Journal of Mechanical Engineering Research and Developments
ISSN: 1024-1752
CODEN: JERDFO
Vol. 43, No. 1, pp. 143-150
Published Year 2020

Experiential Analysis of Mechanical Properties and Strain Energy of Epoxy/Micro Filler Cu-Ni Composite

Salwa A. Abed*, Ahmad A. Khalaf & Thaer G. Shaalan

Mechanical Department, Baquba Technical Institute, Middle Technical University of Baghdad, Iraq

*Email: salwa_77h@yahoo.com

ABSTRACT: Epoxy and their composites used as stand by to metal and alloys In wide engineering application therefore the objective of many studies to improve the mechanical behavior of epoxy composites .Current research proposes composite made by incorporation of Ni-Cu micro fillers reinforced epoxy.The mechanical properties and strain energy of proposal composite of fillers Ni-Cu reinforced epoxy were investigated .The research deal with different weight percentage of fillers (2%,5%) and each weight percentage include implicitly distributed equivalent to wt.% that used in Ni-Cu alloys (70/30) and (90/10) in order to prevent corrosion between base metal alloys and epoxy composite if it is used for coating.The result shows that the strain energy and mechanical properties were improved with adopted the distributed at composition of composite that is used in current study. The best and maximum results achieved at composite C9 at (2wt. %) fillers with implicitly distributed (70%Cu+30%Ni).

KEYWORDS: micro filler Cu-Ni; epoxy resin; Mechanical properties; strain energy

INTRODUCTION

Epoxy, a type of thermoset material and due to the specific properties, They are applied in various domain of industry.It is commonly used as a coating,adhesive,potting compound and binders etc.The mechanical properties of epoxy can be improved by adding variety filler materials and then used in different industry application such as automotive industry and aerospace.The type of selection fillers depends upon the requirements of the final application or produces [1-9].The tensile, flexural and impact strength of epoxy/micro-silica, epoxy/micro filler W-Ni and epoxy/ powder Ni-Al composites studied by [Hamid,Salwa,M.Martin] respectively and the results indicated improvement in mechanical properties[10,11,12]. The mechanical behavior of epoxy with micro alumina and epoxy with micro silica were studied and the results show the flexural and tensile strength increased when micro silica content increase, while micro alumina enhanced both properties too much other [13].Mechanical properties of graphite reinforced epoxy – matrix composites were studied under different amount of graphite filler condition between range (5 to 30 wt.%). The influence of different weight percentage (wt.%)of graphite filler on mechanical behavior epoxy and of carbon fiber reinforced epoxy composites were studied. The result shows enhanced in mechanical behavior of graphite-epoxy composites reinforced with carbon fiber more than carbon fiber reinforced epoxy matrix composites [14]. The dynamic mechanical behavior and thermos dimensional-stability of exfoliated graphite Nano platelets [EGN] epoxy composites were improved by mixture 1wt.% EGN coated with 10wt.% amine terminated poly rubber [15]. The multi walled carbon Nanotube (MWCNTS) reinforced epoxy composites were studied to develop composites for cryogenic use. The experimental results of dynamic mechanical showed that small amount of (MWCNTS) to epoxy can improve glass transition temp and modulus of composites [16].Thermal conductivity and electrical of systems consist of epoxy and poly(viny1 chloride)filled with Cu and Ni powder have been investigated.The results show the influence of the shapes and distributed of particles of metal fillers on thermal conductivity and electrical of composites[17].Composite consist of powder fillers of (Nickel,Copper,Iron and Carbon black)reinforced polymers(polystyrene) were investigated.The result show improvement in mechanical properties and better thermal conductivity with nickel composite [18].

Current research proposal adopted unconventional idea related with type of filler and distributed ratio of weight percentage of filler. The objective of present research is enhanced the mechanical properties and strain energy of epoxy composites. The composites consist of Ni-Cu fillers/epoxy. The research deal with two weight percentage (2%,5%) of Cu-Ni micro fillers with re-distributed that ratio implicitly into wt.% equivalent to that using in Ni-Cu metal alloy (70/30) and (90/10) in order to ensure the resistance composites against galvanic corrosion if it uses as a coated layers of produces have similar base metal alloy.

Why Cu-Ni fillers reinforced epoxy

Many of tubes with metal base Cu-Ni were failure caused corrosion and environmental sources. So that the selected fillers were similar to metal composite of tubes or other produces. This selection will protected the tubes against corrosion by isolated from environment .Also prevents Galvanic Corrosion from occurrence if there is a contact between the two metals of filler during work service .Galvanic corrosion occurs when two different metals have physical or electrical contact with each other and are immersed in a common electrolyte [1**9**]. Epoxy is suitable in both, dry and damp condition, usable at low temperatures high adhesive strength and low viscosity.

MATERIALS AND METHODS

Materials

The Epoxy type Sikadur-52 and hardener were used in current study. The mixture ratio of epoxy to hardener was 2:1. These materials were produced by company (Sika Yapikim asallan A.S/Istanbul/Turkey).The micro filler used consist of pure copper 97% and pure Nickel 99% . It produced by the company (BDH chemical LTD pool England). The different amount of Cu-Ni micro filler reinforced epoxy were adopted in current research.

Methods

Copper - Nickel micro fillers were mixed gently and mechanical stirred in glass beaker according to composition composite with epoxy resin and hardener. The solution was empty from air bubbles while stirring. A wooden mould dimensions was used about 130 mm length x130mm width and 5mm thickness shown in figure(1) . For easy removal of cast the release sheet of mould was put over the wooden mould and inner surface of the mould covered by release spray. The mould was allowed to maintain at room temperature. Heat treatment was done about 6 hours in electric furnace with controlled temperature 600C.Table (1) shows detail composition of composites.All specimens prepared according to ASTM standard of tensile test (ASTM D-638), Flexural test (ASTM D790) , impact test (ASTM-256). Figures (2,3) show the dimensions of research specimens and final shape of specimens after tensile and flexural testing.

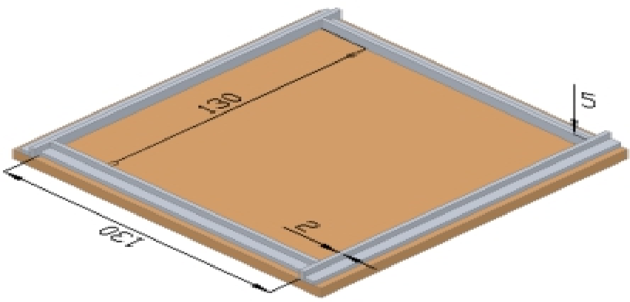

Figure 1. Dimensions and Shape of mould

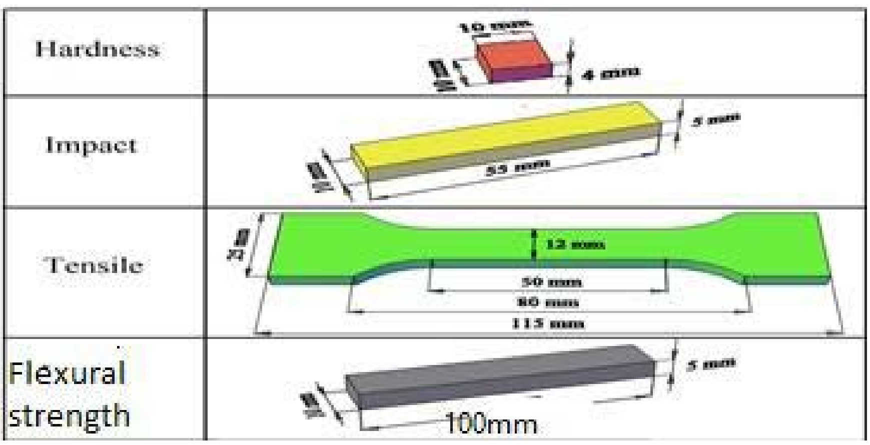

Figure 2. Dimensions of research specimens.

a) Specimens after tensile test b) Specimens after flextural test

Figure 3. Final shape of specimens after a) Tensile Test, b) Flexural Test, respectively

Table 1. Detailed designed and composition of composite

Specimens No.	*Compositions of composite*
C1	*100%Epoxy + Filler(0wt.%)*
C2	*95% Epoxy + Filler of Nickel (5 wt.%)*
C3	*98% Epoxy + Filler of Nickel (2 wt.%)*
C4	*98% Epoxy + Filler of copper (2wt.%)*
C5	*95% Epoxy + Filler of copper (5wt.%)*
C6	*95% Epoxy + Filler 5wt.%=90%Cu+10%Ni*
C7	*98% Epoxy + Filler 2wt.%=90%Cu+10%Ni*
C8	*95% Epoxy + Filler 5wt.%=70%Cu + 30% Ni*
C9	*98% Epoxy + Filler 2wt.%=70%Cu + 30%Ni*

EXPERIMENTAL RESULTS AND DISCUSSION

In current research all prepared specimens were tested in material laboratory of Material Engineering/ Technology university /Baghdad. All testes implemented according to ASTM Standards. The experimental results included studying of mechanical properties and strain energy. The obtained result is shown in tables (2,3).

Table 2. Experimental results of composites

Composites No.	Hardness (Shore D)	Tensile Strength (MPa)	Impact Strength (Joules)	Flexural Strength (MPa)
C1	76.8	30.00	9.93	72.35
C2	80.53	20.64	5.42	57.3
C3	79.00	27.66	6.5	50.15
C4	78.7	31.07	12.6	55.25
C5	78.4	31.39	14.5	99.4
C6	78.55	24.41	16.49	60.97
C7	79.5	31.13	7.8	95.11
C8	78.5	27.85	10.81	53.52
C9	80.2	33.12	19	102.23

Table 3. Strain energy results of composites

Composites No.	Max. displacement (mm)	Max. load (N)	Strain energy (Joules)
C1	5.8	1309.19	8.35
C2	5.2	643.711	5.15
C3	5.5	911.434	7.302
C4	6.1	1753.4	10.29
C5	7.3	1557	10.99
C6	6.3	1336.26	7.38
C7	9.5	1982	14.19
C8	6.31	1734	8.42
C9	10.4	2191.21	16.53

Mechanical Properties

Tensile Strength

It is measured the ability of material against tensile test loading . The tensile strength determines from maximum force per cross-section area of tensile specimens , and it is important for materials properties used industrial applications. Tensile test was implement on universal testing equipment (JIANQIAO) .The results of tensile strength of composite were fluctuated as shown in figure 4 and it can be obviously observed that the highest values of tensile strength of composites were at specimens C4,C5,C9 and the best value achieves at composite C9 (33.12 MPa) . The improvement of tensile property was implemented with filler 2wt.% with implicitly distributed (70%Cu+30%Ni).

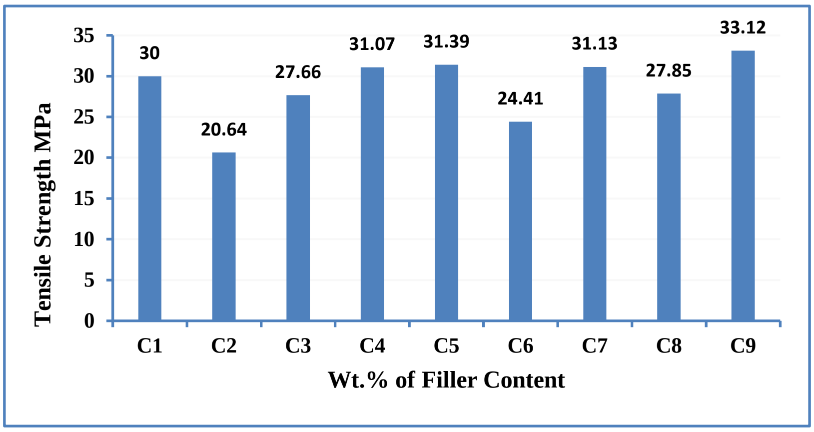

Figure 4. The influence of various composition of composite on tensile strength

Flexural Strength

Flexural strength is highest stress during test of materials. According to ASTM D-790 and using three-point bending method flexural strength tests were done. Figure 5 and table 2 the flexural strength results of specimens composite were compared. The influence of copper in specimens C5, C7 and C9 is clear and lead to improve the flexural property. From the obtained results the composite specimen C9 offered maximum flexural strength (102.23 MPa) compared to other filled composites specimens and then the improvement flexural property was achieved.

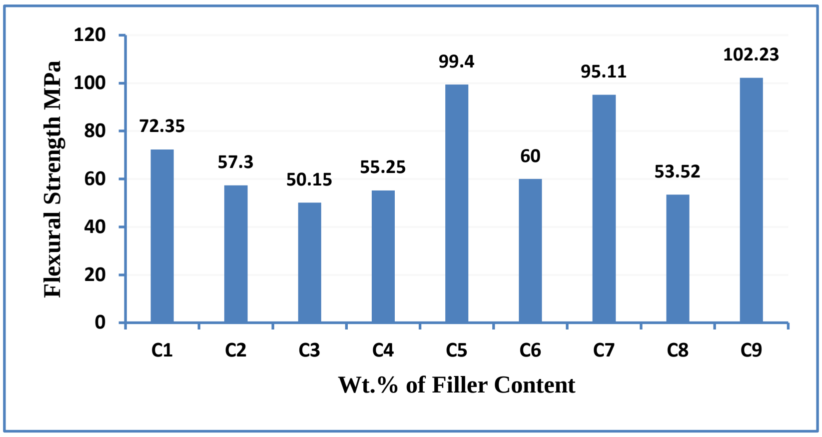

Figure 5. The influence of various composition of composite on flexural strength property

Hardness Property

Shore D hardness test has been carried out on composite sample. It is important to measure the ability of material to resist indentation , penetration and abrasion . Figure 6 shows the effect of various of weight percentage of filler filled of composite with hardness value. Improvement in hardness value was happened and the experimental results show in figure 6 that the composite C2 and C9 have offered maximum hardness number (80.53) and (80.2) respectively .This may be caused uniform dispersion of Ni particles. The improvement in hardness property lead to increase in resistance of composites against indentation , abrasion and penetration. The filler filled composite offered improvement hardness compared to the unfilled composites C1.

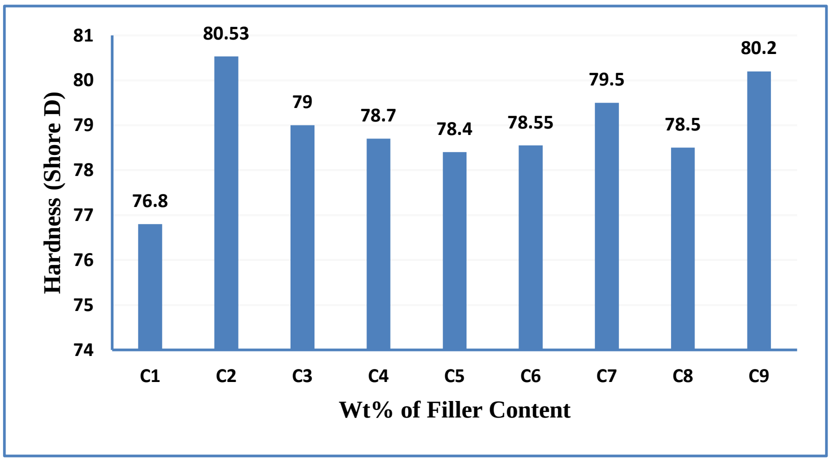

Figure 6. The influence of various composition of composite on hardness property

Impact Strength property

Impact strength test is important to mechanical property for studying the toughness of material and measured the materials ability to absorb energy during plastic deformation. The IZOD impact tester is an instrument used for impact test. Figure 7 exhibited the effect of fillers filled composites on impact strength. It is showed from the figure that the addition copper filler in composition lead to improve impact property. In figure 7 indicated also that the composite C9 (19 Joules) has better improvement in resistance of composites against indentation.

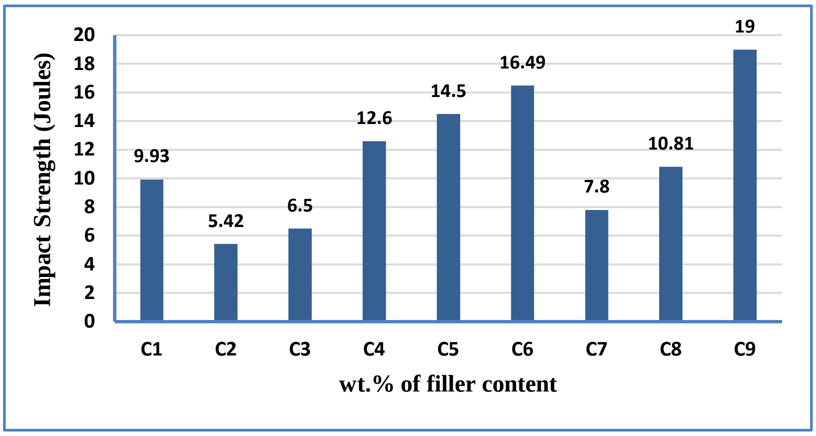

Figure 7. The influence of various composition of composite on impact strength property

STRAIN ENERGY

Strain energy is define as the energy in a body due to deformation. The area under the stress-strain curve or load –displacement curve towards the point of deformation represented the strain energy and usually denoted by U. If the loading is uniform tension the strain energy of each element of uncracked body is the same and equal to so that the strain energy of uncracked body become as following [20].

$$U_{body\ with\ no\ cracked} = (\sigma^2 / 2E) LBW \qquad (1)$$

Where

U= strain energy (Joules)

W=width of specimen (mm)

B=thickness of specimen (mm)

L=length of specimen (mm)

The effect of different filler content on strain energy is shown in figure 8 and obviously indicate that composites C9 offered max. strain energy (16.53 Joules). The good bonding and distributed between micro fillers and flexibility offer the compositions of composite lead to absorb more energy and prevents the early initiation of cracks more effectively [21-24].

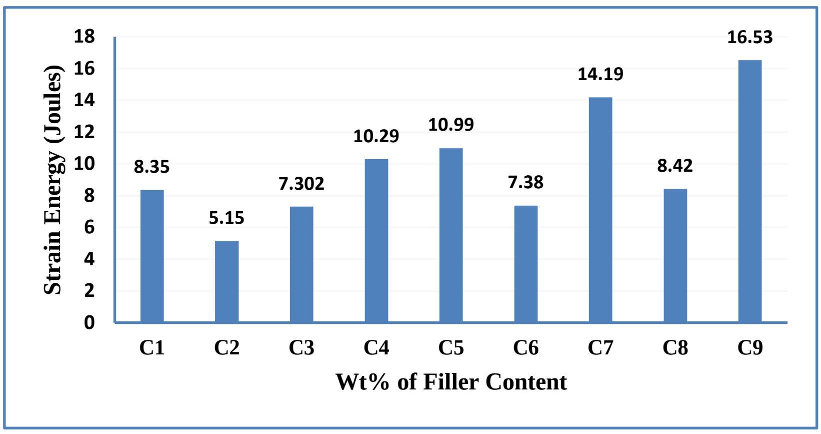

Figure 8. The influence of various composition of composite on strain energy

CONCLUSIONS

In summary, this work has demonstrated the effective of different weight percentage of micro filler Cu-Ni on the mechanical property and strain energy of epoxy based composites. Following is abbreviated conclusions. In tensile testing, the tensile strength improved at specimens (C4,C5,C7 and C9).It is found micro-additive filled of Cu filler shows slight improvement in tensile strength and high tensile achievement at specimen C9 comparative with unfilled specimen. The flextural strength of composites increases with increase in cu filler and it seems clear at specimens (C5,C7,C9) and maximum flexural strength was obtained at specimen C9 about 102.23 Mpa.In hardness testing ,the hardness of composites increases with increase in metal fillers.It is also found that specimens (C2,C9) nickel filled composites show excellent hardness compared to unfilled composites with highest hardness was achievement at specimen C9(2wt.%=70wt.% Cu+30wt.% Ni).The impact strength was increased with increase in metal fillers and maximum value of impact strength was obtained at specimen C9 about 14Mpa.The maximum strain energy obtained from maximum applied loading was at composite C9 (10.8 Joules) that reflected maximum composition of composite resistance against initiation and propagation cracks. In other words the composition of composite C9 improved the mechanical properties and strain energy of proposal composites micro filler Cu-Ni /epoxy. The current research suggests that the composite C9 can be used as a coating of products have base metal alloy of Cu-Ni.

ACKNOWLEDGMENTS

The authors are grateful to the mechanical department for providing financial support for testing and measurements. References and notes.

REFERENCES

[1] S. Sprenger, “Epoxy resins modifid with elastomers and surface modified silica nanoparticles”, *Polymer*, vol. 54, pp. 4790-4797, 2013.

[2] W.B. Ying, et al., “Epoxy resins toughened with in situazide-alkyne Polymerized polysulfones”, *J Appl Polym Sci*, vol. 135, pp. 45790, 2017.

[3] S. Ikram, A. Munir, “Mechanical and thermal properties of chemical modified epoxy resin”, *Open J Synth Theory Appl*, vol. 1, pp. 36-43, 2012.

[4] B.V. Sunil Kumar, et al., “Study in mechanical and cryogenic properties of carbon epoxy composites”, *Iop Conf. series: Materials Science and Engineering*, vol. 376, pp. 012047, 2018.

[5] T.D. Jagannatha, G. Hariosh, “Mechanical properties of carbon/glass fiber reinforced epoxy hybrid polymer composites”, *Int J Mech Eng & Rob Res*, vol. 4, no. 2, pp. 131-137, 2015.

[6] J.M.F. de parira, et al., “Comparison of tensile strength of different carbon fabric reinforced epoxy composites”, *Materials Research*, vol. 9, no. 1, pp. 83-89, 2016.

[7] R. Khan, A. Khan, M.U. Khan, H.U. Khan. “Right Pure Uni-Soft Ideals of Ordered Semigroups”. *Matriks Sains Matematik,* vol. 1, no. 1, pp. 18-23, 2018.

[8] C. Adrian, R. Abdullah, R. Atan, Y.Y. Jusoh. “Theoretical Retical Aspect in Formulatting Assesment Model of Big Data Analytics Environment”. *Acta Mechanica Malaysia*, vol. 1, no. 1, pp. 16-17, 2018.

[9] Z.H. Yan. “Artificial Bee Colony Constrained Optimization Algorithm with Hybrid Discrete Variables and Its Application”. *Acta Electronica Malaysia*, vol. 2, no. 1, pp. 18-20, 2018.

[10] D.Y. Xu. “Research on The Cultural Construction of Homelink Real Estate”. *Engineering Heritage Journal*, vol. 2, no. 1, pp. 24-26, 2018.

[11] B. Solomon, et al., "The effect of fibers loading on the mechanical properties of carbon epoxy composite," *Polymers & Polymer composites*, vol. 25, no. 3, pp. 237-240, 2017.

[12] K. Chawla, *Composite Materials Science and Eng. second Edition*, 1998.

[13] B.Q. Yuan, et al., "Mechanical and thermal properties of epoxy composites containing graphene oxide and liquid crystalline epoxy", *Fibers and Polymers, vol.* 15, pp. 326-333, 2014.

[14] H.M. Mahan, et al., "Effect of silica particles on the enhancement of mechanical properties and thermal conductivity of epoxy composites", *Journal of Advanced Research in Dynamical and Control System*, vol. 6, pp. 748-755, 2018.

[15] S.A. Abed, et al., "Influence of mixing fine powder of tungsten(W) and Nickel (Ni) Upon mechanical behavior of resin (Epoxy)", *Journal of Advanced Research in Dynamical and Control System*, vol. 2, pp. 2290-2295, 2018.

[16] M. Martin, et al., "Mechanical behavior of nickel +aluminum powder-reinforced epoxy composites", *Materials Science and Engineering*, vol. 443, pp. 209-218, 2007.

[17] J.J. Park, "Mechanical properties of epoxy/micro-alumina composite. *A transaction on Electrical and Electric Materials*, vol. 19, pp. 481-485, 2018

[18] R. Baptista, et al., "An experimental study on mechanical properties of epoxy-matrix composites containing graphite filler", *Procedia Structural Integrity*, vol. 1, pp. 074-081, 2016.

[19] J. Hyeon, et al., "Simultaneous enhancement of impact toughness, mechanical properties and thermos-dimensional stability of epoxy composites by rubber-coated exfoliated graphite nanoplatelets", *Fiber and Polymers*, vol. 14, no. 11, pp. 1947-1952, 2013.

[20] Y.X. He, et al., "Surface functionalized carbon nanotubes its effects on the mechanical properties of epoxy based composite at cryogenic temperature", *Polymers Bulletin*, vol. 71, no. 10, pp. 2465-2485, 2014.

[21] Y.P. Mamunya, et al., "Electrical and thermal conductivity of polymers filled with metal powders. *European Polymer Journal*, vol. 38, pp. 1887-1897, 2002.

[22] M.Z. Iqbal, et al., "A study on polystyrene-metal powder conductivity composites", *Journal of Chemical Engineering* IEB, vol. 25, no. 1, 2010.

[23] Corrosion consulting services. Galvanic Corrosion www.corrosionclinic.com/typesofcorrosion/galvaniccorrosion.htm.

[24] D. Broek. The practical use of fracture mechanics, 1988.