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MEASUREMENT OF MAGNETIC FIELDS EMITTED FROM WELDING MACHINES

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ABSTRACT :- The electric arc welding process makes use of the heat produced by the electric arc to fusion weld metallic pieces. An electric arc is formed when an electric current passes between two electrodes separated by a short distance from each other. The aim of this work is to determine the electromagnetic field strength emitted by different electrical welding machines at different ranges and identify the safe ranges in order to avoid its negative health effects on the welder body. The research has been performed in two parts, mathematical calculations and practical measurements using (EMF-827) field tester. Both measurements indicate that these exposure levels lie within permissible international standard limits , but in some very close to the torch the values of magnetic filed are above the standard permissible values, so there is no harm to human health if the exposure is for an intermittent and discontinuous periods.

Keywords:- Electromagnetic field , Health effect, Welding machines .

1-INTRODUCTION

Electromagnetic fields are present everywhere in our environment but are invisible to the human eye, there are natural sources and man made sources of EMF (Electromagnetic Field) such as the electricity that comes out of every power socket associated with low frequency electromagnetic fields. EMF in highly levels exist in work places usually near all electrical equipment including arc and resistance welding machines and leads, electric cranes, even photocopiers are sources of magnetic fields. In welding, strong magnetic fields can be produced close to the power source and the current-carrying cables, and these cables are often close to or touching the welder's body [(1)].

In addition to direct effects of EMF exposure and interaction of the fields with the human body, magnetic fields are created when electric current flows .the greater the current, the stronger the magnetic field. So, the strength of the magnetic field will vary with power consumption. Exposure to strong electromagnetic fields can cause harmful health effects, so limits and guidelines for human exposure are set by WHO (World Health Organization) to prevent a negative health effects to human body due to exposure to the EMF [2,3] .This research will focus on the measuring the EMF levels in the vicinity of the welding torch and cables near the welder in the work place and determine the safe ranges from the torch .

1.1 Background

In arc welding machine one electrode is the welding rod or wire, while the other is the metal to be welded. The arc is started by momentarily touching the electrode on to the plate and then with drawing it to about 3 to 4 mm from the plate. When the electrode touches the plate, a current flows, and as it is withdrawn from the plate the current continues to flow in the form of a spark across the very small gap first formed as shown in figure (1).

Arc welding uses high electric currents up to some hundreds of Amperes which flows through the torch-cable, into the work-place and back to the power source throw the ground cable .The magnetic field-properties around welding machine is primarily defined by the properties of the welding current. Currents flow in the welding and cutting machines produce magnetic fields around all parts of the welding circuit, the most relevant exposure of the welder is to be expected where the torch-cable be close to his body. As the distance to the body of the welder is at a minimum for the torch cable and also the lowest gradient is applicable for this type of field source, this part of the welding circuit represents the most relevant exposure situation. [4] **.**

1.2Previos work

Possible health effects of electromagnetic fields emitted from welding and cutting machines have given rise to discussions in both public and scientific communities for many years. Some researches in this field are:

- The study carried out by Stuchly and Lecuyer (1989) showed the measurements at 10 cm away from the operator's body. Magnetic fields up to 200 μT, 300 μT and 400 μT were measured at the welders head, chest and waist respectively and up to 1000 μT at the welder's hand, due to holding the welding torch or electrode holder. Measurements were also conducted at 10cm away from the welding cables. The maximum magnetic field measured at 10cm from the welding cable was in level of 1256 µT, which is about three times of the ICNIRP reference level at 50Hz [(5)].

- Allen (1994) also stated some measurements were carried out by the NRPB (National Radiological Protection Board) on a TIG (tungsten inert gas) welder. Magnetic fields of 100-200 µT were measured at the operators position, 100 µT close to the power supply and 1000µT at the surface of the welding cable..[5]

- In a study of electrical workers, Bowman et al (1988) took spot measurement at ELF (extremely low frequency) below 100Hz, adjacent to eight TIG welders. The magnetic fields measured were relatively low compared to those reported by other researchers at 2.4-9.0 µT (mean) for AC TIG and 0.4-1.6 µT (mean) for DC TIG. No values for the welding currents were given. [(6)] .
- Skotte and Hjollund (1997) assessed exposure to ELF magnetic fields of welders and other metal workers and compared exposure from different welding processes. Measurements were carried out over the working day using personal exposure meters attached to a belt. Some measurements were also made for short durations 1cm away from the welding cables. [(7)].

2-BEOLOGICAL EFFECTS OF EMF

Welding and cutting arcs produce electromagnetic radiation. .The radiation potential effect on the body depends on the type and intensity of radiation, the distance from it and the duration of exposure. [(8)]. Time varying magnetic fields induce eddy currents in structures of conductive material. The published average conductivity of living tissues is 0.2 S/m, which is sufficiently high to create relevant currents in body tissues. These currents, flowing in cross-sections of the body are characterized by the resulting current density J, usually expressed in mA/m2. Cells may be stimulated by these currents if their amplitude is high enough, the time duration of the induced current exceeds the “response time” of the cell and the rise time of the excitation is faster than an established threshold value. The workers are must be aware of potential risk and to take appropriate precautions [(9)] .

Laboratory studies to date have not answered questions about possible human health effects. These studies are, however, providing clues about how EMFs interact with basic biological processes. The cell membrane may be an important site of interaction with induced currents from EMFs. Some of these effects are:

- Changes in functions of cells and tissues

- Decrease in the hormone melatonin
- Alterations of immune system
- Accelerated tumor growth
- Changes in biorhythms
- Changes in human brain activity and heart rate (10).

3-RESEARCH PROCEDURE

In this research there have been two methods of determining the levels of EMF ,the mathematical calculations and the practical measurements.

3-1- Mathematical calculations

The value of magnetic flux density (B) which depends on the distance from the source and the amount of current that flowing through the device . It can be calculated using Amperes law as follows [11]:

$$B = \frac{\mu_0 I}{2\pi r} \qquad \text{(1)}$$

Where:

- ***B*** *: Magnetic field (density), measured in Tesla (T)*
- ***r*** *: distance from the source of EMF , measured in meter (m)*
- ***I*** *: Electrical current , measured in ampere (A)*
- μ_0 *: Permeability of free space , measured in Tesle. meter/ampere (T . m / A)*

$\mu_0 = 4\pi \times 10^{-7}\ T \cdot m / A$

1-The value of (B) for a (3) ranges from the DC generator ARC welding machine can be calculated using eq. (1) as: For a distance : r = 1m and current : I = 120 A :

$$B = \frac{120 \times \mu_0}{2\pi \cdot (1)} = \frac{120 \times 4\pi \times 10^{-7}}{2\pi \cdot (1)} = 240 \times 10^{-7}$$

$= 24 \times 10^{-6}$ Tesla = 24 micro Tesla < 100 micro Tesla ………...……….(2)

It is within the guideline limits, So, according to (WHO), It is a safe range

2 - For a distance : r = 50cm and for the same current : I =120 A

$B = 48 \times 10^{-6}$ Tesla = 48 micro Tesla = guideline limits

It is equal the guideline limits, So, according to (WHO), It is a critical range

3- For a distance : r = 10cm and for the same current : I = 120 A

$B = 240 \times 10^{-6}$ Tesla = 240 micro Tesla > guideline limits

Calculation result of EMF are indicated in table (1) .

2-The value of (B) for a (3) ranges from the single-phase AC /AC ARC welding machine can be calculated using eq. (1) as:

1. For a distance : r = 1m and current : I = 150 A :

$$B = \frac{150 \times \mu_0}{2\pi \cdot (1)} = \frac{150 \times 4\pi \times 10^{-7}}{2\pi \cdot (1)} = 300 \times 10^{-7}\ \mathbf{T}$$

$$= 30 \times 10^{-6} \text{ Tesla} = 30 \text{ micro Tesla} < 100 \text{ micro Tesla} \qquad \text{……….……….(3)}$$

It is within the guideline limits, So, according to (WHO), It is a safe range

2 - For a distance: r = 50cm and for the same current: I = 150 A

$B = 60 \times 10^{-6}$ Tesla = 60 micro Tesla = guideline limits

It is equal the guideline limits, So, according to (WHO), It is a critical range

3- For a distance: r = 10cm and for the same current : I = 150 A

$B = 300 \times 10^{-6}$ Tesla = 300 micro Tesla > guideline limits

Calculation result of EMF are indicated in table (2) .

3.The value of (B) for a (3) ranges from the three-phase AC/ DC ARC welding machine can be calculated using eq. (1) as: For a distance : r = 1m and current : I = 250 A : For a distance : r = 1m and current : I = 250 A :

$$B = \frac{250 \times \mu_0}{2\pi \cdot (1)} = \frac{250 \times 4\pi \times 10^{-7}}{2\pi \cdot (1)} = 500 \times 10^{-7}$$

$$= 50 \times 10^{-6} \text{ Tesla} = 50 \text{ micro Tesla} < 100 \text{ micro Tesla} \qquad \text{……….……….(4)}$$

It is within the guideline limits, So, according to (WHO), It is a safe range

2 - For a distance : $r = 50cm$ and for the same current : $I = 250$ A

$B = 100 \times 10^{-6}$ Tesla = 100 micro Tesla = guideline limits

It is equal the guideline limits, So, according to (WHO), It is a critical range

3- For a distance : $r = 10cm$ and for the same current : $I = 250$ A

$B = 500 \times 10^{-6}$ Tesla = 500 micro Tesla > guideline limits

Calculation result of EMF are indicated in table(3) .

3-2- Practical measurement

In this work the practical measurements of the electromagnetic field produced by the three types of arc welding (single phase, three phase with rectifier and engine driven generator) for high, medium and low current are carried out by using electromagnetic field tester EMF- 827 which is available in electrical engineering laboratory. This portable device provide the user with resalable and easy way for measuring the electromagnetic field at low frequencies up to (50HZ), see figure (5)

Measurements have been conducted at the following three ranges:

1. (10 cm) from the torch.
2. (50cm) from the torch.
3. (1 m) from the torch .

From the practical measurements and mathematical calculation results, it can be conclude that there is symmetry in some results and difference in others ,but the most of results generally are indicate that there is a risk on the welders health in the very close distance (10cm), according to guideline limits set by the (WHO) [12].

The results of practical measurements for the three types of welding machine at three distances are indicated in tables (4,5,6) and the graphical representation of these results are indicated in figures (6,7,8) as follows :

DISCUSSION

This work has examined the magnetic fields in the vicinity of a three types of arc welding equipment operated using typical welding conditions. The results shows that in many cases the magnetic fields are higher than the effective ICNIRP(International Commission on Non-Ionizing Radiation Protection) reference levels and in the other cases the magnetic fields are within the effective ICNIRP reference levels:

1- Very high fields have been indicated close to the three-phase welding electrodes. The highest field recorded was (410 μT>100 μT) at 50Hz, 10 cm away from the electrode for a current of (250A).so, according to ICNIRP standard reference it consider not a safe range.
2- Fields have been indicated close to the welding electrodes. The field recorded was (220 μT) at 50Hz, 10 cm away from the electrode for a welding current of (150A). So, according to ICNIRP standard reference it can be considered as unsafe range.
3- For the three-phase welding machine, all the measured field results at >50cm are within the ICNIRP standard reference, so, they considered a safe ranges.
4- For the single phase welding machine, the ICNIRP reference levels are exceeded at a typical operating position of 30 cm away from the electrodes and up to distances of the order of 1m. Measurements close to a kick less cable, as if used to supply a welding head from a remote transformer showed that the magnetic field was less than the reference level at a working distance of 20 cm away from the cable.

From the previous mathematical calculations and the practical results, we can conclude:

1. According to the results indicated in tables (1,4) , both results are deferent.The reason may be because in the case of loading of the DC generators lead to decrease the motor speed which drive the generator and that cause voltage drop which lead to drop in the current ,
2. According to the results indicated in tables (2,5) , both results are deferent because in case of the single phase ARC welding machine the current will decrease as a result of voltage drop in the electrical power supply .
3. While in tables (3,6) mathematical calculations and the practical results are approximately identical because the current and voltage in the three phase AC/DC ARC welding machine are stable .

RECOMMENDATION

Based on the results obtained and above discussion, some precautions must be taken into account to reduce the EMF health effects as follows:

1. The welders should wear protection clothing to protect them from EMF radiation.
2. The welder must keep away the hand which holds the torch-cable as possible from his body to reduce the impact of radiation on his body.

3. The welder should not be used the arc welding in case of high currents, except in emergency cases.
4. The welder should keep a way from the negative lead, because it will pass through it the same current producing electromagnetic field around it.
5. Shielding and mitigation is a common terms for reducing exposure to electromagnetic fields. It covers shielding with ferromagnetic and/or conductive materials on the one hand and field reduction using passive or active cancellation wire loops on the other.

Ferromagnetic material shielding creates an alternative path for the magnetic flux.

From all previous results and discussion we can conclude that there is no health hazard from working with these welding machines if the working time is for short and discontinued periods.

CONCLUSION

In this research ,the electromagnetic field strength emitted by different electrical welding machines at different ranges are investigated and the safe ranges from torches electrode have been determined in order to avoid its negative health effects on the welder body. The research haves been performed in two parts, mathematical calculations and practical measurements. Results indicate that the mathematical calculation generally identical to practical measurement and comparison the obtained results with the international standard limitation indicate that the levels exceed the standard level >100 at a range of (R=10cm),but for a range (R >50cm),the EMF levels are within the permissible limits set by the ICNIRP. so it pose no harm to human health if the exposure is for an intermittent and discontinuous periods.

REFERENCES

1- Electromagnetic field: Nobel Koura, MD, DO, MBA, FABMISSA NeJersey, USA peril 9, (2000).

2- Hansson Mild K, B. Greenebaum. Environmental and occupationally encountered electromagnetic fields. In: Barnes FS, Green ebaum B, editors. Handbook of biological effects of electromagnetic fields. 3rd ed. (Vol. 1. Bioengineering and biophysical aspects of electromagnetic fields). Boca Raton, FL, USA: CRC Press;. p. 1–34. (2007).

3- International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting Exposure to Time-Varying Electric, Magnetic, and electromagnetic fields (up to 300 GHz). Health Phys.;74(4):494–522.(1998).

4- W. A. Creasey and R. B. Goldberg, "Status Report On Potential Human Health Effect Associated With Power Frequency Electric And Magnetic Fields (PSE-T-39). ," Maryland Dept. of Natural Resources and Public Service Commission of Maryland, Contract No. PR94-009-008, Final Report, September 1994, 238 pp, (1994).

5- Allen et. al. Review of occupational exposure to optical radiation and electric and magnetic fields with regard to the proposed CEC Physical Agents Directive. NRPB-R265, 1994

6- Bowman et. al. Exposure to extremely low frequency (ELF) electromagnetic fields in occupations with elevated leukemia rates, Appl. Ind. Hyg. Vol 3, No 6, (1988).

7- Skotte JH and Hjollund HI, Exposure of welders and other metal workers to ELF magnetic fields, Bioelectromagnetics 18:470-477 (1997)

8- Phirke, P S, Kubde, A B, Umbarkar, S P, The Influence of Magnetic Field on Plant Growth, Seed Sci Technol, 24 : p375 - 392, (1996).

9- International Journal of Occupational Safety and Ergonomics (JOSE),Vol. 15, No. 1, pp.(3–33). (2009).

10- Guenel. P. and. Lellouch, J. "Effects of very low frequency - Electromagnetic field: Analysis of epidemiologic literature" Les Editions Inserm.vol. 101, 54 pp.(1992)

11- Elements of Electromagnetic by :Matthew N. O. Sadiku .page:292 Saundars College ublishing .(1989.).

12- Reilly, J. P. Peripheral nerve stimulation by induced electric currents: exposure to time-varying magnetic fields. Med. Biol. Eng Computing 3:101–109; (1989).

Table (1): mathematical measurements of magnetic field levels from DC generator ARC Welding machines.

welding machine	at (10cm)from the lead	at (50cm)from the lead	at (1 m)from the lead	Current(I) flow in welding machine
	B (µT)	B (µT)	B (µT)	I(ampere)
DC generator ARC Welding machines	240>100	48	24	120 Amps
	180>100	36	18	90 Amps
	120>100	24	12	60 Amps

Table (2): mathematical measurements of magnetic field levels from Single phase AC /AC ARC Welding machines.

welding machine	Current(I) flow in welding machine	at (10cm)from the lead	at (50cm)from the lead	at (1 m)from the lead
	I(Ampere)	B (µT)	B (µT)	B (µT)
Single phase AC /AC ARC Welding	150 Amps	300>100	60	30
	130 Amps	260>100	52	26
	92 Amps	184>100	36.8	18.4

Table (3): mathematical measurements of magnetic field levels from Three-phase AC/ DC ARC welding machine

welding machine	Current(I) flow in welding machine	at (10cm)from the lead	at (50cm)from the lead	at (1 m)from the lead
	I(Ampere)	B (µT)	B (µT)	B (µT)
Three-phase AC/ DC ARC welding machine	250 Amps	500>100	100	50
	150 Amps	300 >100	60	30
	100 Amps	200 >100	40	20

Table (4):practical measurements of EMF levels from DC generator ARC Welding machine

welding machine	Current(I) flow in welding machine	at (10cm)from the lead	at (50cm)from the lead	at (100cm)from the lead
	I(Ampere)	B (μT)	B (μT)	B (μT)
DC generator ARC welding	120	81	26	6
	90	40	13	7
	60	18	8	3

Table (5): practical measurements of electromagnetic field levels from single phase AC /C ARC Welding machine

welding machine	Current(I) flow in welding machine	at (10cm)from the lead	at (50cm)from the lead	at (100cm)from the lead
	I(Ampere)	B (μT)	B (μT)	B (μT)
Single phase AC /AC ARC Welding	250	180>100	140>100	18
	130	140>100	49	22
	92	58	34	18

Table (6): practical measurements of electromagnetic field levels from three phase AC /DC ARC Welding

Welding machine	Current(I) flow in welding machine	at (10cm)from the lead	at (50cm)from the lead	at (100 cm)from the lead
	I(Ampere)	B (μT)	B (μT)	B (μT)
THREE PHASE AC/DC ARC WELDING	٢٥٠	٤١٠>100	٤٦	١٨
	١٥٠	٢٢٠>100	٣٢	١٤
	100	92	28	9

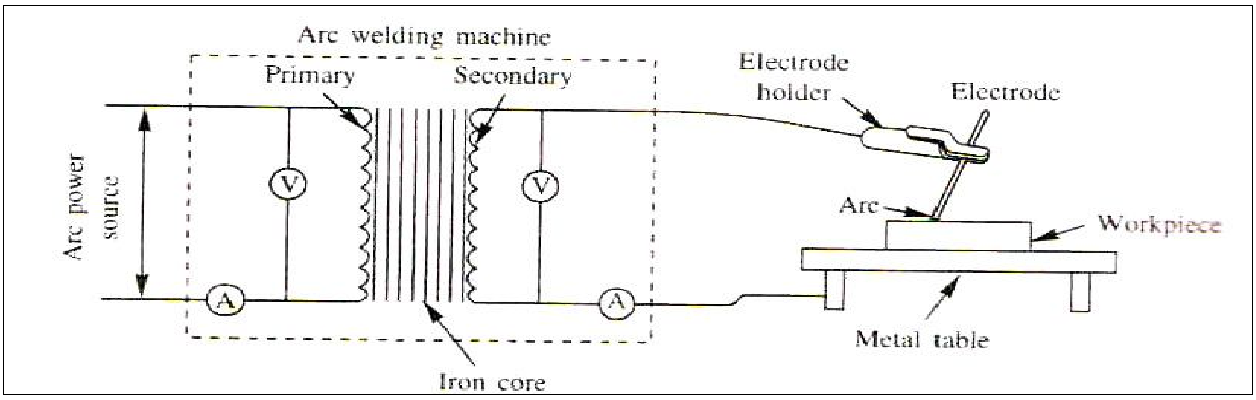

Fig. (1): Welding process.

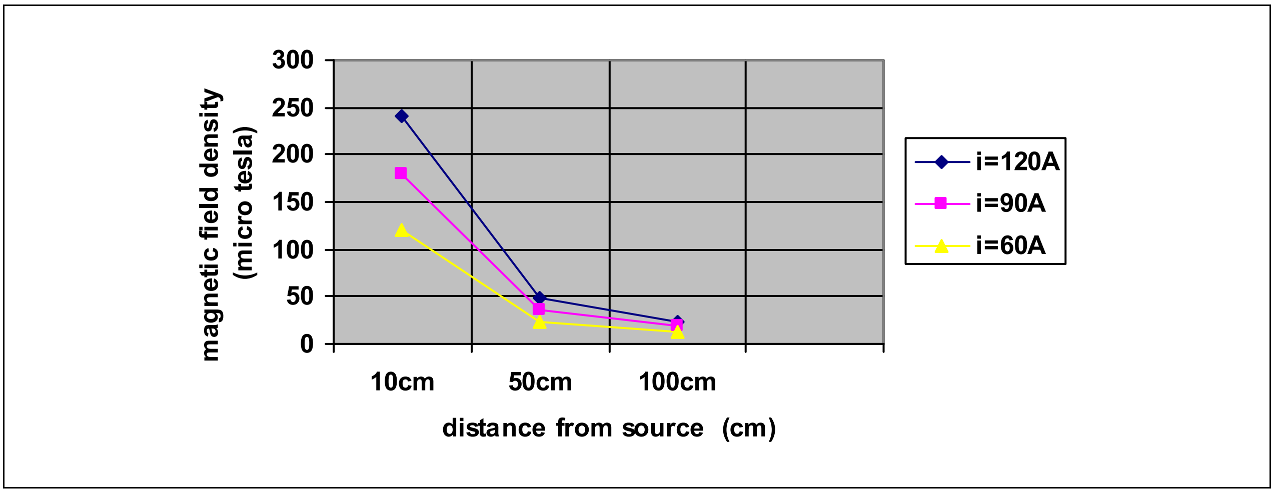

Fig. (2): Graphical representation of mathematical measurement for DC generator ARC Welding machines.

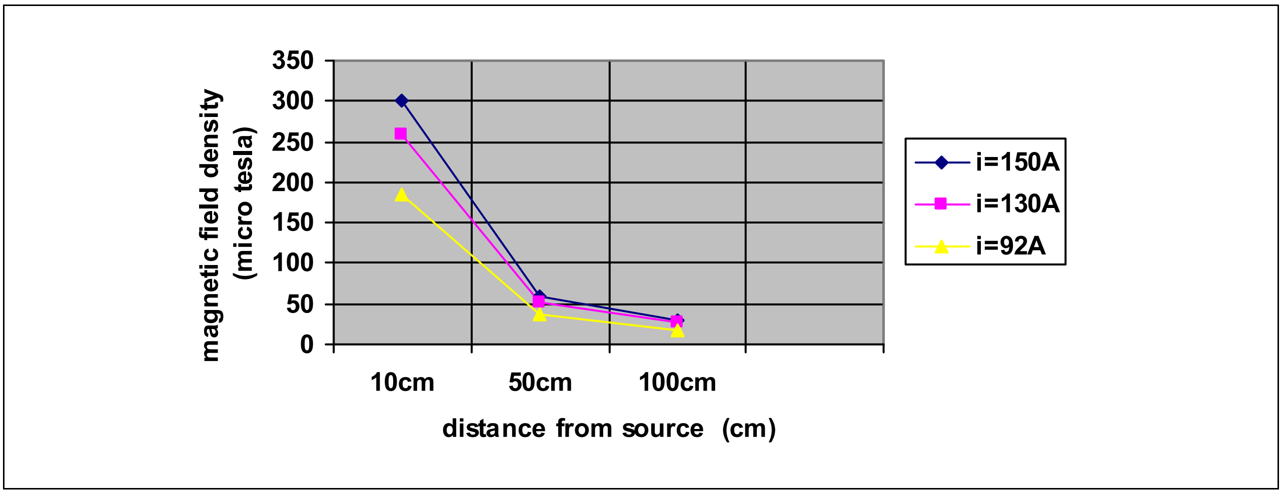

Fig. (3): Graphical representation of mathematical measurement for Single phase AC /AC ARC Welding machines.

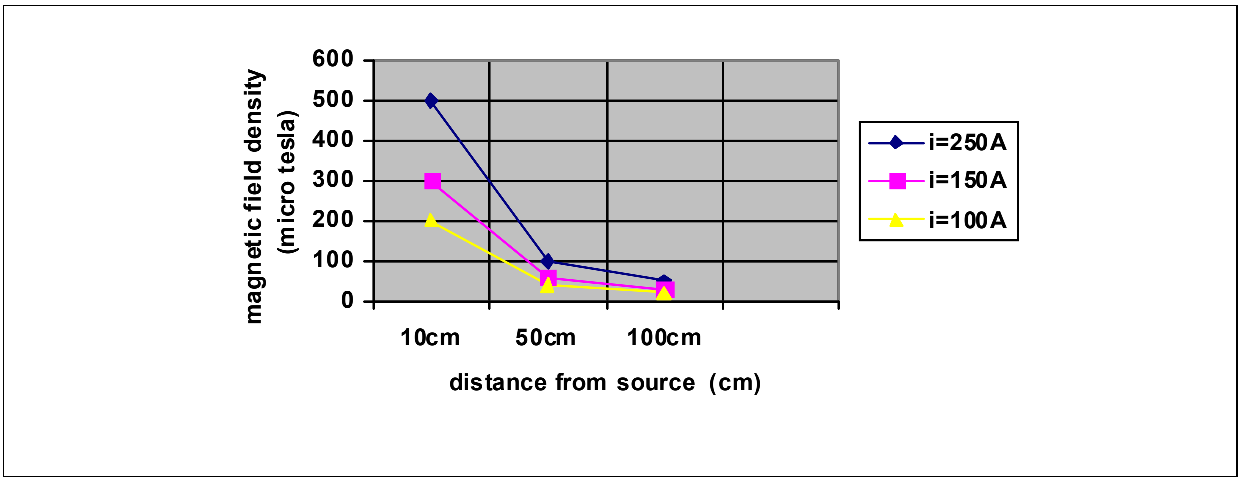

Fig. (4): Graphical representation of the mathematical measurement for Three-phase AC/ DC ARC welding machine

Fig. (5): electromagnetic field tester (EMF- 827).

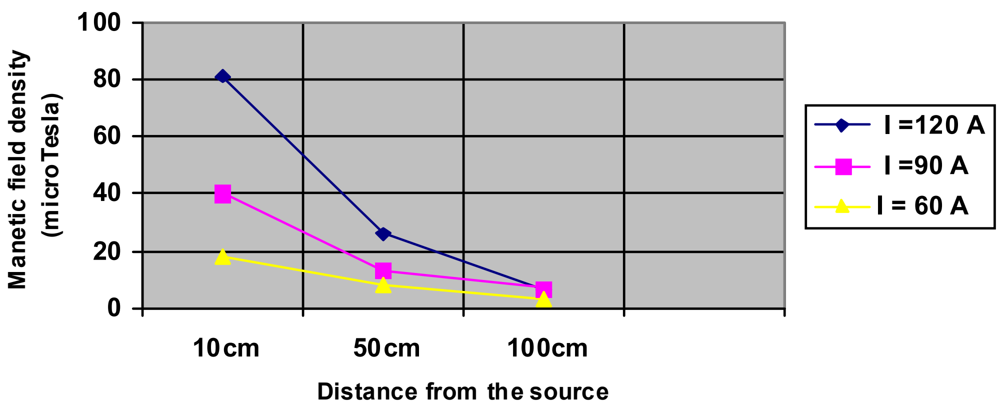

Fig. (6): Graphical representation for the practical measurements of EMF levels from DC generator ARC Welding machine.

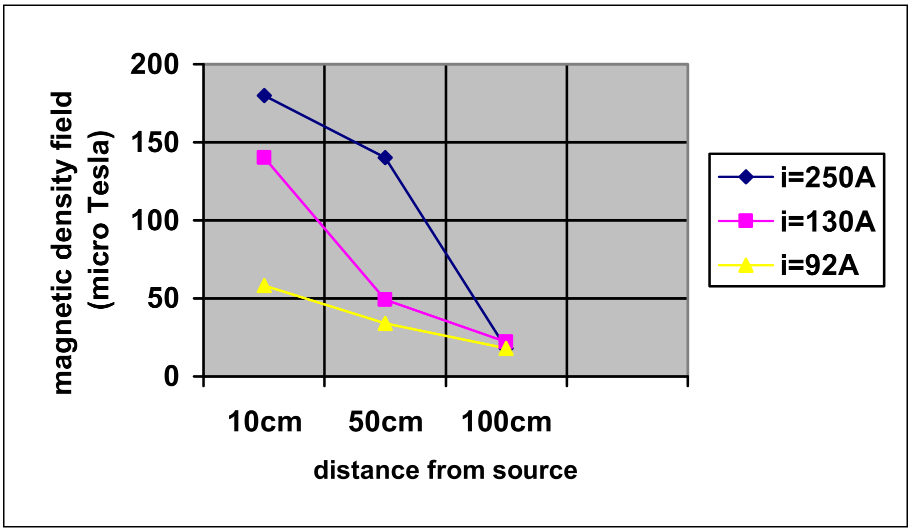

Fig.(7):graphical representation for practical measurements of electromagnetic field levels from single phase AC /C ARC Welding machines.

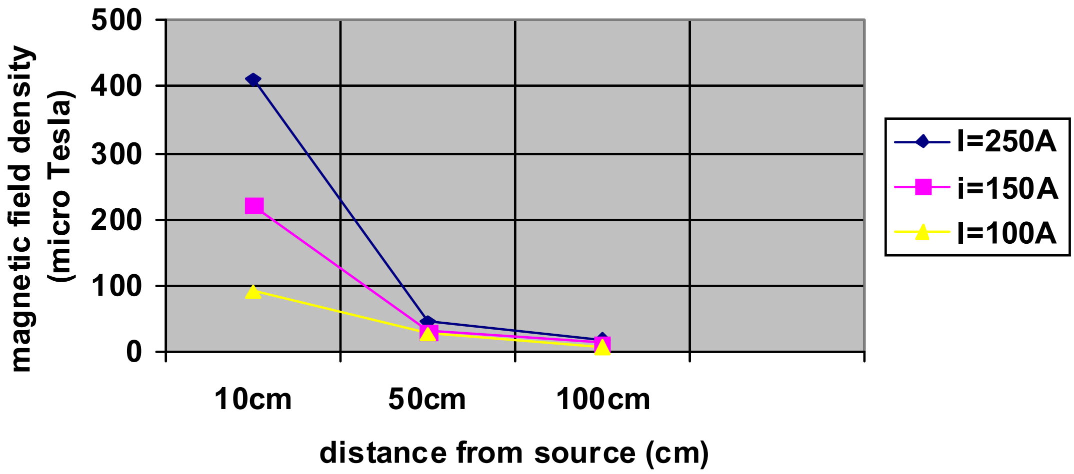

Fig. (8): Graphical representation for the practical measurements of electromagnetic field levels from three phase AC /DC ARC Welding.

حساب المجالات الكهرومغناطيسية المنبعثة من مكائن اللحام

كامل جدوع علي
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الخلاصة:-

ان ماكنة اللحام الكهربائية تستخدم الحرارة الناتجة عن القوس الكهربائي في لحام القطع المعدنية بعد انصهار المنطقة المراد لحامها . يتشكل القوس الكهربائي عندما يمر تيار كهربائي بين قطبين مفصولين عن بعضها البعض بمسافة قصيرة. إن الهدف من هذا البحث هو تحديد شدة المجالات الكهرومغناطيسية المنبعثة من مكائن اللحام الكهربائية ولمديات مختلفة وتحديد المديات الآمنة لتجنب الآثار الصحية السلبية لهذه المجالات على اللحامين . تم انجاز البحث بطريقتين،الحسابات الرياضيه و القياسات العمليه. وقد أشارت البيانات التي حصلنا عليها أنها مطابقة للمعايير المسموح بها دوليا الا في بعض المسافات القريبة جدا من اللحام . و هذا يعني انه لا خطورة من التعرض لهذه المجالات إذا كانت ضمن المستويات والمديا ت المذكورة ولفترات زمنية قصيره متقطعة.

الكلمات الدالة : المجال الكهرومغناطيسي ،التاثير الصحي ،مكائن اللحام.