Sudan University of Science and Technology

College of Graduate Studies

The Effect of High Voltage and Emission Current in X-Ray Tube on Sodium Chloride (NaCl) Crystal

تأثير الجهد العالي و تيار الأنبعاث فى أنبوبة الاشعة السينية على بلورة كلوريد الصوديوم

Thesis submitted in partial for requirement of the degree of master in physics (solid state)

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December 2020

الأيــة

بسم الله الرحمن الرحيم

قال تعالى (قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا ۖ إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ)(32)

صدق الله العظيم

سورة البقرة

Dedication

I dedicate to my parents, and to my family

Acknowledge

My praise and thanks to Allah, who give me the strength to conduct such work

I am greatly indebted to my

Thanks are also due to all those who helped and encouraged me to do this work.

Abstract

In this thesis, the effect of changes of high voltage and emission current in X-Ray Tube was verified on the rate of penetration through NaCl crystallization (NaCL). Where was checked the effect of applied high voltage used to accelerate electrons to produce X-ray also emission current were investigated as a function of penetrating rate with different angle of incidence on sodium chloride (NaCL) Crystal as nondestructive testing method the method was used in case of changing the applied voltage and fixing the emission current to 1 mA it was revealed increase of penetrating rate with increasing the applied voltage and decreasing with increasing of angle of incidence.

In case of fixing the accelerated voltage at 35 KV and changing the emission current (0.6, 0.8 and 1 mA) it was revealed logarithmic decay with higher penetrating rate 1 mA than 0.8 mA.

المستخلص

تم في هذا البحث التحقق من أثر تغير الجهد العالى وتيار الانبعاث فى أنبوبة الاشعة السينية على معدل الاختراق خلال بلورة كلوريد الصوديوم (NaCL).حيث تم فحص تأثير الجهد العالي المطبق المستخدم لتسريع الإلكترونات لإنتاج الأشعة السينية وايضا الإنبعاثات الحالية كدالة لمعدل الاختراق بزاويا سقوط مختلفة على بلورة كلوريد الصوديوم (NaCL) بطريقة الاختبار اللإتلافي، تم استخدام الطريقة في حالة تغيير الجهد المطبق وتثبيت تيار الانبعاث إلى 1 مللي أمبير وُجد أن هنالك زيادة فى معدل الاختراق مع زيادة الجهد المطبق وتناقصه مع زيادة زاوية السقوط.

وفي حالة تثبيت الجهد المتسارع عند 35 كيلو فولت وتغيير تيار الانبعاث (0.6 ، 0.8 ، 1 مللي أمبير) وُجد أن هنالك اضمحلال لوغاريثمي عند معدل اختراق أعلى 1 مللي أمبير من 0.8 مللي أمبير.

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CHAPTER ONE

INTRODUCTION

1.1 Preface

X-Ray and Ultra- Sound testing nondestructive tests are often used to determine the physical properties of materials such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength, but discontinuities and differences in material characteristics are more effectively found.

1.2 Research Problem

I-V characteristics is important in defining the electrical properties of sample, so it was necessary to contact the effect of applied high voltage and emission current to produce high energy photon and subject if to crystals as non destructive methods.

1.3 Research Objectives

i. The effect of High voltage in x-ray tube on penetrating rate through the NaCL crystal.
ii. The effect of emission current in x-ray tube on penetrating rate through NaCL Crystal.

1.4 Research Methodology

This thesis was carried out using X- ray device.

1.5 Thesis Layout

This research contains four chapters; chapter one introduction, chapter two Non-Destructive Testing, Chapter three The X-Ray Radiation Techniques, Chapter four Material, results and Method, while chapter five consists of Discussion n and Conclusion.

CHAPTER TWO

X – RAY PRODUCTION AND NONDESTRUCTIVE TESTING

2.1 Introduction

X-ray was discovered by Wilhelm Conard Rontgen in November 1895 accidentally when he noticed that with enough voltage supplied to the tube that contain a cathode ray and anode

Electromagnetic radiation emitted by charge particles (usually electron) in changing atomic energy level (characteristic x-ray) or in slowing down Coulomb force field (white or bremsstrahlung) the energy of x-ray ranging from low energy (soft x-ray) to megavoltage X-Ray[1, 2].

X-rays are electromagnetic radiation, emitted either:

a) As a result of the interaction of the charged particles (mainly light particles such as the electrons) with the negative orbital electrons or the positive atomic nuclei or,

b) As a result of the transfer of an orbital electron from an orbit with higher energy to another one with lower energy. So, based on the origin of x-ray there are two types which are:

1- **Bremsstrahlung**: the bremsstrahlung x-rays, is the x-rays which are emitted from x-ray tubes as a result of acceleration of the electrons by a voltage difference, and then braking these electrons by high Z elements (e.g. in the electric field of the orbital electrons and nuclei). These bremsstrahlung rays are characterized by a continuous energy spectrum, (e.g. energies of the photons may vary from zero up to the maximum energy of the accelerated electrons). With some approximation, the average energy of the x-ray photons may be considered equal 0ne third of the energy of the accelerated electrons.

2- **Characteristic X-Rays:** the characteristic x-rays, is these x-rays which are emitted as a result of the transfer of an electron from an orbit with higher energy to another one with lower energy, when there is an electron vacancy in the lower shell. Since electronic orbits have definite discrete energy values for each element, there will be a characteristic x-ray discrete spectrum for each element. This means that x-ray will be emitted from all atoms of same element with the same definite energy values, which are characteristic values for this element.

The frequencies of these rays lay in the region from about $1x10^{10}$ up to about $1x10^{22}$ Hz and even higher. So, the x and gamma radiation are widely overlapping with respect to their energies.

2.2 X-Ray Productions

X-Ray Produced when electrons (within filament usually prefer tungsten has melting temperature $3370^{0}C$) produced by thermionic emission in the cathode accelerated towards anode (usually prefer tungsten have a greater atomic number $Z = 74$) by potential that applied. When the electrons hit target of tungsten there was two possibility: accelerated electron interact with electrons in the inner shell ejected it due to coulomb interaction then rearrangement of atomic electrons results with the release of the elements characteristic x-ray, or some Beta particles, particularly those with higher energy, may travel close to the positively charged nuclei of absorber atoms. These particles will experience an attractive force which causes them to be deflected, thus losing energy which appears in the form Bremsstrahlung (continuous-ray) [1, 2].

Whenever charged particles (electrons or ions) of sufficient energy hit a material, X-rays are produced.

2.3 Production by Electrons

X-rays can be generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate the electrons released by a hot cathode to a high velocity. The high velocity electrons collide with a metal target, the anode, creating the X-rays [3]. In medical X-ray tubes the target is usually tungsten or a more crack resistant alloy of rhenium (5%) and tungsten (95%), but sometimes molybdenum for more specialized applications, such as when softer X-rays are needed as in mammography. In crystallography, a copper target is most common, with cobalt often being used when fluorescence from iron content in the sample might otherwise present a problem.

The maximum energy of the produced X-ray photon is limited by the energy of the incident electron, which is equal to the voltage on the tube times the electron charge, so an 80 kV tube cannot create X-rays with an energy greater than 80 keV. when the electrons hit the target, X-rays are created by two different atomic processes:

1. Characteristic X-ray emission (X-ray electroluminescence): If the electron has enough energy, it can knock an orbital electron out of the inner electron shell of the target atom. After that, electrons from higher energy levels fill the vacancies, and X-ray photons are emitted. This process produces an emission spectrum of X-rays at a few discrete frequencies, sometimes referred to as spectral lines. Usually these are transitions from the upper shells to the K shell (called K lines), to the L shell (called L lines) and so on. If the transition is from 2p to 1s, it is called Kα, while if it is from 3p to 1s it isK_β. The frequencies of these lines depend on the material of the target and are therefore called characteristic lines. The Kα line usually has greater intensity than the $K_\beta$one and is more desirable in diffraction experiments. Thus the K_β line is filtered out by a filter. The filter is usually made of a metal having one proton less than the anode material (e.g., Ni filter for Cu anode or Nb filter for Mo anode) [4].
2. Bremsstrahlung: This is radiation given off by the electrons as they are scattered by the strong electric field near the high-Z (protonnumber)

nuclei. These X-rays have a continuous spectrum. The frequency of bremsstrahlung is limited by the energy of incident electrons.

So, the resulting output of a tube consists of a continuous bremsstrahlung spectrum falling off to zero at the tube voltage, plus several spikes at the characteristic lines. The voltages used in diagnostic X-ray tubes range from roughly 20 kV to 150 kV and thus the highest energies of the X-ray photons range from roughly 20 keV to 150 keV [4].

Both of these X-ray production processes are inefficient, with only about one percent of the electrical energy used by the tube converted into X-rays, and thus most of the electric power consumed by the tube is released as waste heat. When producing a usable flux of X-rays, the X-ray tube must be designed to dissipate the excess heat.

A specialized source of X-rays which is becoming widely used in research is synchrotron radiation, which is generated by particle accelerators. Its unique features are X-ray outputs many orders of magnitude greater than those of X-ray tubes, wide X-ray spectra, excellent collimation, and linear polarization [5].

Short nanosecond bursts of X-rays peaking at 15-keV in energy may be reliably produced by peeling pressure-sensitive adhesive tape from its backing in a moderate vacuum. This is likely to be the result of recombination of electrical charges produced by triboelectric charging. The intensity of X-ray triboluminescence is sufficient for it to be used as a source for X-ray imaging [6].

2.4 Production by Fast Positive Ions

X-rays can also be produced by fast protons or other positive ions. The proton-induced X-ray emission or particle-induced X-ray emission is widely used as an analytical procedure. For high energies, the production cross section is proportional to Z12Z2−4, where Z1 refers to the atomic number of the ion, Z2 refers to that of the target atom [7]. An overview of these cross sections is given in the same reference.

2.5 Production in Lightning and Laboratory Discharges

X-rays are also produced in lightning accompanying terrestrial gamma-ray flashes. The underlying mechanism is the acceleration of electrons in lightning related electric fields and the subsequent production of photons through Bremsstrahlung [8]. This produces photons with energies of some few keV and several tens of MeV [9]. In laboratory discharges with a gap size of approximately 1 meter length and a peak voltage of 1 MV, X-rays with a characteristic energy of 160 keV are observed [10]. A possible explanation is the encounter of two streamers and the production of high-energy run-away electrons[11]; however, microscopic simulations have shown that the duration of electric field enhancement between two streamers is too short to produce a significantly number of run-away electrons[12] . Recently, it has been proposed that air perturbations in the vicinity of streamers can facilitate the production of run-away electrons and hence of X-rays from discharges [13, 14].

2.6 Uses of X-ray

X-ray has many used in both main fields:

2.6.1 Medical Field

There are many uses of radiation in medicine. The most well-known is using x-ray to see whether bones are broken. The broad area of x-ray use is called radiology. Within radiology, we find more specialized areas like mammography, computerized tomography (CT), and nuclear medicine (the specialty where radioactive material is usually injected into the patient). Another area of x-ray use is called cardiology where special x-ray pictures are taken of the heart.

There are additional areas in medicine using radiation. These are for treatment of disease or cancer and are commonly called therapy. A subspecialty in nuclear medicine is nuclear medicine therapy. A common example of nuclear medicine therapy is the use of radioactive iodine to treat thyroid problems, including thyroid cancer. A subspecialty of oncology (the study and treatment of cancer) is radiation oncology. As the name suggests, this area of oncology focuses on the use of radiation to treat cancer [1, 2].

2.6.2 Industrial Field

X-rays are used in business and industry in many other ways. For example, x-ray pictures of whole engines or engine parts can be taken to look for defects in a nondestructive manner. Similarly, sections of pipe lines for oil or natural gas can be examined for cracks or defective welds. Airlines also use x-ray detectors to check the baggage of passengers for guns or other illegal objects [1, 2].

In recent years an interesting new source of x rays has been developed called synchrotron radiation. Many particle accelerators accelerate charged particles such as electrons or protons by giving them repeated small increases in energy as they move in a circular path in the accelerator. A circular ring of magnets keeps the particles in this circular path. Any object moving in circular path experiences acceleration toward the center of the circle, so the charged particles moving in these paths must radiate and therefore lose energy. Many years ago, the builders of accelerators for research in nuclear physics considered this energy loss a nuisance, but gradually scientists realized that accelerators could be built to take advantage of the fact that this radiation could be made very intense. Electrons turn out to be the best particle for use in these machines, called electron synchrotrons, and now accelerators are built for the sole purpose of producing this radiation which can be adjusted to produce radiation anywhere from the visible region up to the X-ray region. This synchrotron radiation, from which very intense beams at nearly one wavelength can be produced, is extremely useful in learning about the arrangement of atoms in various compounds of interest to biologists, chemists, and physicists.

One of the more important commercial applications of synchrotron radiation is in the field of x-ray lithography, used in the electronics industry in the manufacture of high-density integrated circuits. The integrated circuit chips are made by etching successive layers of electric circuitry into a wafer of semiconducting material such as silicon. The details of the circuitry are defined by coating the wafer with a light sensitive substance called a photoresist and shining light on the coated surface through a stencil like mask. The pattern of the electric circuits is cut into the mask and the exposed photoresist can easily be washed away leaving the circuit outlines in the remaining photoresist. The size of the circuit elements is limited by the wavelength of the light-the shorter the wavelength the smaller the circuit elements. If x rays are used instead of light, the circuits on the wafer can be made much smaller and many more elements can be put on a wafer of a given size, permitting the manufacture of smaller electronic devices such as computers[1, 2].

2.7 Advantages and Disadvantages of Using X-Ray

There were many advantages of using x-ray in both medical an industry field:

2.7.1 Advantages of X-Rays

- X-rays are used to treat malign tumors before its spreads throughout the human body.
- Help radiologists identify cracks, infections, injury, and abnormal bones.
- help in identifying bone cancer.
- X-rays help in locating alien objects inside the bones or around them.

2.7.2 Disadvantages of X-Rays

- X-rays make our blood cells to have higher level of hydrogen peroxide which could cause cell damage.
- A higher risk of getting cancer from X-rays.
- The X-rays are able to change the base of the DNA causing a mutation [15, 16].

2.8 Nondestructive Testing (NDT)

Nondestructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used.

In contrast to NDT, other tests are destructive in nature and are therefore done on a limited number of samples ("lot sampling"), rather than on the materials, components or assemblies actually being put into service.

Today modern nondestructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public.

It should be noted that while the medical field uses many of the same processes, the term "nondestructive testing" is generally not used to describe medical applications [17, 18].

Ultrasonic Testing (UT) uses high frequency sound energy to conduct examinations and make measurements. Ultrasonic inspection can be used for flaw detection/evaluation, dimensional measurements, material characterization, and more. To illustrate the general inspection principle, a typical pulse/echo inspection configuration as illustrated below will be used.

A typical UT inspection system consists of several functional units, such as the pulsar/receiver, transducer, and display devices. A pulsar/receiver is an electronic device that can produce high voltage electrical pulses. Driven by the pulsar, the transducer generates high frequency ultrasonic energy. The sound energy is introduced and propagates through the materials in the form of waves. When there is a discontinuity (such as a crack) in the wave path, part of the energy will be reflected back from the flaw surface. The reflected wave signal is transformed into an electrical signal by the transducer and is displayed on a screen. In the applet below, the reflected signal strength is displayed versus the time from signal generation to when an echo was received. Signal travel time can be directly related to the distance that the signal traveled. From the signal, information about the reflector location, size, orientation and other features can sometimes be gained.

Ultrasonic Inspection is a very useful and versatile NDT method. Some of the advantages of ultrasonic inspection that are often cited include:

- It is sensitive to both surface and subsurface discontinuities.
- The depth of penetration for flaw detection or measurement is superior to other NDT methods.
- Only single-sided access is needed when the pulse-echo technique is used.
- It is highly accurate in determining reflector position and estimating size and shape.
- Minimal part preparation is required.
- Electronic equipment provides instantaneous results.
- Detailed images can be produced with automated systems.
- It has other uses, such as thickness measurement, in addition to flaw detection [17, 18].

As with all NDT methods, ultrasonic inspection also has its limitations, which include:

- Surface must be accessible to transmit ultrasound.
- Skill and training is more extensive than with some other methods.
- It normally requires a coupling medium to promote the transfer of sound energy into the test specimen.
- Materials that are rough, irregular in shape, very small, exceptionally thin or not homogeneous are difficult to inspect.
- Cast iron and other coarse-grained materials are difficult to inspect due to low sound transmission and high signal noise.
- Linear defects oriented parallel to the sound beam may go undetected.
- Reference standards are required for both equipment calibration and the characterization of flaws.

The above introduction provides a simplified introduction to the NDT method of ultrasonic testing. However, to effectively perform an inspection using ultrasonic, much more about the method needs to be known. The following pages present information on the science involved in ultrasonic inspection, the equipment that is commonly used, some of the measurement techniques used, as well as other information [17, 18].

2.9 Nondestructive Testing (NDT) Techniques

1. Magnetic Particle Testing (MT)
2. PT Techniques
3. UT Techniques
4. ET Techniques
5. RT Techniques

2.10 RT Techniques

- **Film Radiography**

Film radiography uses a film made up of a thin transparent plastic coated with a fine layer of silver bromide on one or both sides of the plastic. When exposed to radiation these crystals undergo a reaction that allows them, when developed, to convert to black metallic silver. That silver is then "fixed" to the plastic during the developing process, and when dried, becomes a finished radiographic film.

- **Computed Radiography**

Computed radiography (CR) is a transitional technology between film and direct digital radiography. This technique uses a reusable, flexible, photo-stimulated phosphor (PSP) plate which is loaded into a cassette.

- **Computed Tomography**

Computed tomography (CT) uses a computer to reconstruct an image of a cross sectional plane of an object as opposed to a conventional radiograph, as shown in Figure 9

- **Digital Radiography**

Digital radiography (DR) digitizes the radiation that passes through an object directly into an image that can be displayed on a computer monitor. The three principle technologies used in direct digital imaging are amorphous silicon, charge coupled devices (CCDs), and complementary metal oxide semiconductors (CMOSs) [19].

CHAPTER THREE
THE INTERACTION of X-RAY WITH MATTER

3.1 Introduction

An X-ray, or X-radiation, is a penetrating form of high-energy electromagnetic radiation. Most X-rays have a wavelength ranging from 10 Pico meters to 10 nanometers, corresponding to frequencies in the range 30 Peta hertz to 30 exa hertz (30×10^{15}Hz to 30×10^{18} Hz) and energies in the range 124 eV to 124 keV. X-ray wavelengths are shorter than those of UV rays and typically longer than those of gamma rays [20].

3.2 Interaction of X-Rays with Matter

Röntgen’s studies in the late nineteenth and early twentieth centuries quickly established the penetrating nature of X-Rays, and the potential for medical imaging was soon realized. However, the interaction of X-Rays with matter is more complex than simply ‘passing through’. On reaching a material, some of the x-rays will be absorbed, and some scattered – if neither process occurs, the X-Rays will be transmitted through the material.

When absorption occurs, the X-Rays interact with the material at the atomic level, and can cause subsequent fluorescence – it is this X-Ray Fluorescence which forms the basis of XRF spectroscopy, and the process is discussed in more detail in the next section. In addition to the absorption/fluorescence process, the X-Rays can also be scattered from the material. This scattering can occur both with and without loss of energy, called Compton and Rayleigh scattering respectively [20].

The ratio of absorption/fluorescence, Compton and Rayleigh scatter and transmission depends on the sample thickness, density and composition, and the X-Ray energy.

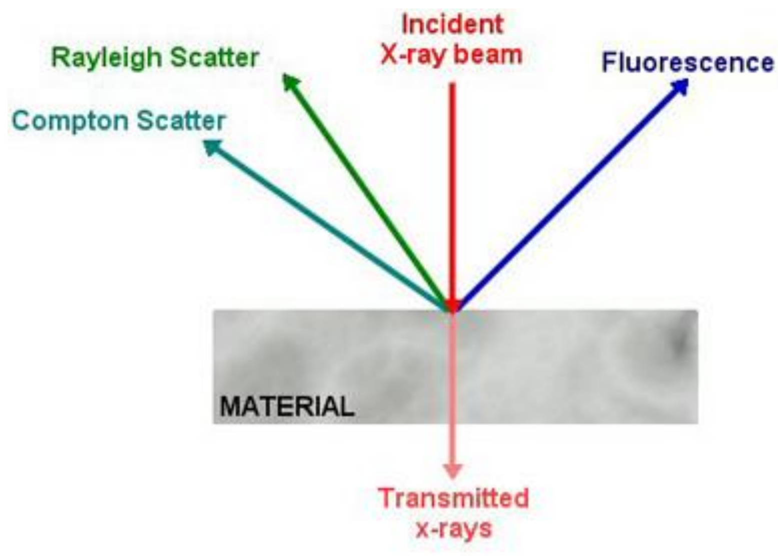

Figure (3.1): X-Ray Interactions with Matter

X-rays interact with matter in three main ways, through photo absorption, Compton scattering, and Rayleigh scattering. The strength of these interactions depends on the energy of the X-rays and the elemental composition of the material, but not much on chemical properties, since the X-ray photon energy is much higher than chemical binding energies. Photo absorption or photoelectric absorption is the dominant interaction mechanism in the soft X-ray regime and for the lower hard X-ray energies. At higher energies, Compton scattering dominates [20].

- **Photoelectric interaction (PE)**

All of the incident photon energy transferred to an electron, which is ejected from the atom. The kinetic energy of the ejected photo-electron E_e is equal to the incident photon energy E_0 minus the binding energy of the orbital electron E_b .i.e.

$$E_e = E_o - E_b \tag{3.1}$$

In order for photoelectric absorption to occur, the incident photon energy must be greater than or equal to the binding energy of the electron that is ejected. The ejected electron is most likely one whose binding energy is close to, but less than, the incident photon energy. Following a photoelectric interaction, the atom is ionized, with an inner shell electron vacancy. An electron from a shell a lower binding energy will fill this vacancy. This creates another vacancy, which in turn filled by an electron from an even lower binding energy shell. Thus, an electron cascade from outer to inner shells occurs. The difference in binding energy is released as characteristic x-ray or auger electron. The possibility of characteristic x-ray emission decreases as atomic number of absorber decreases. The probability of photoelectric absorption per unit mass is approximately proportional to Z^3/E^3.where Z is the atomic number and E is incident photon energy[21, 22].

- **Compton Scattering**

Which is known as incoherent scattering, occurs when the incident x-ray photon ejects an electron from an atom and x-ray photon of lower energy is scattered from the atom. Relativistic energy and momentum are conserved in this process and the scattered x-ray photon has less energy, therefore greater wavelength than incident photon. Compton scattering is important for low atomic number specimens. At energies of 100kev-10kev the absorption of radiation mainly due to the Compton effect.

- **Pair production**

Occur when the x-ray photon energy is greater than $1.022 MeV$, when an electron and positron are created. Positron are very short lived and disappear (positron annihilation) with the formation of two photons of $0.511 MeV$ energy. Pair production is of particular importance when high energy photons pass through material of high atomic number.

- **Rayleigh scattering**

Occur when the x-ray photon interacts with the whole atom so that photon is scattered with no charge in internal energy to the scattering atom, Rayleigh scattering is never more than a minor contributor to the absorption coefficient. The scattering occur without the loss of energy [21, 22].

CHAPTER FOUR
MATERIAL AND METHOD

4.1 Introduction

In this chapter the practical work which was done using X-ray apparatus was conducting.

4.2Method

X-ray used to study the effect of the high voltage and emission current penetrating rate in NaCL crystal.

4.3 Methodology

i. Applying high voltage 20, 25, 30, 32, 34 and 35 KV with different angle of incidence.
ii. Applying emission current of 0.4, 0.8 and 1 MA with different angle of incidence.

4.4 Setup

Set up the experiment.

X-rayapparatus. 554 811

Or 1 X-ray apparatus. . . . . 554 812 1 Goniometer. 554 83

End-window counters for a, b, g and x-ray radiation. 559 01

Collimator was mounted in the collimator mounts

(a) (Note the guide groove). The goniometer was attached to guide rods

(d) And connected ribbon cable

(c) For controlling the goniometer.

Then the protective cap was removed of the end-window counter, place the end-window counter in sensor seat

(e) And the counter tube was connected cable to the socket in the experiment chamber marked GM TUBE.

Demount the target holder

(g) Target stage from the holder of the goniometer was removed.

The guide edge Placed of the set of absorbers I (f) in the 908 curved groove of the target holder and carefully slide it into the target holder as far as it will go.

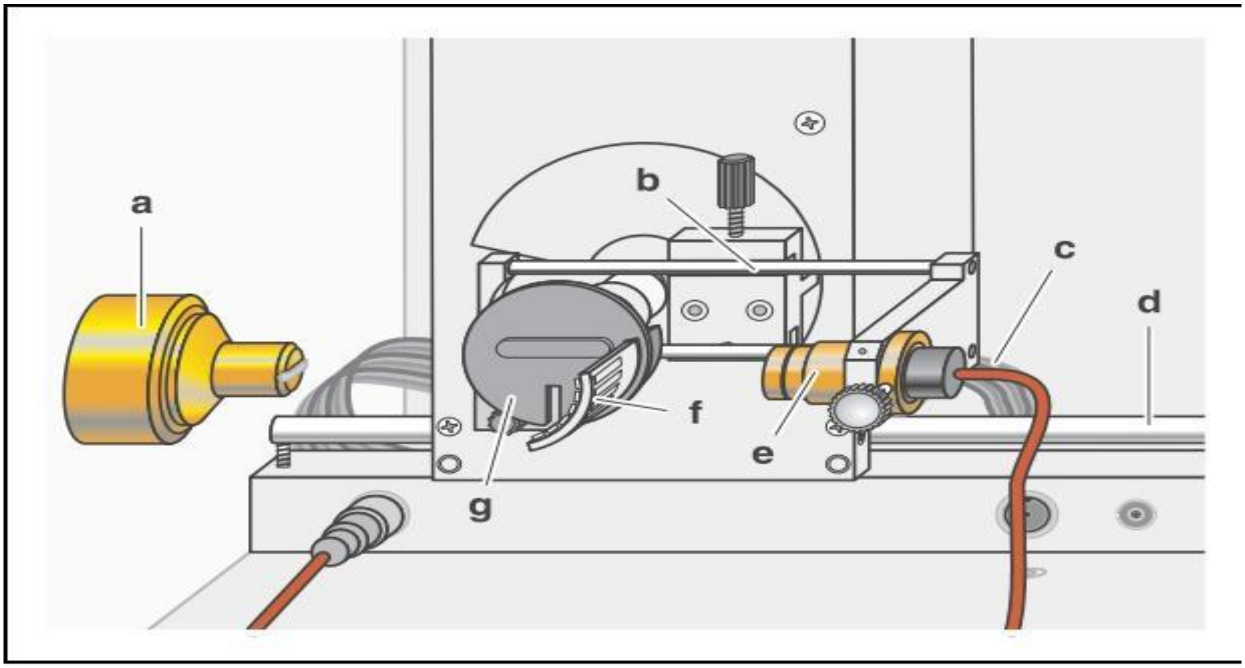

Figure (4.1): X-Ray Device

4.5 Results

Table (4.1) showing Results between angle of incidence and the penetrating rate

β^o	$R_0 s^{-1}$ V= 35 KV	$R_1 s^{-1}$ V= 34 KV	$R_2 s^{-1}$ V= 32 KV	$R_3 s^{-1}$ V= 30 KV	$R_4 s^{-1}$ V= 25 KV	$R_5 s^{-1}$ V= 20 KV
0	10132.20	8921.07	8449.67	7022.97	4612.37	8238.9
10	8981.67	10128.10	10069.53	3674.27	2650.20	4290.3
20	6456.57	8707.03	9384.77	2362.00	1659.23	2759.1
30	4399.00	6337.10	7331.70	1508.07	1018.83	1798.6
40	3183.50	4262.13	4899.50	903.40	601.30	1094.1
50	2572.10	3470.33	3977.63	639.20	420.53	783.7
60	1906.67	2602.77	3014.30	357.60	233.80	447.40

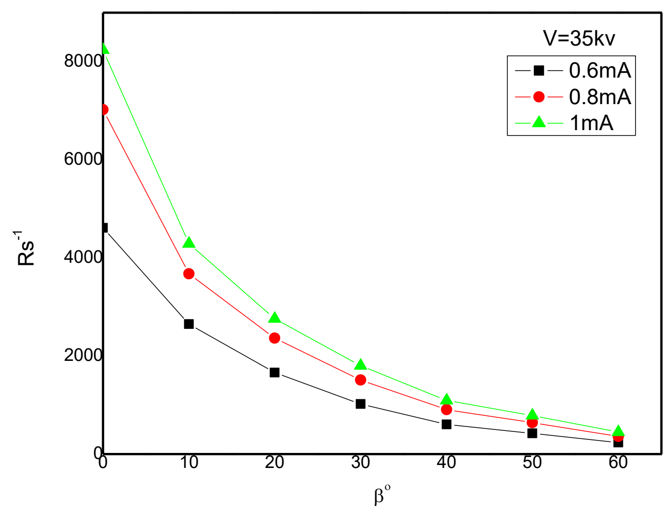

Figure (4.2): Relation between angle of incidence and the penetrating rate with V=35 kv and Different current

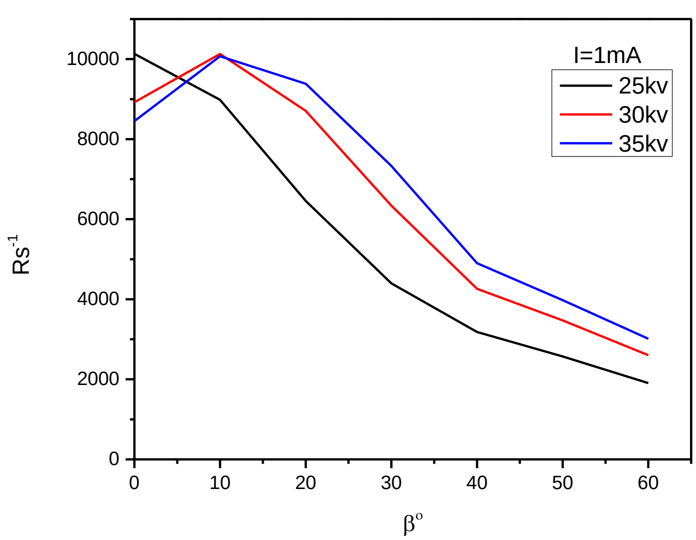

Figure (4.3): Relation between angle of incidence and the penetrating rate with I=1mA and Different Voltage

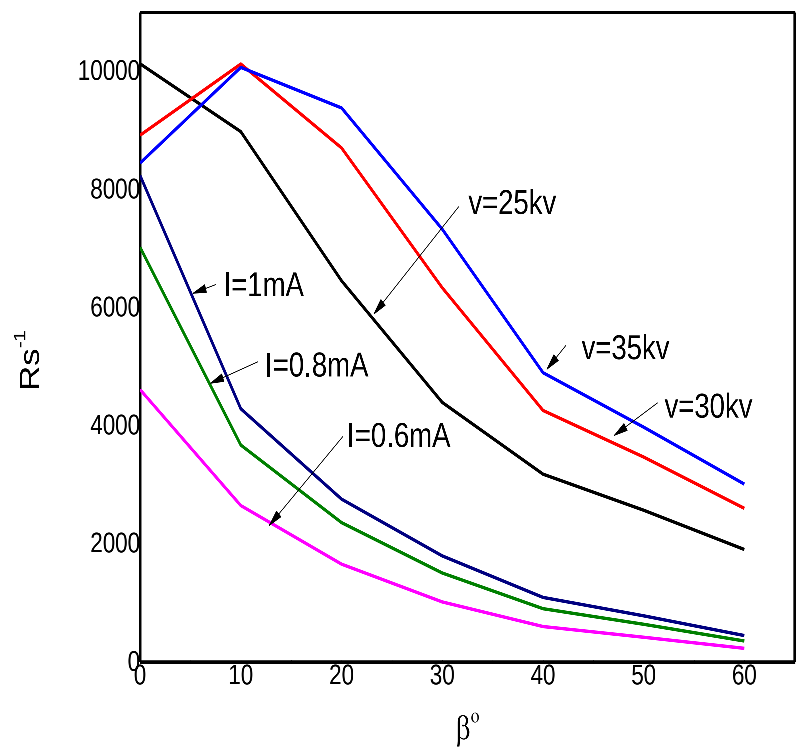

Figure (4.4): Relation between angle of incidence and the penetrating rate

CHAPTER FIVE

DISSOCIATION AND CONCLUSION

5.1Introduction

In this chapter, the results were analyzed, discussed, and a conclusion

5.2 Dissociation

Farm figure if was clear the penetrating rate of X-ray through the crystal is higher when the higher voltage increase and decreases with increase the angle of incidence In case Y increasing emission current with constant applied higher voltage (35KV) the penetrating rate increases but in low manner than that Y higher voltage and also decrease with increases the angle of incidence

5.3 Conclusion

It was clear that from the results obtained the high voltage and emission current applied in different angle is has great effect on the penetrating.

5.4 Recommendation

To Rate which depend upon increasing or decreasing the applied voltage and emission current

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