THE EFFECT OF SHOT PEENING ON BENDINGSTRENGTH FOR MIG WELD JOINT ALUMINUM ALLOYS 2024 T351 +

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Abstract :

Theinfluence ofshot peening onbending strength using MIG welding joint aluminum alloys 2024-T351 was studied. The paper implements many series of experimental techniques to figure the bendingstrength of all specimens , by performance hardness, shot peen, remaining stress and bending examinations for un-joint and joinedsamples.

(MIG) process has implemented onsheets of "8mm thickness" to getbutt joiningconnections with measurement of (200 *100* 8) mm with joining readying angle in formsingle and double V of $75^0$and flatjoinby "ER- 4043(Al-Si_5)"as a "groutmetal"and "argon" as protected gas. The juncturesareexamined by"X-ray radiography"and exceptedtheimperfect joint, then Welding joint exposed to heat treatment to removed joiningresidual stress.

Hardness was measured using Vickers test and the specimens microstructure were examined, finally bending testimplemented on the samples which fabricated into typicalexaminationsample dimensionagreeing to the ASTM (E 190-92) of welded and un welded joints, and then ejaculation by steel ball in diameter 1.25 mm for 10 min to show the influence of shot peening on weld bending

The Results of bendingqualities for MIGweld connected showdecay when comparing it with theunwedded joints and chiefly along the HAZ .but unweddedsamples were fiascoes nigh the middle line of the sample shot peening contributed in improvement of bending process for all specimens. Ansysprogram was used to conduct stress analysis operations.

Key words: Aluminums alloy2024; MIG welding joining, bending properties, shot peen

تأثير القصف بالكرات على مقاومة الانحناء لسبائك الالمنيوم 531 T 2024 الملحومه بطريقة MIG

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المستخلص:

درس هذا البحث تاثير طريقة القذف بكرات فولاذية على مقاومة الحني لسبيكة من سبائك الالمنيوم عالية المتانة هيT3512024 تم لحامها بطريقة القوس الكهربائي المحمي بغاز خامل وقد اجريت سلسلة من التجارب التقنية لتقييم مقاومة الحني للسبيكة تضمنتكل من اختبارات الصلادة، القذف بالكرات ، الاجهادات الضغطية و البنية المجهرية للعينات الملحومة وغير الملحومة .

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انجز اللحام باستخدام لحام القوس الكهربائي المحمي بغاز على قطعتين من السبيكةالتي تم ذكرها بهدف انتاج وصلات تناكبية بالابعاد(8*100*200)ملم اذ تم كسر حافات القطع من جهة ومن جهتين بزاوية مقدارها75درجة على شكل حرف Vووصلات بدون زوايا تحضيرية بواسطة سلك لحام رمزهER 4043والاركون كغار حمايةبعد عملية اللحام تم التاكد من عدم احتواء الوصلة على العيوب حيث تم فحصها بواسطة جهازX-ray radiography ثم اجريت معاملة حرارية لغرض التخلص من اجهادات اللحام المتبقيه.

صنعت عينات اختبار الحني من وصلات اللحام والمعدن بدون اساس اعتمادا على الابعاد القياسية ASTM (E 190-92) وكذلك اجراء عمليات فحص البنيةالمجهريه , تم تعريض العينات الى القذف بكرات فولاذية قطرها 1.25mm وصلادة RC 55Hوبزمن 10 دقائق لبيان تاثير عملية القذف بكرات فولاذية على مقاومة الحني. للعينات الملحومة وغير الملحومة ومن النتائج التي تم الحصول عليها وجد ان القذف بكرات فولاذية ساهم في تحسين مقاومة الحني للعينات الملحومة من خلال معالجة عيوب اللحام . وتم استخدام برنامج Ansys لاجراء عمليات تحليل الاجهادات

Introduction :

Because of good mechanical properties and low densities of Aluminum and its alloys, they are used in many applications in industries such as automotive and aerospace sectors; these alloys have an edge over other conventional structural materials.For dangeroususesthruinnovative mechanical characteristic of high strength and ductility heat treatable aluminum alloys such as(2024 and 6061) are particularlymanufactured. [1, 2]
MIG welding is tooknown by gas metal arc welding. In this methodexpendablefluidity cored incessant wire or metallic electrode of diameter 0.8-2.4mm wound in spool shape is fattened at a desired assistancerapidity through a welding gun, it picks up electric current from copper connectionpipe which is electrically related to the DC power authority and a protective gases such as helium, argon, carbon dioxide, argon-helium mixture, carbon dioxide-argon mixture, protective gases are similarly apply to cooled down the gun. MIGjoining is applied to raisemanufacturing and constancy of character [3]. The joining of aluminum and its alloys has continuouslydescribeda hugedefiance for technologists& designers. Really, amounts of problems are established to this sort of joint method, mostlypertain to the existenceof a stickingoxide film,great coefficient ofcaloric dilation great thermal conductivity, rigiditycontraction and, above all, great solubility of "hydrogen", and another gases, in liquidcase [4].Moreglitches can increase during welding"heat-treatable"alloys, since heat, obtainedusing joiningmethod, is accountable of the reduction of "mechanical qualities" because of stage alterations and softening-result in alloy. These aluminum alloys are commonlycategorized as non-weld able due to lack solidification microstructure and porosity in the melting area.
Hence, it is significant to realizetechniques to develop the debilitated mechanical characteristicmanufactured from the joiningmethod for ingredients joinedby FSW. Peening methodssuch as "laser and shot peening" has been notify to increase mechanical qualities inmelting welds[5].
Shot peening is a cold working surface treatmentmethodin which bullet bangs the surface of components byspeeds of 20-100 m/s or beads are ousted versus a target surface to manufacture film of compressive remaining stress at the surface of component rely s upon the qualities of the material being shot peened, pasttreating, and the specific peening factorsapplied such as time of peening, stream speed, air pressure on the peened element, distance from nozzle to material surface (peening distance), nozzle angle, peening intensity, and mainly the type, size

and form of the shots . Several of the factors may be taken as steady during SP process while others must be finding through tests and mathematical calculations. [6]

Shot peening can just be reliably repressed and optimized by gauging the interior leftover stress allocation manufactured. (XRD) is an important and precisetechnique to quantify leftover stresses manufactured from surface hardening treatment like laser penning and shot peening, this method considered as a favorable method comparing with other various methods as non-linear elastic, ultrasonic or magnetic ways. XRD is a linear-elastic method in which the remaining stress in the alloy is computed from the strain measured in the crystal lattice [7].Many studies concerned this subject as:-

Omar Hatamleh [8] studied laser peening and shot peening techniques to alter the surface of F.S.W 7075-T7351 Aluminum Alloy samples.The peening impacts on mechanical properties through the different zones of the weld were investigated. surface hardness from numerous peening methods were tooactualize for both sides of the welds. Shot peening caused in ariseto "surface hardness"levels, but no development was observed on the "mechanical"quality. In opposite to"mechanical"qualities were developedusing laser peening when analogy to the un peened material.

Khiaria Salman Hassan [9] studied Corrosion of welded Aluminum Alloy 6061 T6 in sea water at different velocities,many butt welded joints were gotby Two diverse welding methods, tungsten inert gas (TIG) and a solid state welding methodrecognized as friction stir welding Another butt weld processed in the equalmeasurementsexposed to synergistic weld method TIG and FSW weld method at the same preceding weld. Corrosion rate results that for TIG weld joint it was upper than the others but synergistic weld process contributed in improving its corrosion resistance by a percentage of 14.3% and that anaddition in media speedparticipated in reducing corrosion rate.

Nashwa Abdul [10] studied the time influenceof shot peening using steel balls on mechanical characteristic of AA2024-T4 alloy. Examinationimplementedontypical tensile samplesatdifferent peening periods"(5,10,15,20 and 30 minutes)". Consequencesindicate a rise in "yield" and "tensile strength" values with more and more peening time up to 15 minutes.While the extremeratio of "elongation"is 22.7% got at 30 minute peening period.

Henri-Paul Liberdade[11] studied the mechanical propertiessubjected to shot peening, on two TIG weld joint "aluminum alloys"5083 and 6061 which weld atnumerous weld joint shapes thenchoose the chieffactors, to optimize the shot peening method, and to insist on theinfluence of the early weld property, finally to condense the impacts of the loading factors on the advancelevel. Theconsequencesdisplayaimportantdevelopment in the "fatigue" strength of shot peened welded jointsfrom 50 to 150 %, with respect of the initial quality of the welded joint

The paper aims to study the influence of "shot peening" on bending strength for "aluminum alloy" 2024T3weld joint was investigated in addition stress distribution was studied using Ansys software V.15.

Experimental procedure

Metal select.

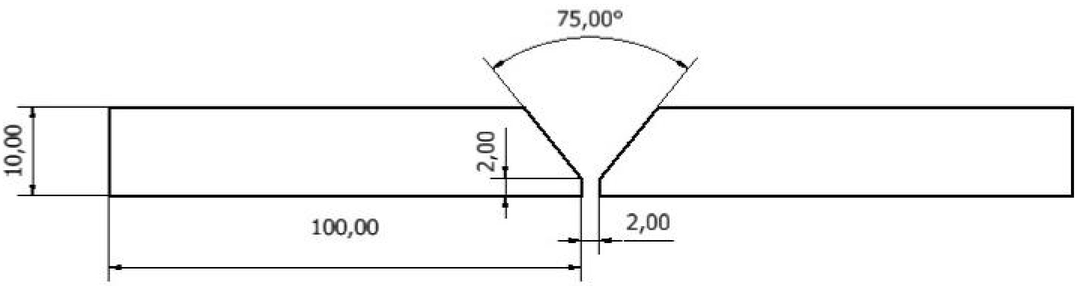
2024-T351 aluminum alloys sheet metal which was used in aerospace industriesand the Chemical analysis of the alloys was investigated using (Thermo ARL 3460 optical Emission spectrometer) device. The analyses results are shown in **Table (1)**comparing itwith the American standardspecification.

Sheets werecombined together by GMAW methodand "ER4043 ($Al\text{-}Si_5$)" as a packing metal bar, its"chemical composition is"exposed in **"Table" (2).Fig.(1)** shows the alertnessangle in formsingle, double V of 75^0 angle to obtained butt weld joint by dimensions (200,120,8)mm .

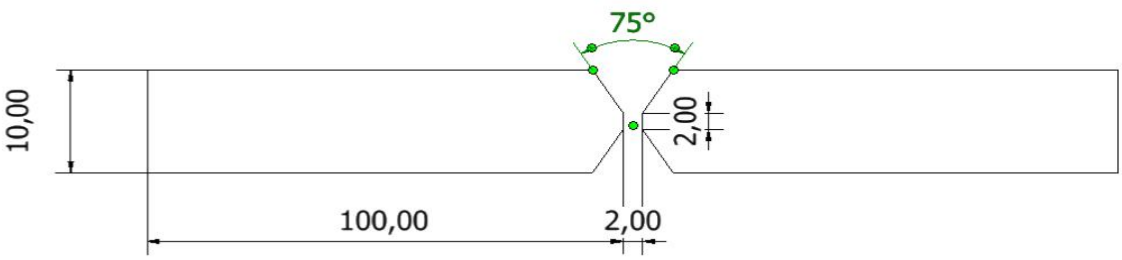
Then they were "butt welded" (two pass for each side) using a "MIG-350"sort"semiautomatic"joiningdeviceand the weld factors were presented in**Table (3)**

$$Heat\ \ Input = \frac{543 \times I \times V \times 60}{S} \text{ --------------------------- (1)}$$

Where:
V= welding voltage (volt)
S= welding speed (m/min)
I= welding current (Ampere)
Heat Input= Joule



Sample (B)



Sample (C)

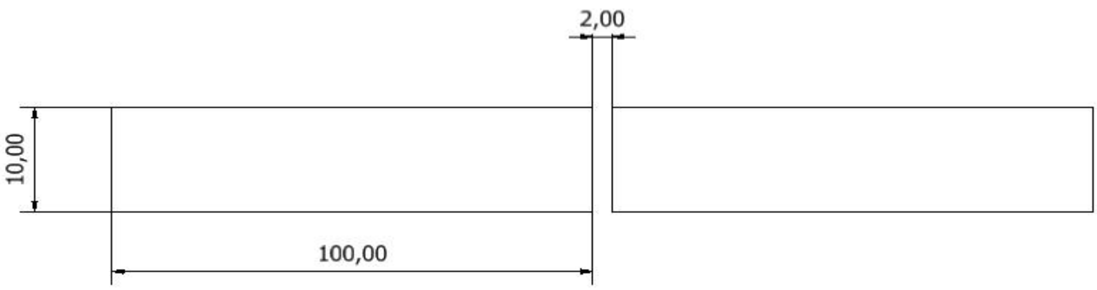


Fig (1) the dimension of butt welding joint (for samples A,B,C)

Table (1) Chemical composition of the AA (2024T351)[12]

Element	Al%	Ti%	Zn%	Cr%	Si%	Fe%	Mg%	Mn%	Cu%
Actual value	92.6	0	0.1	0.05	o.4	0.3	1.5	0.6	4.4
Standard value	Rem.	0-0.15	0-0.25	0-0.1	0-0.5	0-0.5	1.2-1.8	0.3-0.9	3.8-4.9

Table (2) Chemical analysis of the packing metal Al Si_5 [13]

Elements Wt%	Si	Cu	Fe	Mn	Mg	Zn	Cr	Sn	Al
Actual value	5.0	0.1	0.4	0.08	0.06	0.15	0.25	0.15	93.44
Nominal value	4.5-6	<0.3	<0.6	< 0.15	<0.2	<0.1	-	-	Rem.

Table (3) MIG welding parameters

Symbol	Current (Amp.)	Voltage (v.)	Travelspeed (mm/s)	Flow rate L/min	No. of passes	Heat input (Joule)	Wire diameter (mm)
B	140	22	220	10	2	456120	1.2
C	150	22	110	16	2	977400	1.2
D	160	24	220	10	3	568669	1.2

Preparation of bending specimens :

The weld joints were tested using X-ray radiography component which was worked for 2 min at 140 kV, 2 mA to figure the welded defects. The joints deprived offaults wereemployed for manufacturing numeroussamples for all tests and then many bending specimens were machineusing CNC milling machine intoASTM (E 190-92) standard bending test specimen dimensions .

Classification of welded combined:

After finishing preparation of the sample, samples werecharacterizedinto sets as presented in **Table (4)**

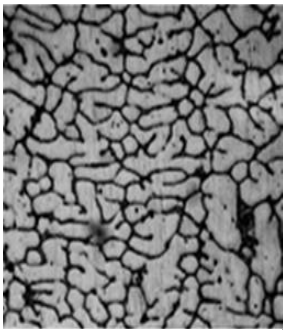
Table (4) specimen's categorizing

Symbol	Condition
A	as received
B	Butt Single V at 75°
C	Butt Double V at 75°
D	Flat butt "weld joint"

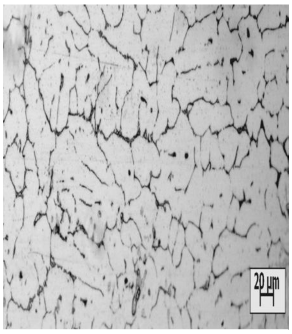
Micro-structure examination:

"Micro-structural"variationswere examined from weld zone to the uninfluencedoriginal alloysby"optical microscope". To prepare samples for "microstructure"examination it includes many steps ,"wet grinding operation"by emery papers of SiC in different grits" of (220¸500, 800 and 1000). Polishing method was done using diamond paste of size (0.2µm) with special polishing cloth. Between these steps specimens were cleaned with water and alcohol then dried with hot airdryer.

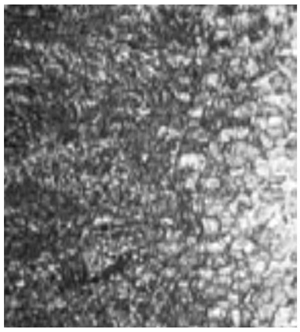
Keller's reagentconsisting of 95 ml distill water, 2.5 ml HNO3, 1.5 ml HCl and 1 ml HF was used for structureetchingand photo it with "ME-600 computerized optical microscope" provided with a "NIKON camera", the testedconsequenceisrevealed in**Fig.(2)**



Sample(A)



Sample B (weld zone)



Sample (B) (HAZ zone)

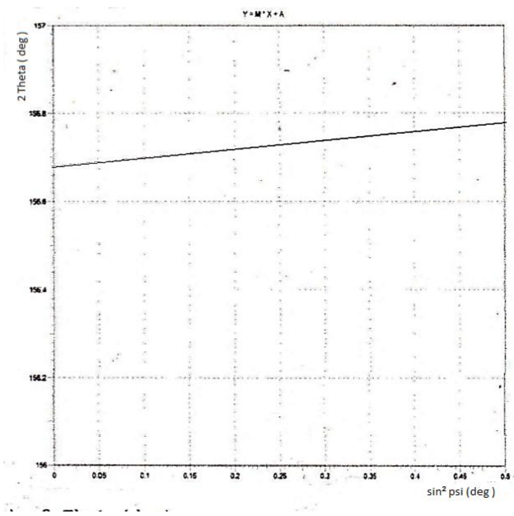
Fig (2) microstructure of specimens at X 40

Shot peening process :

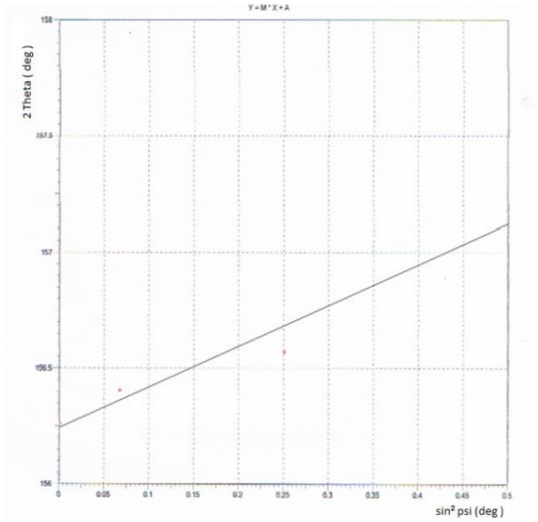
All specimens in table (4) were SP-treated for 10 min from all sides by an air-blast device. Balls used for the shot were Steel ball shot with a hardness of 60 HRC and a diameter of 1.25 mm. The angle of nozzle inclination was shifted by 10° with regard to the vertical axis, and the distance between the specimen and the nozzle of around 120 mm was supported. Thenremaining compressive stress from the on-side were quantified by Lab "XRD-6000 shimadzu x-ray diffraction meter", results of aremaining stresses are presented in "Table(5)"and Fig.(3)

. **Table (5) compressiveresidual stress for all specimens**

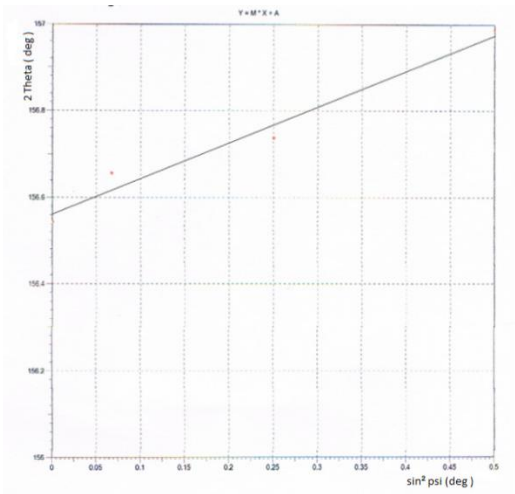
Specimens symbol	Residual stress Mpabefore shot peening	Residual stress Mpa after shot peening
A	-18	-162
B	-76.02	-140
C	-89.132	-186
D	-97.9	-143



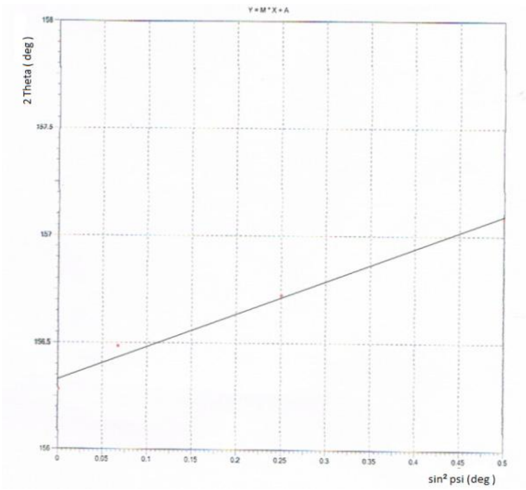
Sample (A) before shot



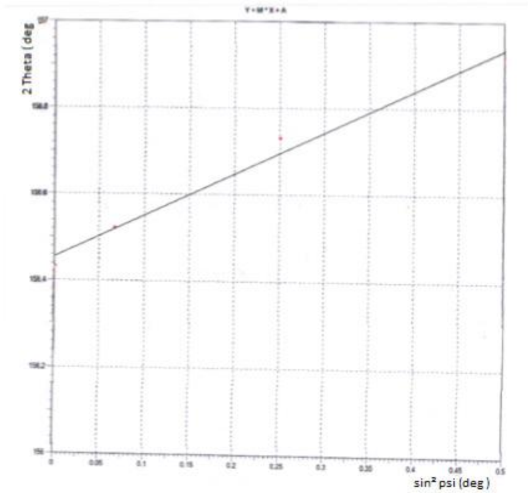
b- Sample (A) after shota-

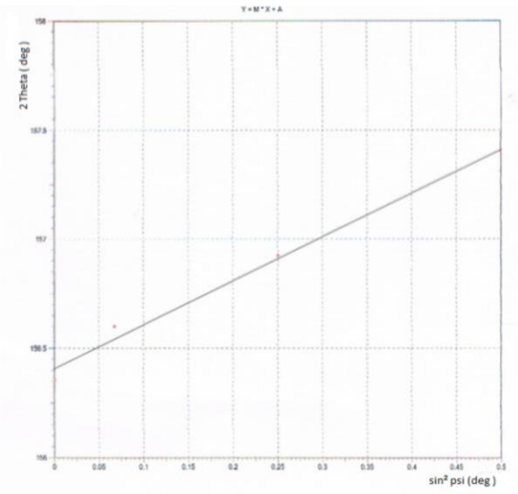


c-Sample (B) before shot

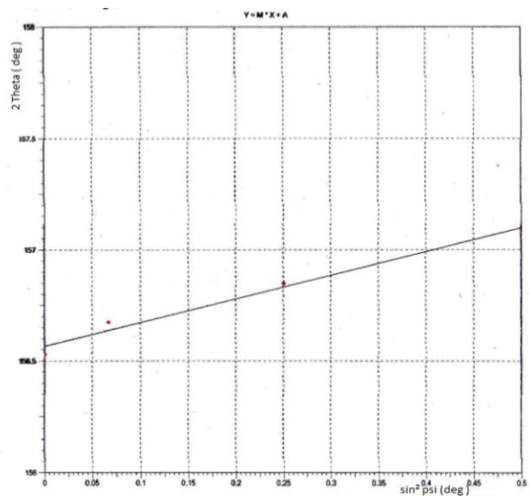


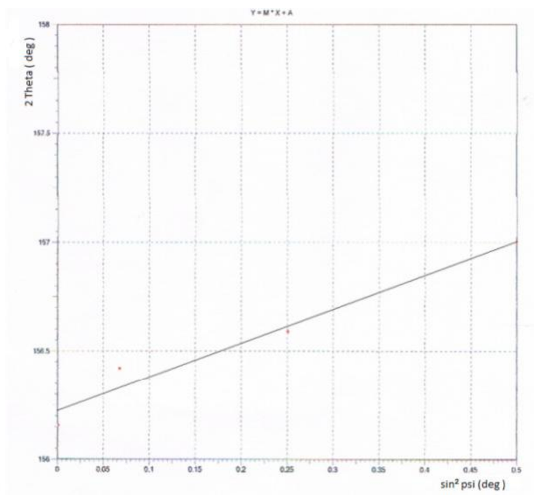
d- Sample (B) after shot





e- Sample (C) before shot f- Sample (C) after shot





g- Sample (D) before shoth- Sample (D) after shot

Fig.(3) photo graph of residual stress (a,b,c,d,e,f,g,hfor all samples before and after shot)

Surface roughness

The mean measure of the free surface roughness (Ra) representthe center-line average of adjacent peaks, is quantified at the surface space of all samples in Table(5) ,results are revealed in Table (6)

Table (6) Surface roughnessresults and hardness

Specimen symbol	Surface roughness Ra (μm) before shot	Vickers hardness Kg/mm^{2}beforshot	Surface roughness Ra (μm) after shot	Vickers hardness Kg/mm^{2}after shot
A	0.016	84	-	118
B	0.085	80	1.23	124
C	0.19	70	1.5	100
D	0.12	82	1.42	130

Micro hardness Test

on a cross section perpendicular to the welding direction, "Vickers hardness" profile of the weld zone was measured by "micro hardness" examined with 200 gm load for 15 sec. for all specimensbefore and after shot peening,the result are shown in**Fig.(4), Fig(5)**

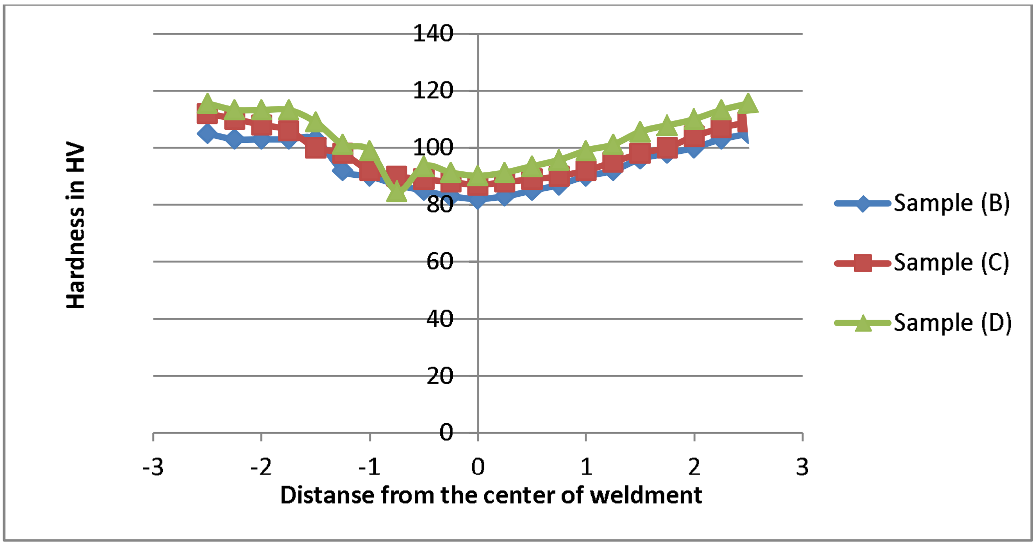


Fig.(4)micro hardness result for all specimens beforeshotpeening

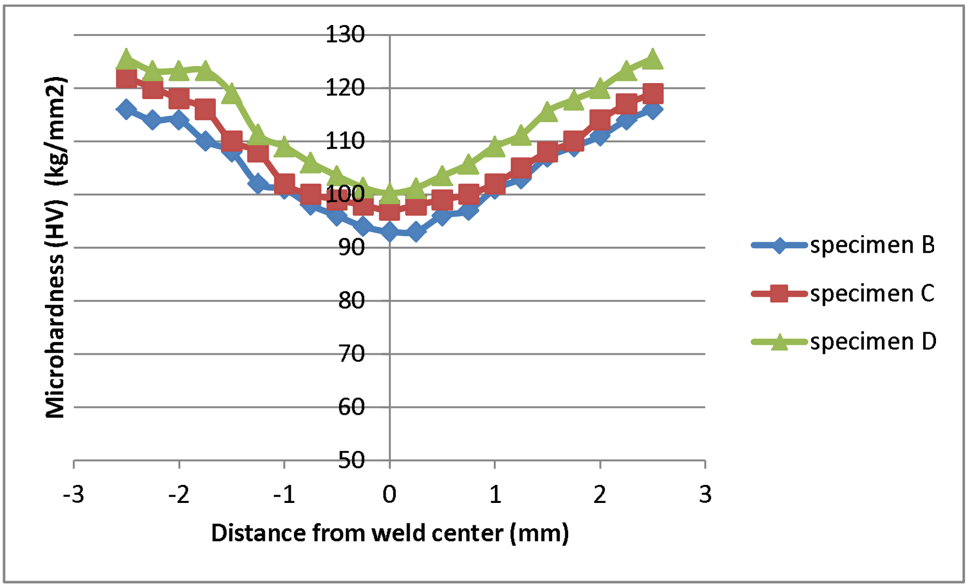


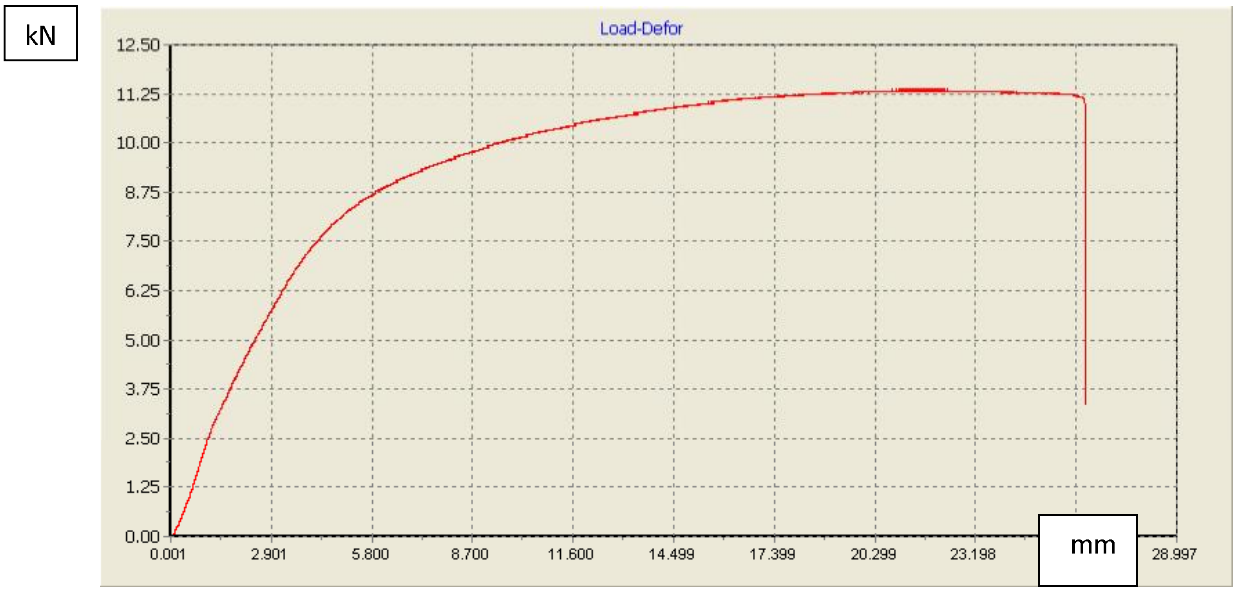
Fig.(5) micro hardness result for all specimens after shotpeening

Bending testing

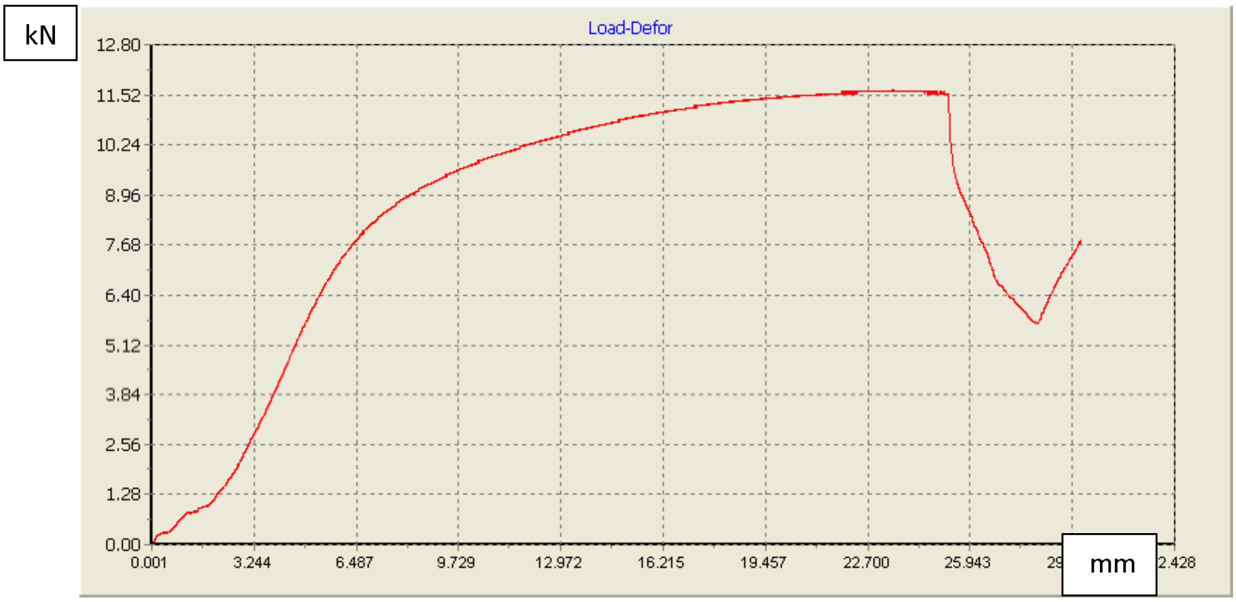
Face bending tests were implementedusing a three point's method.Theexamination was executed out on a 100-kN "universal"examination device at velocity of 3.5 mm/min, and to apply the testa"cylinder"-formedline load is validopposite to the weld line, also the center line of the unwelded sample. As the sample is fixed on the sides using a steel confirmation, it initiates to yield because of "bending". The results were shown in **table** (7) and photograph (7)

Table (7) Result of Bending strength

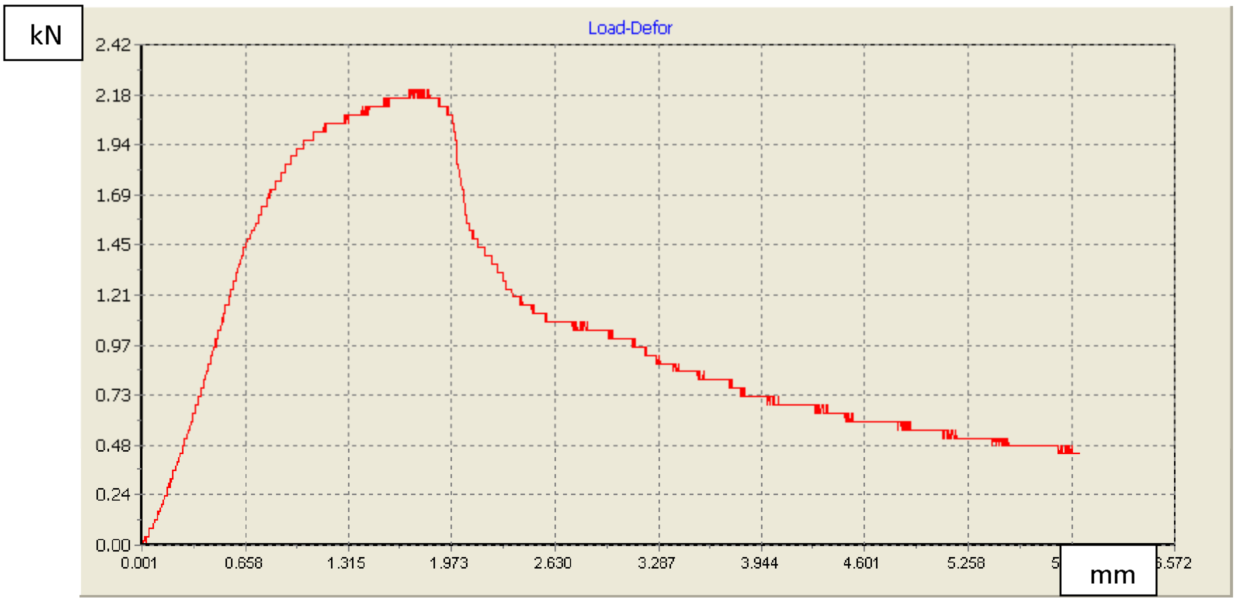
Specimen symbol	Bending strength before shot Mpa	Bending strength after shot Mpa
A	11.25	11.52
B	2.18	5.39
C	2.46	4.32
D	1.19	4.0



a- Sample (A) before shot

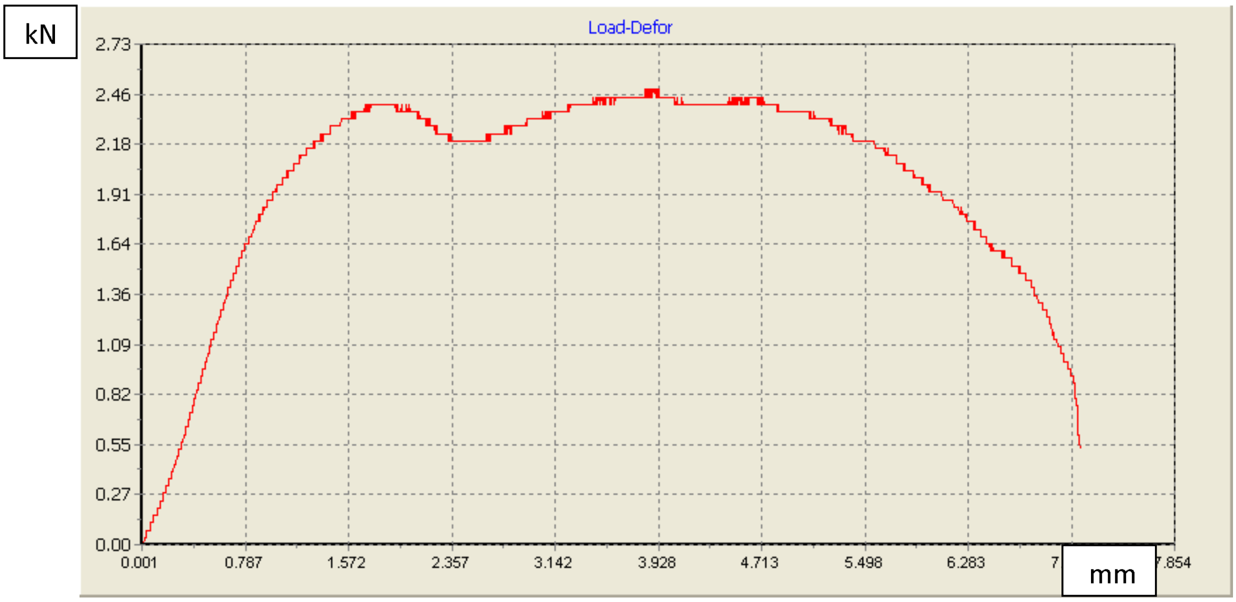


b- Sample (A) after shot

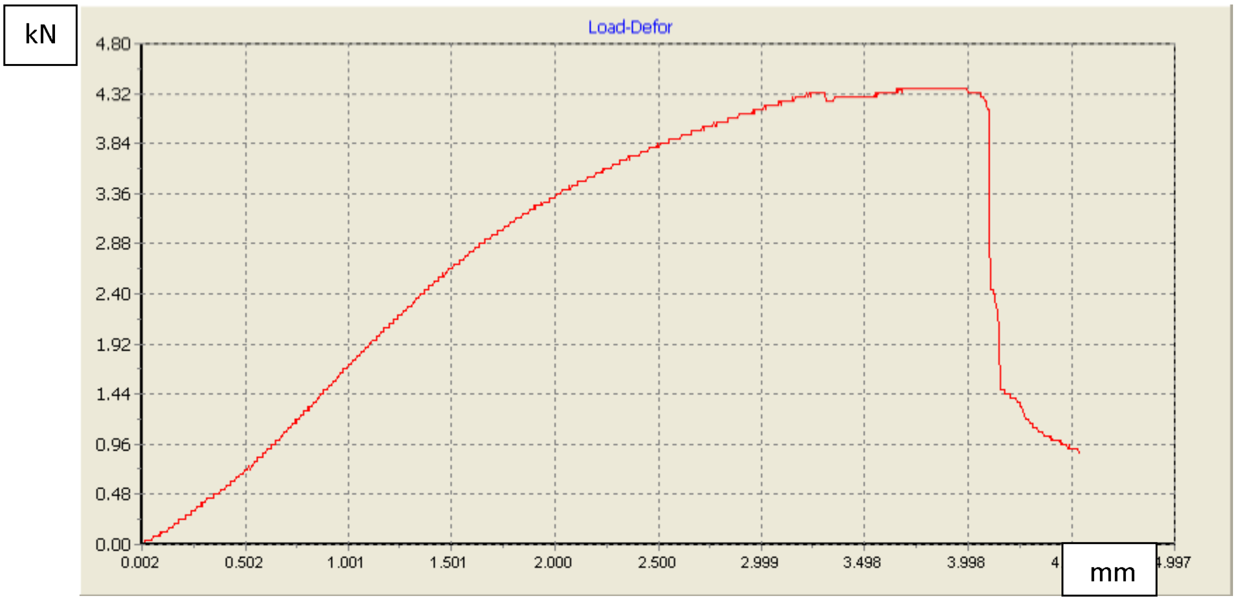


c- Sample (B) before shot

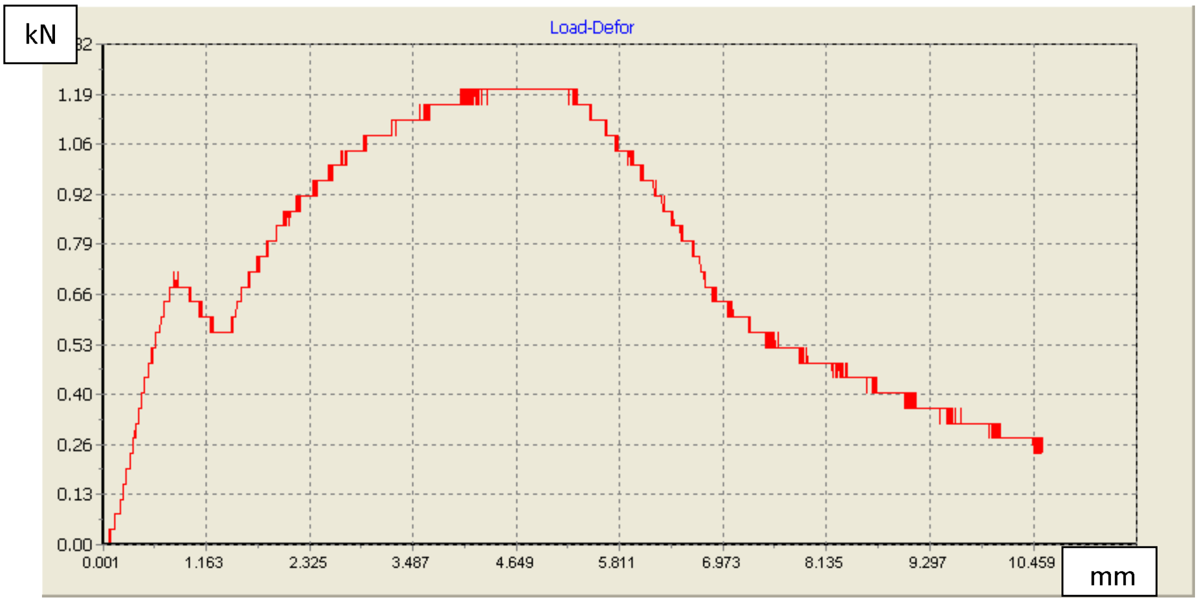
d- Sample (B) after shot



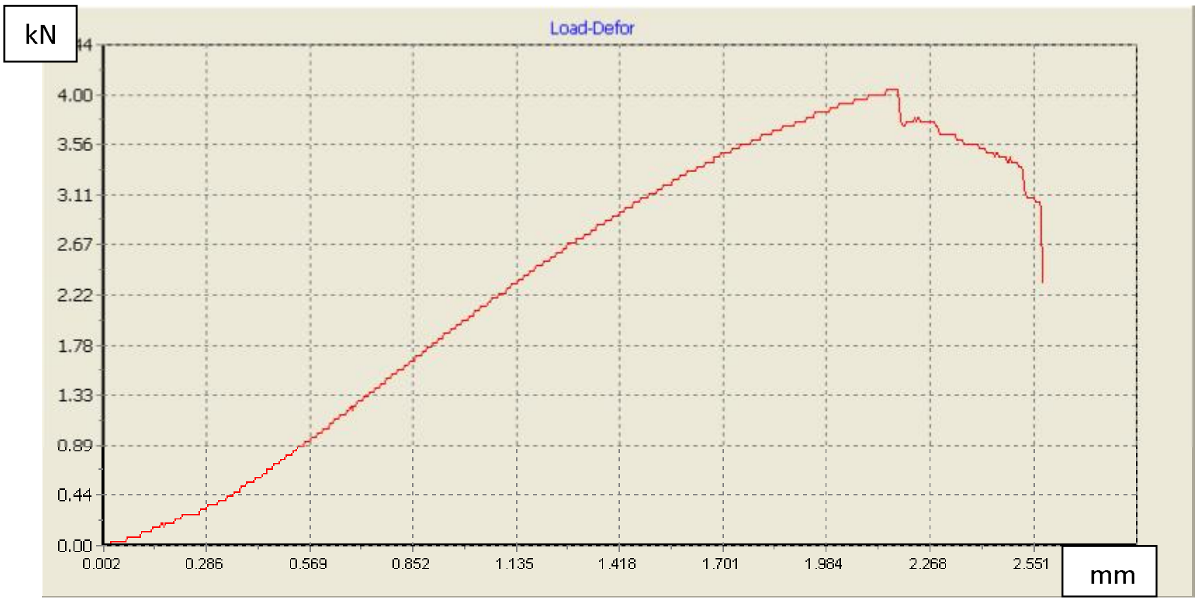
e- Sample (C) before shot



f-Sample (C) after shot



g-Sample (D) before shot



h-Sample **(D)** after shot

Fig.(7) photograph of bending test (a,b,c,d,e,f,g,h, Sample A,B,C,D before and after shot)

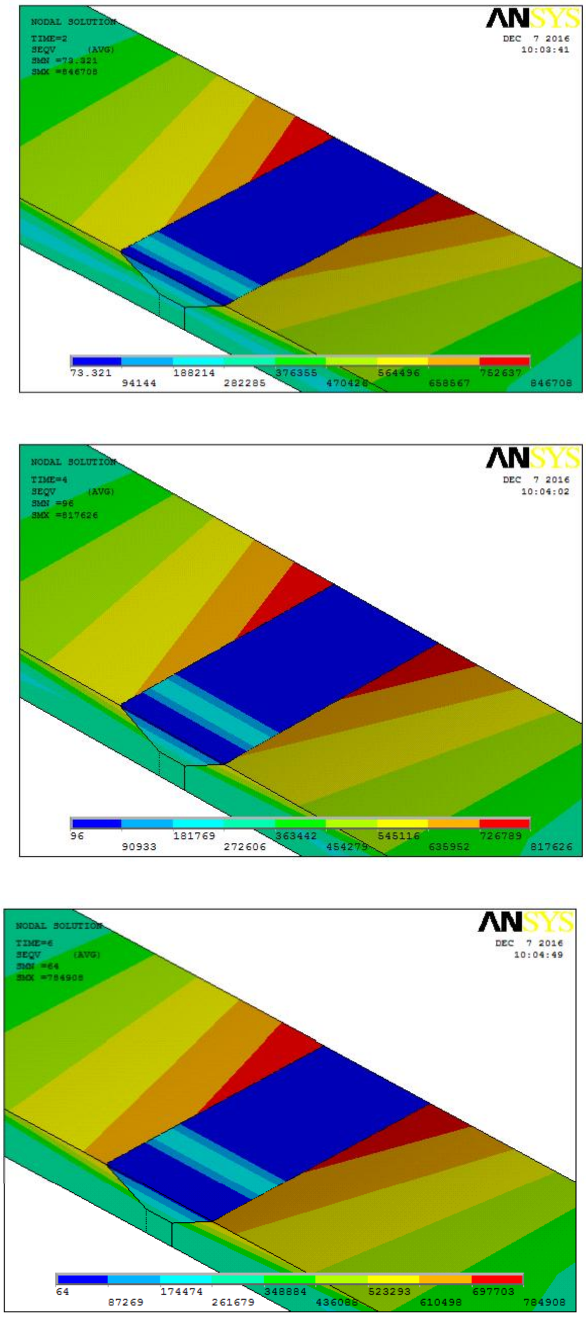
Discussion:

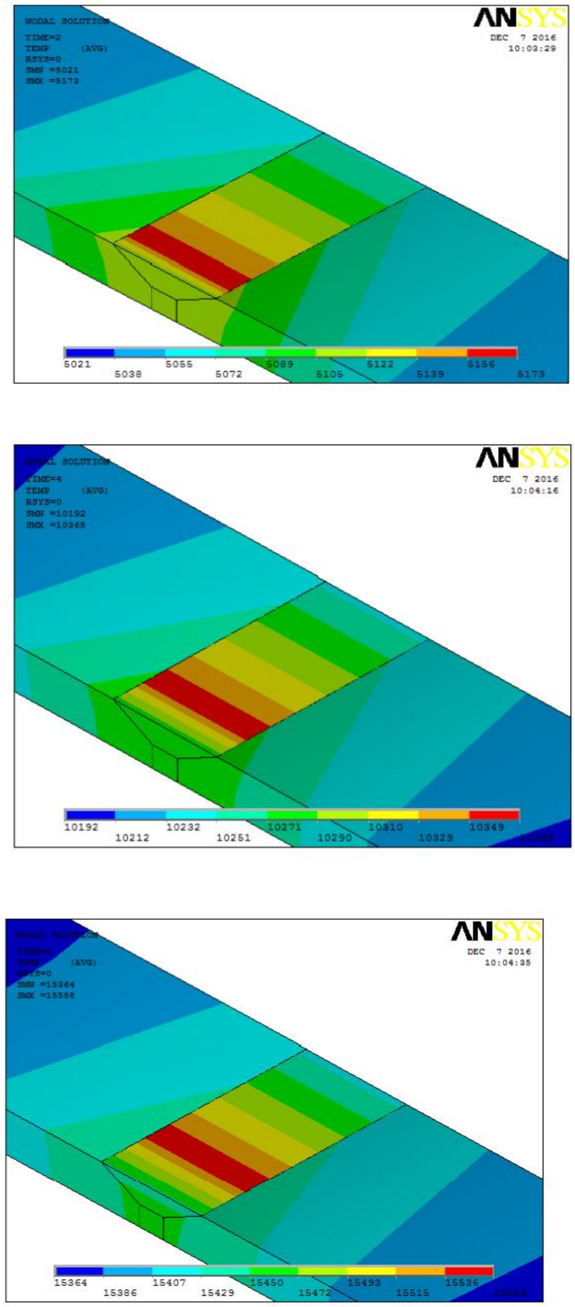
Fig,(2) Themicrostructure of base metal aluminum alloy 2024T351 represented by specimen(A), shows a coarse dendritic structure witha fine elongated grains distributed uniformly in the structure. From table (1) the chief element alloy is copper (Cu) in 2024 T3 which awarda considerablerises in strength, licensessedimentation hardening.[12] The fusion zone of MIG welded joints for 2024T351 specimens (B,C,D) have also a dendritic structure and this isbecauseof the melting of the original metal with filler metal which produces a region with a configuration that is in diverse from that of the original metal .

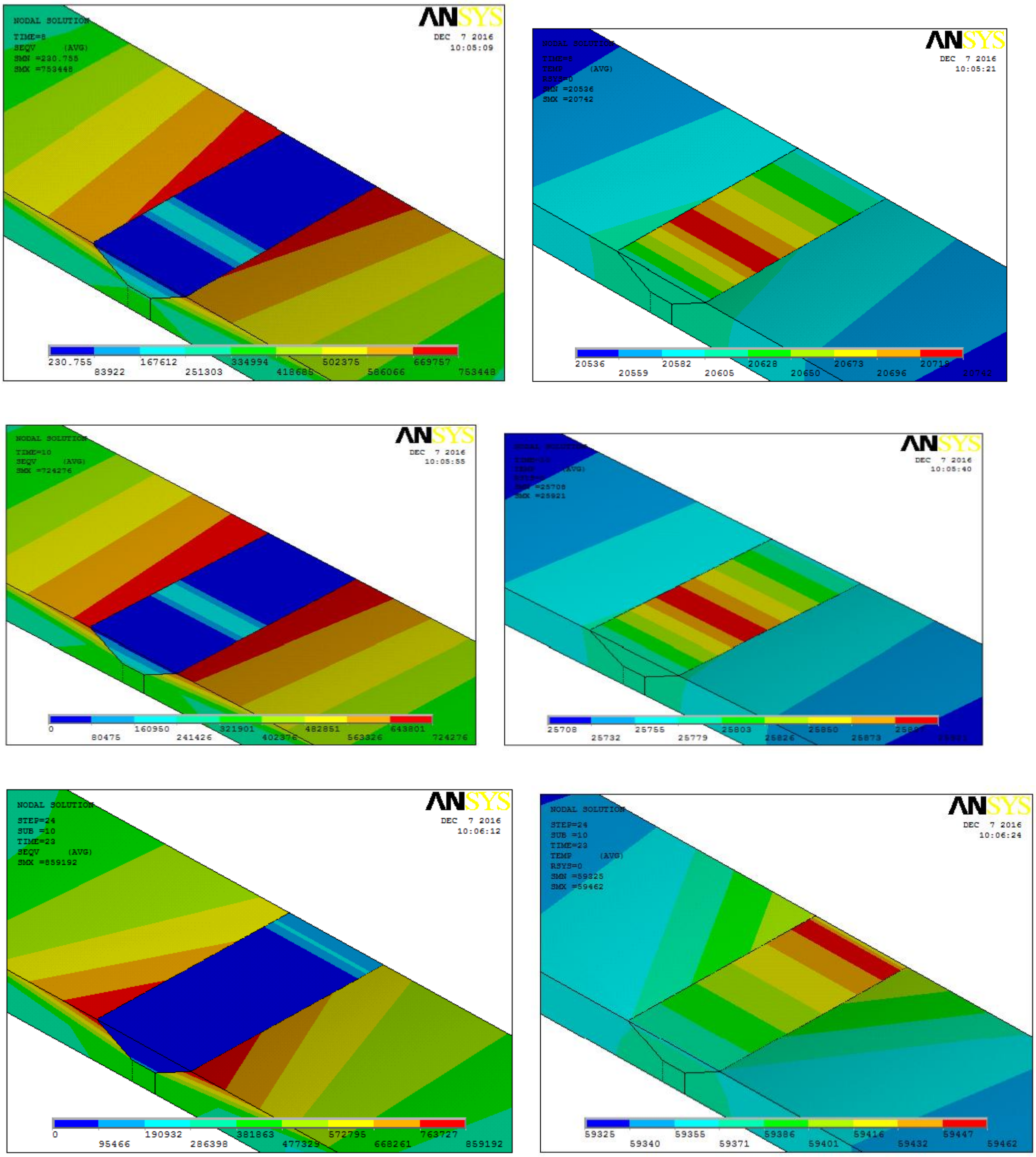
As a result of therequired great temperature for meltingjoining by MIG process, the HAZ area was great as well as and the followingfusion and hardening that happen have an effect on bending strength, The bending strength test results are shown in Fig**. (2)** that indicates that joints welded in all welding circumstances were very hard and exposed of greatly little bend angle deprived of cracks due to voids which areusual faultsoriginate in melting joints that participated in that deterioration. specimens (B,C,D) offers a lesser bending force analogy with un welded alloys that drives with [13], whereas bending in shot peening sampleshas a somewhatwell bending consequence than specimen without shot so shot peening contributed in improvement of bending strength due to the residual stress that reduces the welding defects.
specimens(B,C) gives better results than specimens (D) before and after shotdue to the welding angle training, where' V shape" angle participate of heat input distribution result ina "homogeny in microstructure".

Hardness guardianof the samples are shown in Table (7); in common it waslowered as equated with the original alloy. The lowest hardness is verifiedin specimen (C), where hardness injoinalloyzone was near"(82 HV)" and in the HAZ was near"(100 HV)".
The modeling analysis (deflection with heat) with thermo couple analysis was carried out by usingAnsys software V.15. The Element solid 5 which be the degree of freedom temperature

with displacement was adopted. The sense that it was to shed heat by Equation 1 and the introduction of the current values and voltages, each according to Table 3, were obtained the following results in **Fig.(8) and Fig.(9)**which represents the equivalent stress distribution during the welding process and temperature distribution . Those figures show that the value of stress and heat with angle weld 75^{o} are more than their values with 90^{o} angle weld and the reason of this result belongs to the surface area which becomes larger at 75^{o} and causes arise in heat generation through welding process.

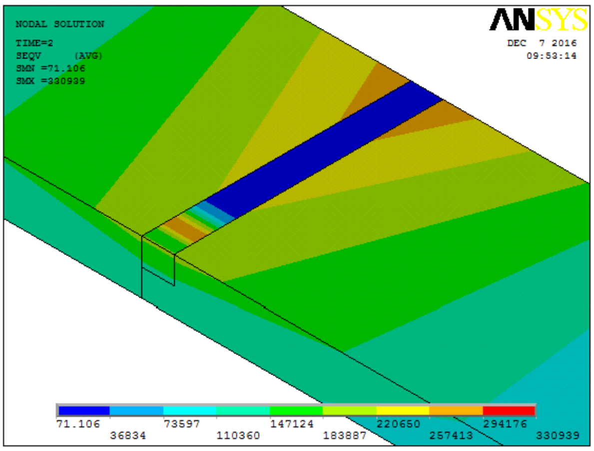






(a) (b)

Fig.(8) the equivalent stress distribution during the welding process and temperature distribution, at angle welding 75^{o}. a) Heat distribution b) Stress distribution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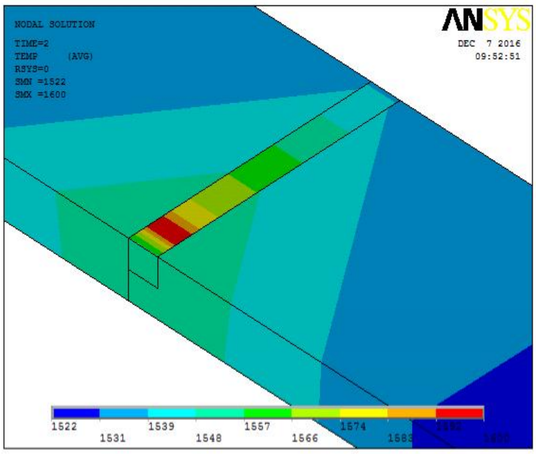
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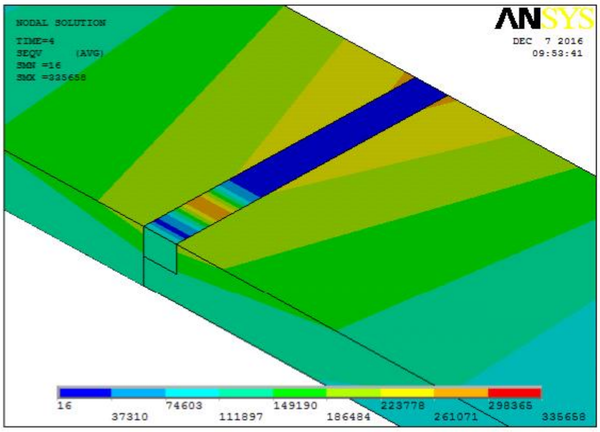
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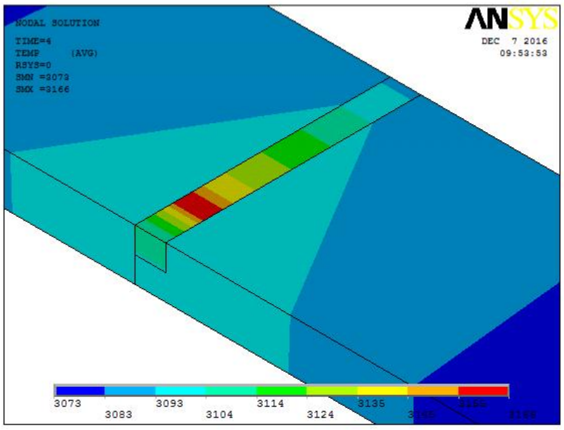
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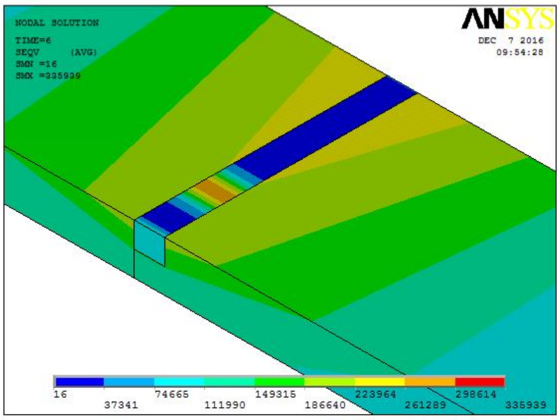
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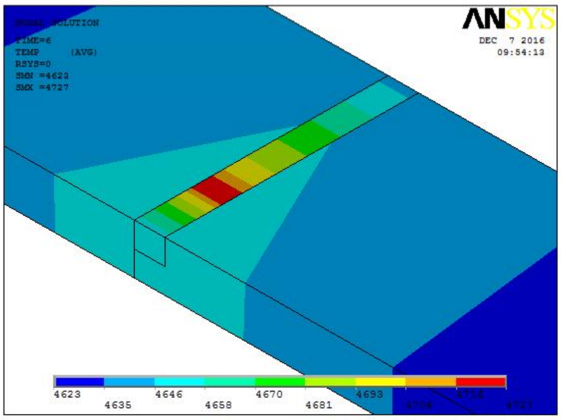
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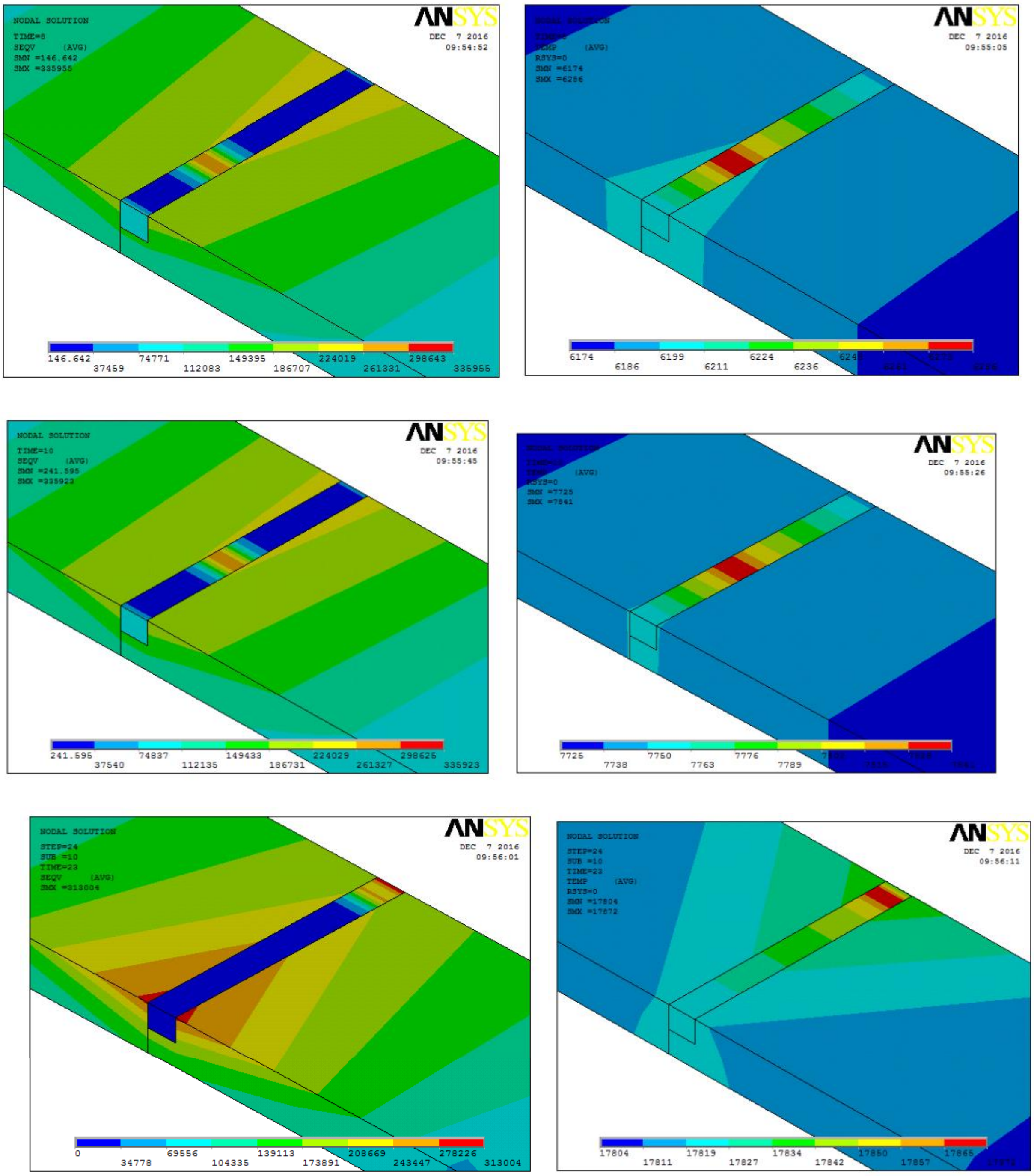

(a) (b)

Fig.(9) the equivalent stress distribution during the welding process and temperature distribution at angle welding 90^o. a) Heat distribution b) Stress distribution

Conclusion :

1- In MIG welding, the chemical structure of the weld zone was variationdue to the new established mixture produced between filler and base metal alloy.

2- Greateramountof heat in the MIG method produces many defects which affects negatively on the bending properties of the welded material

3- Compressive residual stress was main inducing in increasing bending strength.
4-Shot penning process improves bending strength by a percentage of 35.21% for the double V weld joint , while using double V welded joint improve the strength by 12.76% more than the single V weld joint.
5- Stress and heat analysis show that the angle weld 90^o is less than angle weld 75^o in this welding process.

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