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Modelling The Relationship Between Thickness and Hardness With Energy Attenuation of x-ray for Pure Aluminum

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Abstract: In this paper the theortical relation between thickness and hardness with energy attenuation of x-ray for pure Aluminum has been calculated, and found the interrelation between this parameters given by the following: $I \alpha\ T^{-0.0064 \pm 0.0005}\ H^{0.16641 \pm 0.014}$. The average of the standard deviation for above relation is 0.012. Also, error rate accompanied to slope and constant values has been accounted for. The relation is essential because the energy attenuation can be recognized directly without radiating metal by x-ray to measure energy attenuation, rather by metal hardness and thickness.

Key words: Attenuation coefficients, Hardness, thickness, Aluminum.

INTRODUCTION

The attenuation of x-rays by materials provides a wide variety of information about the fundamental properties of matter at the atomic, molecular and solid-state levels. In particular, relative and absolute measurements of the mass attenuation coefficient are used to test theoretical predictions of photoelectric absorption using bound-state electron wavefunctions (Chantler *et al*., 2001)(Tran *et al*., 2003) to investigate the dynamics of atomic processes, including shake-up, shake-off and Auger transitions (Lindle 1988). and to provide information on the density of electronic states (Joly *et al*., 1999). molecular bonding and other solidstate properties (Sayers *et al*., 1971).

The diversity of these studies is evidence of the wide variety of processes that influence the attenuation of x-rays. In order to develop a better understanding of these processes, it is necessary to make accurate measurements, allowing each process to be isolated, studied and compared with theoretical models. While relative measurements are adequate for some comparisons with theory, absolute attenuation measurements provide an additional, crucial and demanding test of theoretical predictions. For example, while the finite-difference calculations of Joly (Joly 2001) have had significant recent success in predicting EXAFS on a relative scale, they are in relatively poor agreement with the results of absolute measurements (Chantler *et al*., 2001).

The lack of highly accurate measurements and current limitations faced by theoretical prediction provide serious barriers to the understanding of x-ray interactions with matter. Many independent measurements of x-ray attenuation coefficients have been published. Thesemeasurements exhibit considerable discrepancies (Hubbell 2003) which, in the 1980s, led the International Union of Crystallography (IUCr) to devote a multi-laboratory project to the investigation of their causes (Creagh. and Hubbell. 1990). An important conclusion of that project was that the discrepancieswere the result of an inadequate understanding of a wide range of random and systematic sources of uncertainty. In a number of recent reports (Dachun 1992: Unonius and Suortti 1989) it has been observed that, at accuracies between 0.5% and 2%, the dominant and limiting source of error in the measurement of mass attenuation coefficients is the inaccuracy in the determination of the thickness of the absorber along the path traversed by the x-ray beam.

The theory:

X-ray:

The principle that depends on the technique of production of x-ray was the spontaneous stopping of fast electrons after it collides with target material which it becomes a source of x-ray (Skofronick *et al*., 1992) when a beam of x-ray photons passes through attenuated material, each photon in the beam either it is not reacted absolutely with the medium material or it is reacted by absorption and scattering reactions, the beam
due to the removing of photons from it, it will suffer an attenuation, such attenuation may be intensity attenuation or energy attenuation, such that the intensity or the energy decreases along the path it cross it through this medium (Leo 1987).When a beam of monoenergetic photon falls with intensity (I_0) on a medium of thickness dx, the decreasing in intensity dI due to reaction of photons by scattering and absorption in the medium can be expressed by:

$$I = I_0 e^{-\mu x} \quad (1)$$

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The quantity $e^{-\mu x}$ represents the probability that the photon passes a distance (x) through the attenuated medium without reaction (Azzoz Assem Abdulkarim 1983). The x-ray have a various applications in medicine, radiography, in discovering the cracks in bridges and buildings, the corrosion friction in instruments and mineral tools, it is used in testing the foods, checking the bags and luggage in airports, in security purposes, in geology the x-ray plays a major rule in fluorescent &radiographic test and soil chemistry
(Normal *et al*., 2005)(Al-qaysee Ghazi Yaseen 2007).

The Data:

In this study, the data of metal hardness and thickness values and x-ray energy attenuation have been adopted as in following table (Alalusi. 2011).

Table 1: values of thickness, hardness and energy attenuation for pure Aluminum.

Thickness T(mm)	Hardness HV (kg/mm^2)	Energy attenuation I(kV)
1.2	62.90	3612
1.1	67.80	3665
1.0	72.02	3720
0.9	76.60	3765
0.8	78.80	3787
0.7	83.30	3820
0.6	85.50	3854
0.5	90.50	3871
0.4	94.90	3901
0.3	98.30	3937
0.2	101.20	3985
0.1	106.70	4015

Theoretical:

To find the thoretical relation that relate between metal thickness and hardness with penterating ray intensity for Aluminum it is hypothesized:

$$I \alpha T^{A} H^{B} \tag{2}$$

I: penterating ray intensity
T: metal thickness
H: metal hardness

Changing propotion relation to equality it is found:

$$I = C\, T^{A} H^{B} \tag{3}$$

C: constant propotion
Taking the two sides logarithm it is found:

$$\log I = A \log T + B \log H + \log C \tag{4}$$

It is hypothesized

$$(K = \log C) \tag{5}$$

Substituting equ (5) by (4) it is found:

$$\log I = A \log T + B \log H + K \tag{6}$$

To find the best correlation showing the relation between these parameters equation (6) has been adopted.
A and B: slope
K: constant value

To calculate the best value for A,B and K, a program has been made based- Least-Square Fitting by using MATLAB programs(see appendix A).

The values of A,B,K, root mean square (rms) and error rate accompanied to slope and constant values as seen in Table (2)

Table 2: values of A,B,K, root mean square (rms).

A	B	K	rms
-0.0064 ± 0.0005	**0.16641 ± 0.014**	**3.2612 ± 0.028**	**0.012**

Based on constant values it is concluded that the relation adopted in this study can be formed as follows:

$$I \alpha T^{-0.0064 \pm 0.0005} H^{0.16641 \pm 0.014} \quad (7)$$

According to this ralation (7) it seems that penterating ray intensity propotes inversly with metal thickness while it propotes linearly with metal hardness. The following figure shows the relationship between thickness and hardness with energy attenuation.

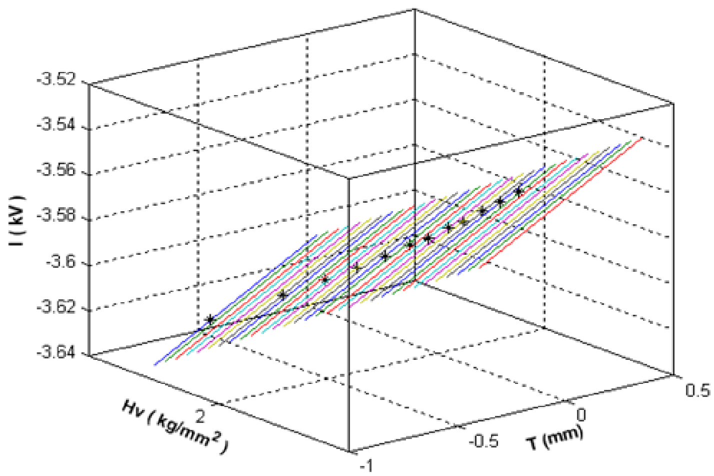

Fig. 1: The relationship between thickness and hardness with energy attenuation

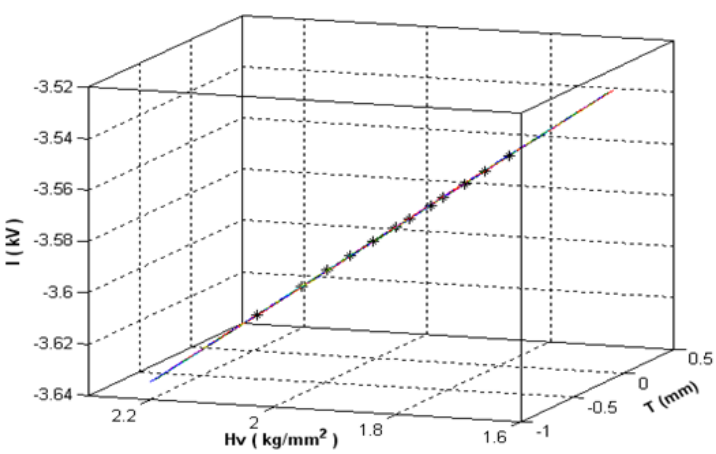

Fig. 2: Side view of figure(1).

RESULTS AND DISCUSSIONS

Figure(1) shows correlation between parameters under investigation. Through this figure it is observed that there is a significant between the parameters, and the standard deviation for the correlation is 0.012. This predicates many future discoveries in terms of x-ray attenuation because the energy attenuation can be recognized directly by metal hardness and thickness without radiating metal by x-ray to measure energy attenuation.

It seems that 'improved' physical models do not necessarily lead to improved agreement with experiment. However, in order to produce 'science' at this juncture it is necessary to question and criticise the models and their implementations to determine the causes of such observations. Empirical observation provides justification for the use of the less sophisticated model: however, unquestioning acceptance of the conclusions of such empirical observations denies insight into the underlying physics and its implementation (de Jonge. 2005).

Conclusions:

It is found that the correlationship between thickness and hardness with energy attenuation of x-ray for pure Aluminum is represented by the following.

$$I \alpha T^{-0.0064 \pm 0.0005} H^{0.16641 \pm 0.014}$$

1- Intensity propotes inversly with metal thickness while it propotes linearly with metal hardness.
2- Coefficients of x-ray attenuation can be accounted theortetically.

Appendix (A):

Reviewing program calculation values of A,B,K, root mean square (rms)

```
% To read  from file and to write to another file
 syms('NAME1', 'NAME2','INP', 'OK', 'N', 'I', 'J', 'A');
 syms('AA','FLAG','OUP');
 TRUE=1;
 FLAG=1;
 FALSE=0;
for i=1:1
   ydata=[];xdata=[];
 fprintf(1,'Input the name of the input data file\n');
 fprintf(1,'for example:  DATA.m\n');
 NAME2 = input(' ','s');
 INP = fopen(NAME2,'r');
 ss= fscanf(INP,'%c',40)
 fprintf(1,' ',ss)
  format short g
 fprintf(1,'Input the number of raws \n');
 N = input(' ');
   fprintf(1,'Input the number of coloum \n');
  M1 = input(' ');
  OK = FALSE;
   while OK == FALSE
            a = zeros(N,M1);
            for I = 1:N
               for J = 1:M1
                  a(I,J) = fscanf(INP, '%f',1);
               end;
            end;
   OK = TRUE;
%    fclose(INP);

   end;

  end
n=a(:,3);
M=a(:,2);
z=a(:,1);
figure(1)
Ln=log10(n);
Mure=log10(M);
```

```
Lren=log10(z);
xdata=[Lren    Mure];
ydata=Ln;
x1=[3.2611 -0.0061593 0.16635];
[xn,resnormn,residualn,exitflagn,outputn,lambdan] =lsqcurvefit(@myfun,x1,xdata,ydata)
B=xn(3)
A=xn(2)
b=(B)/((A))
k=xn(1)
rms=sqrt((resnormn)/((length(x))))
```

REFERENCES

Alalusi, S.M.I., 2011. " The effect of grain size for aluminum and some of its alloys on attenuation coefficents of x-ray", Department of Physics , College of education, University of tikrit, Iraq.

Al-qaysee, Ghazi Yaseen, 2007. "Principle of modern physics", 1st publ. Dar Almay Sara for publication, Amman, Jordan.

Azzoz, Assem Abdulkarim, 1983. "Introduction to nuclear physics", translated From English, Dar Alkutub for publishing and distribution, Mosul University.

Chantler, C.T., C.Q. Tran, D. Paterson, D.J. Cookson and Z. Barnea, 2001. " X-ray extended-range technique for precision measurement of the x-ray mass attenuation coefficient and Im(f) for copper using synchrotron radiation", Phys. Lett. A 286 338–46.

Chantler, C.T., C.Q. Tran, Z. Barnea, D. Paterson, D.J. Cookson and D.X. Balaic, 2001. "Measurement of the x-ray mass attenuation coefficient of copper using 8.85–20 keV synchrotron radiation", Phys. Rev. A 64: 062506/1-15.

Creagh, D.C. and J.H. Hubbell, 1990. "Problems associated with the measurement of x-ray attenuation coefficients: II. Carbon. Report on the International Union of Crystallography X-ray Attenuation Project", Acta Crystallogr, 46: 402-8.

Dachun, W., D. Xunliang, W. Xinfu, Y. Hua, Z. Hongyu, S. Xinyin and Z. Guanghua, 1992. "X-ray attenuation coefficients and photoelectric cross sections of Cu and Fe in the range 3 keV to 29 keV", Nucl. Instrum. Methods B 71: 241-8.

de Jonge, M.D., 2005. "High-accuracy measurements of the x-ray mass attenuation coefficients of molybdenum and tin: testing theories of photoabsorption", School of physics, The University of Melbourne, Australia.

Hubbell, J.H., J.S. Coursey, J. Hwang and D.S Zucker, 2003. Bibliography of photon total cross section (attenuation coefficient) measurements (version 2.3) http://physics.nist.gov/photoncs (originally published as: Hubbell J H 1994 NISTIR 5437 (Gaithersburg, MD: NIST)).

Joly, Y., 2001. "X-ray absorption near-edge structure calculations beyond the muffin-tin approximation", Phys. Rev. B 63: 125120/1-10.

Joly, Y., D. Cabaret, H. Renevier and C.R. Natoli, 1999. " Electron population analysis by full-potential x-ray absorption simulations", Phys. Rev. Lett, 82: 2398-401.

Leo, W.R., 1987. "Techniques for Nuclear and Particle Physics Experiments", Springer-Verlog , Berlin.

Lindle. D.W., L.J. Medhurst, P.A. Heimann, M.N. Piancastelli, S.H. Liu and D.A. Shirley, 1988. "Angle-resolved photoemission from the Ar 2p subshell", Phys. Rev. A 28: 2371-4.

Machali, F., G.G. Al-Barakati, A.A. El-Sayed and W.J. Altaf, 1987. "The hotoelectric cross section of gamma rays in the energy range 43 to 152 keV", J. Phys. F: Met. Phys. 17: 1279-84.

Nathuram, R., I.S.S. Rao and M.K. Mehta, 1988. "Photoelectric cross sections for 6–20-keV photons in beryllium, carbon, magnesium, aluminum, silicon, copper, silver, and lead", Phys. Rev. A 37: 4978-81.

Normal, L., Browse, John Black and Keriu G. Burnand, 2005. "Browser's Introduction to the symptoms and signs of surgical Disease" , India.

Sayers, D., E. Stern and F. Lytle, 1971. "New technique for investigating noncrystalline structures: Fourier analysis of the extended x-ray-absorption fine structure", Phys. Rev. Lett, 27: 1204-7.

Skofronick, James, G., R. Cameron, John, 1992. "Medical Physics ", Florida.

Tran, C.Q., C.T. Chantler, Z. Barnea, D. Paterson and D.J. Cookson, 2003. "measurement of the x-ray mass attenuation coefficient and the imaginary part of the form factor of silicon using synchrotron radiation", Phys. Rev. A 67: 042716/1-12.

Unonius, L. and P. Suortti, 1989. "Mass attenuation coefficients of the elements Ti, V, Fe, Co, Ni, Cu and Zn for the K emission lines between 4.51 and 10.98 keV", J. Appl. Crystallogr, 22: 46-52.