, Vol 34, No.2, 2009.