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Microstructure Refinement for Fe-34Mn-10Al-0.76C Alloy Using Variable Pulsing Magnetic Field (PMF) Solidification

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Abstract

Background: The effect of the pulsed electromagnetic fields with different fluxes (voltages) on the microstructure of an alloy during all stages of solidification under specified thermal conditions will be discussed in this project. Experiments were carried out in the university laboratory for this purpose. The optical scanning, electron microscopy scanning, and dispersed X-ray analysis methods were used to analyze the results of the micro-solidification formulations of the alloy with different fluxes. To perform the required evaluation, a control sample was tested without any treatment, then the results of every flux were compared with the results of this control sample. The applied magnetics flux and Lorentz forces were considered as the main reasons for the achieved grain refining and diffusion of the improved solubility in the sample. The fully equiaxed dendritic structure has been realized for the aluminum alloys at 180 Volts flux. Lorentz's strong force, induced by the magnetic field, deactivates the developing direction of the bifurcation (dendrites), as well as spoils the directions of growing the intermetallic alloy, as a result of the formation of solid microstructures. Further refinements were achieved, by increasing the voltages. Therefore, it can be concluded that the pulsed electromagnetic field is a promising technique that can be utilized in the metallurgy evolution. **The effect of PMF with** different fluxes on the microstructure of the Fe-34Mn-10Al-0.76C alloy samples will be examined experimentally using optical scanning, EDX and SEM and by applying various analysis techniques. Then, compared with the control sample that don't treated with any PMF. The initial dendrites growth direction and size were changed according to the PMF flux. Also, the lengths of the initial dendrites were reduced by increasing the voltage, which led to the formation of different dendrite equiaxed grains. The PMF flux affects the initial dendrites growth direction and size. While, increasing the PMF voltage reduces the lengths of the initial dendrites. Moreover, the PMF has a great impact on diffusion of solute through solidification that then influences the formation of eutectic microstructural.

Keywords: Fe-34Mn-10Al-0.76C, Microstructure Refinement, Pulsing Magnetic Field, Solidification

1. Background

Solid metals and alloys have a consisting metallic structures, can be classified into the following three main types which are *Amorphous solids, Crystalline solids, and i. Quasiperiodic crystals (quasicrystals).* Most solids are found in amorphous form. These solids are characterized by the absence of a specified arrangement between their atoms, moreover, no uniformity has been found on the wide range. Therefore, no equation formula can be used to express the positions of the atoms (Stachurski, 2011). But at the atomic level, there may be some uniformity. For example, wax and glass (Hu, Wang, & Zhang, 2017). Unlike amorphous solids, the crystalline solids are distinguished with a high degree of uniformity and symmetry between the atoms over the whole structure. This uniformity depends on principles, such as the permissible rotational symmetry of the structure (Bruce, 2007; Shechtman & Candace, 1997). The quasi-crystalline solids are feature with repeated symmetry in the arrangement of their atoms, In addition to the rotational symmetry unlike the crystalline solids just as the multiple folds (high level) of rotational symmetry. Furthermore, instead of the unit cells of the crystalline solids, the quasicrystals are split into several structural elements as icosahedral and decagonal (Goldman, Sordelet, Thiel, & Dubois, 1997; Huttunen-Saarivirta, 2004).

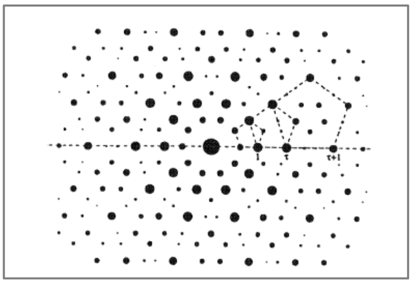

Figure 1. A quasicrystal with five-folds symmetry (Goldman, Sordelet, Thiel, & Dubois, 1997)

For atoms of high-order symmetry organized in good patterns they are accumulated, which gives them properties similar to crystals, for example Bragg peaks. However, the bonding between units is more flexible, but still not random, with regard to the bonds between each other, which results in a linear symmetry and restricting the atoms' movement in a single direction. When comparing the arrangement of the atoms' plans in both crystals and quasi-crystals, it was found that the crystals are characterized by uniform and periodic patterns, in contrast to the quasi-crystals in which the arrangement of atoms is not periodic. But despite the existence of this un-uniformity, the ordering of its plans' arrangement makes it easier to predict the atoms' location, for example, using the golden ratio number (Giacovazzo, Monaco, Viterbo, Scordari, Gilli, Zanotti, & Catti, 1992). On the other hand, not all quasi-crystalline solids have a regular periodicity in their three axes. for example, the Icosahedral quasicrystals characterized by the quasi-periodicity in all axes. However, other types of quasi-crystals such as octagonal, decagonal and dodecagonal may have only two directions of quasi-periodicity (Cahn, 2001).

Many applications in various fields are depend on using metals and their alloys. The study of the microstructure of these materials is very important, as they directly impact their mechanical characteristics. In previous, these investigations were carried out using the optical microscopes after appropriate preparation for the investigated samples. However, modern engineering trends tend to define methods for investigating as well as improving the microstructure of studied metals in order to optimize their mechanical characteristics. In connection with this project, the pulsed magnetic field (PMF) process will be used to treat and improve the microstructure of the investigated metal (Zhang, Hu, Zhou, Zhan, & Jin, 2017).

1.1 Solidification of Metals Alloys (Sintering)

In general, to produce stable quasi-crystals, the pure metals are melted and casted into ingots. To keep away from the contamination, the melting process should be carried out in the vacuum. pores should be provided in the micrometre range, because both crystals and quasi-crystals characterized by different structures and atomic sizes. A powder sintering containing the required components can be used to eliminate the obstacles of the coexistence of crystal and quasicrystal structures as well as the unrestricted grain refining. Sintering is a popular process for producing large amounts of the required microscopic structure. Using the proper formulations of the primary powder enables the production of an amalgam mixture of crystalline and quasi-crystalline solids (Dubois, 2005; Ul'shin, Poznyak, & Ul'shin, 1999).

1) Rapid solidification

According to the aforementioned fact, it is not necessary for all the quasi-crystalline stages to be stable. Consequently, traditional methods of casting and treatment may be unsuitable to produce pure quasicrystals. Therefore, the rapid solidification technique is used to alloy the quasi-crystalline metals. This technique can be used to produce thermally unstable metals by promoting the solubility of the alloy metals in the basic metal. In the rapid solidification technique, the mixture is solidified very fast so that it does not have enough time for changing the microstructure, which helps to maintain the high-temperature microstructure. Nowadays, melt spinning consider the only type of rapid solidification that used to produce stable quasi-crystalline metals, such as, aluminium, magnesium, and copper. Whereas in melt spinning technology, the liquid melt is quickly suppressed, by transporting the molten metal to the outer surface of a copper roller, which rolls over a specified frequency. The (quenching) cooling rate fulfilled by the metallic spin is about 105.5°C. This technique is not suitable for mass production, because it usually produces fragile strips of quasi-crystals (Tkach, Limanovskii, Denisenko, & Rassolov, 2002).

It has been shown that the mechanical properties of these strips and their microstructure depend largely on the working parameters. The following factors have been introduced to control the formation of quasi-crystals according to the required characteristics.

- The wheel frequency.
- The ambient (surrounding) gas.
- The melting temperature.
- The pressure of ejection.

An inert ambient gas can be used to boost the wheel's speed and improve the solidification rate. Moreover, raising the temperature of the melted alloy, and by reducing the pressure of the ejaculation can lead to reducing the solidification rate (Tkach, Limanovskii, Denisenko, & Rassolov, 2002; Humphreys, Warren, & Cerezo, 1998).

In general, it has been concluded that high quenching rates are recommended as they produce strips of lower diameter and hence more refined microstructures (Humphreys, Warren, & Cerezo, 1998).

The use of gas atomization technology enables more quick quenching rates than molten spinning technology. As the gas atomization leads to splitting the molten liquid into very little droplets, with sizes smaller than 150 µm (0.15 mm). As the fineness of the size of the drops relies on the melting temperature. Gas atomization technology is commonly used for producing commercial types of quasicrystals because of its improved ability to produce sphere-shaped powders featured with adequate flux characteristics (Sudarshan & Srivatsan, 1993).

In addition, the gaseous atomization technology produces highly qualified spherical powder particles. Therefore, it is also usually applied to thermal spraying, sintering and alloying.

Moreover, quasi-crystals structures can be produced using the mechanical alloying techniques where the alloying metals are dissolved more widely into the primary metal. Mechanical Alloying can be used to produce stable quasicrystal structures directly. to eliminate the duplication of melting and solidification processes, the alloy powder may be used in the solid condition. The process of mechanical alloying begins with the preparation of a mixture containing the elemental quantities of the required alloy composition. The mixture is then placed in the grinding bowl of the mill with the addition of the grinding and the process control components. All components were pressed together, while the powder was between them, as a result for shaking the mill. Which causing spherical milling that produces a microscopic structure with layers and an assumed powder composition (EckertL, Schultz, & Urban, 1989; TravessaI, Cardoso, Wolf, Junior, & BottaII, 2012).

After mechanical alloying, a stage that is sensitive to grinding (milling) conditions is formed. Low-energy grinding can result in an amorphous stage rather than a quasi-crystalline stage. However, high-energy grinding can result in a crystalline stage. In addition, if the milling period increases than the determined, this leads to the development of the quasi-crystalline stage among them. To obtain a quasi-crystalline stage for some alloys, the powder must be diffused by heat (Suryanarayana, 2001).

Concerning the alloys containing Fe and Al and as per several studies to develop the icosahedral structure of the $Al_{70}Cu_{20}Fe_{10}$, mechanical alloying powder, it has been concluded that:

- by milling for a period of 10 hours, the proportion of the icosahedral stage with regard to the cubic stage (β- Al-Cu-Fe) has been reduced compared to milling for 40 hours.
- The most effective parameter in the preparation of Fe- Al alloys that controlled the creation of the icosahedral stage is the proportion of Al in relevant to Cu and Fe.

Although a lot of effort has been made to assemble the icosahedral stage in the $Al_{63}Cu_{25}Fe_{12}$ alloy, this process has not yet succeeded. The importance of Al content to forming the icosahedral quasi-crystal structures has been demonstrated to average from (63 to 64.5)% by weight. It has also been detected that the existence of the fourth component into the alloy can enable the formation of the icosahedral quasi-crystals (Huttunen-Saarivirta, n. d.; Gogebakan & Avar, 2011).

1.2 Pulse Magnetic Field

Refinement of the grain is a significant phenomenon which prescribes the metals mechanical characteristics. The PMF presents a method for the grains refinement in addition to the improvement of the solidification microstructural (Li, Liu, Jie, Guo, Chen, & Li, 2017). PMF is considered a necessary parameter in the industry of materials processing due to the widely usage of it for the solidification realizing. This method is unlike the other traditional methods of solidification because it conserves the melt of the liquid from the pollution. Generally, a

PMF with direct current can significantly reduce the convection through the solidification, while changing the flux can be aided in controlling and modifying the solidification then the microstructural.

The solidification process of Mg-Al-Zinc alloy was investigated while exposed to PMF. This study aimed to examine the impact of the low voltage PMF (LVPMF) on several mechanical characteristics such as the Ultimate tensile strength (UTS), the yield strength and the microstructure formation. It was resulted that;

- Applying the LVPMF during the solidification process, it leads to a significant refining for the microstructure.
- LVPMF greatly improving the yield strength of the alloy in semi and normal casting.
- There is a reduction in UTS while casting at the normal conditions. that can be summarized that the shrinkage exists with PMF is the reason of reduce the UTS. This percentage of the reduction in UTS was eliminated by using the semi continuous casting, which led to raise the UTS (Fu & Yang, 2012).

The effect of the PMF on the alloy of Mg-Zn-Y solidification process has been investigated. Along with the influence of the vibrational power on the microstructure and mechanical characteristics of the alloy of of $Mg_{93}Zn_6Y$. Hence, it was summarized the following:

- Due to the increase of the vibration power, the alloy of $Mg_{93}Zn_6Y$ microstructural started to be more and more refined. Furthermore, the stage of icosahedral was modified from the structure of constant thick to the shape of discontinuous fine particle-like.
- The ratio of increasing the icosahedral stage was noticed to be reduced over the specimen, when the Zn and Yttrium density inside the grains were raised because of PMF. The stage of icosahedral was the reason of larger concentration of stress, consequently providing opportunity for the initiation of micro crack.
- The alloy of $Mg_{93}Zn_6Y$ mechanical characteristics presented distinction higher than the alloy that wasn't treated via PMF. A 350 W of power was used for the operation of treatment. The compared characteristics were (UTS, yield strength and alloy). The outcome was (221 MPa, 162 MPa and 1.99%), respectively. While comparing these values with the alloy that wasn't treated by PMF, they raised significantly by ratios of (66%, 65% and 124%), respectively (Zhang, Zhou, Hu, & Zhou, n. d.).

The influence of the (LVPMF) on Al-Cu alloy microstructural was investigated. Therefore, the cooling cycle was studied to observe its effect on the mechanism of grain enhancement by PMF. It was founded that, the PMF has a considerable effect while using through the phase nucleation phase, because it produces finer structure of grain. It was also observed that, when LVPMF was used through the fluid stage, it has not any impact on the solidification microstructure. Likely manner was reported for the phase of the crystal growth (Li, Tao, & Yang, 2012; Zhang, Gao, & Xu, 2015).

2. Method

After finishing this analysis, specific software and determine tools were applied to analyze of the microstructural of the alloy specimens. For preparing such alloy samples, row materials of carbon (C), Magnesium (Mn), iron (Fe) and Aluminum (Al) and were used. At the first, the undesired impurities of the surface that might impact the alloy microstructural through the process of solidification just as water vapor have been removed by drying and cleaning the materials. In order to dry the prepared samples, they were heated to 150°C for a period of 5 minutes to become dry. Then they were poured in a crucible (melting-pot) which placed inside a furnace of a high temperature. Such pot's capacity must be taken into account over the process of pouring. the melting-pot was sprayed by boron nitride (wall coating type) to eliminate its reaction with the molten alloy. A furnace that connected to a device (pid controller type) to measure and control the temperature of melting was used to alloying the samples. For measuring the temperature, a temperature controller attached with thermocouples was used. Furthermore, the samples can be picked immediately from the furnace using a certain tube of suction that attached to a device of vacuum pressure, such suction tube must be also cleaned and pre-heated to 150°C as aforementioned previously. Various PMFs were used in order to realize the solidification. Different researches have investigated the PMF impact.

A study aimed to investigate the effect of applying (PMF) to an alloy regarding the grain refinement, microstructural and the mechanical properties. It was concluded that the structure of grain converted from coarse to fine via applying PMF. The experiment consequences proved that, after PMF treatment at room temperature, the alloy's UTS improved by 47% while the elongation raised by 73%. The process of surface finishing was applied to modify the properties of the surface before the inspection of the microstructure. optical microscopes and scanning electron devices were used for capturing of the microstructural, the zooming of these devices used to clear the boundaries of the grains. The obtained images were analyzed by the software of ImageJ (FiJi) to determine the types and sizes of the crystals structures (Zhang, 2013).

3. Results

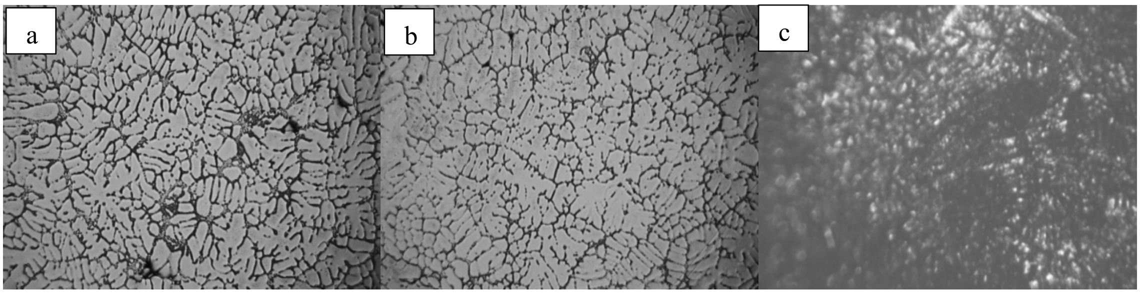

Figure 2. The optical scanning results of the control specimen a) Top b) Middle c) bottom

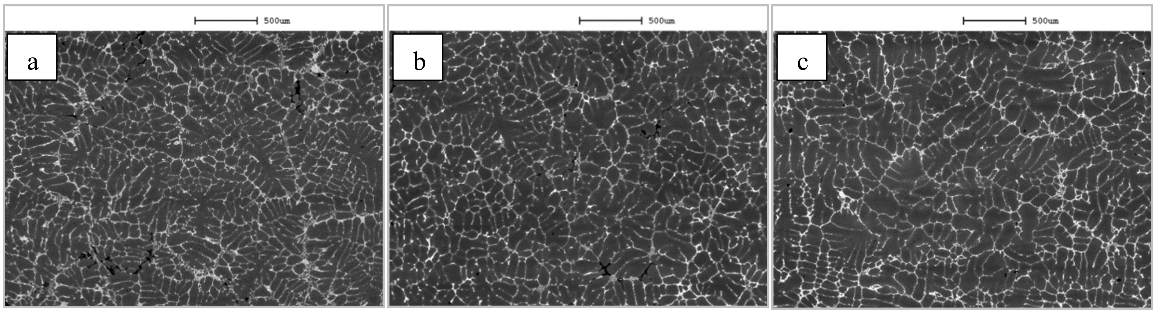

Figure 3. SEM results of the control specimen at the bottom at 100x a) Top b) Middle c) bottom

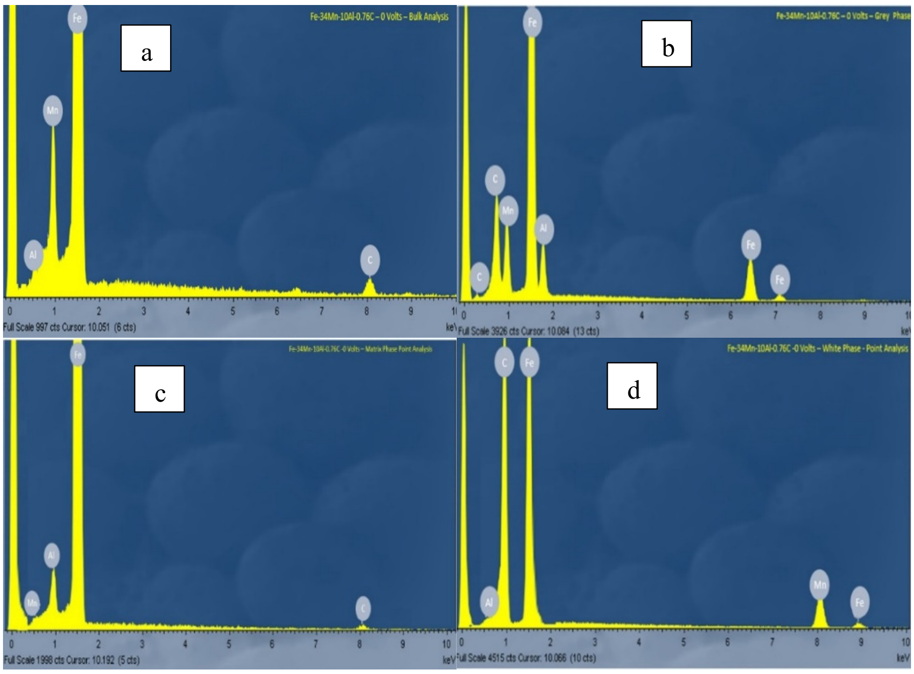

Figure 4. EDX Analysis of the control specimen at 0 V.a) Bulk b)gray phase c) Matrix d) white phase

The results were obtained for the prepared specimens of PMF with various voltages (0, 40, 60, 100, 120 and 180) volts. Along with the results of the alloy microstructural analysis under various conditions of examining. The results of the temperature detection, optical microscopic, the electron microscopic and EDX are presented and discussed below. In order to optimize the Fe-34Mn-10Al-0.76C steel alloy's microstructural and refinement of grain, the examined specimens were exposed to the PMF at a specific temperature through the process of solidification. For analyzing the impact of such magnetic field perfectly, it requires examining the control sample with no treatment at all, and the resulting microstructural will be recorded using various methods.

Figure 2, illustrates the optical scanning result for the control specimen with zooming of 100x. it was observed that, the specimen with no treatment has a dendrites network in which these dendrites reduced the Al alloy's mechanical characteristics. The sample was examined at the top, middle and bottom. It has observed that more dendrites are exist in the bottom. the SEM results of the control specimen's microstructure with a zoom of 100x are represented in Figure 3. It was observed that, the distribution of the big sizes grains is non-uniform. In addition to various distributions of white, grey and black colored areas.

The results of the previous SEM stages (various colors) are clarified via fulfilling the analyses of the (EDX) energy-dispersive X-ray. The EDX have been applied in order to analyzing chemical description of the examined specimens. The SEM was provided for the microstructures of each stage, the EDS identified which elements of the chemical are provided in each stage. The EDS analysis is estimated at first the stage as a Bulk material where the overall control sample chemical composition was defined as represented in Figure 4(a). The specimen contains different compositions of Al, C, Mn, and Fe. EDX was also helped in evaluating the chemical composition of the grey areas (grey stage) as represented in Figure 4(b). It is noted that the grey stage includes high amounts of C and Fe additionally to Al and Mn. Concerning the matrix stage (the black areas), EDX outcoming that, this stage includes high quantities of Al and low quantities of Cu. No Fe was noted in this stage, as presented in Figure 4(C). The EDX results concerning the white stage illustrated that the white stage includes a higher composition of Al-Cu, as represented in Figure 4(d).

Figures 5 illustrates the control sample results when the zooms are (400 and 1000). However, the structure of the primary and secondary dendritic at zoom 400x. Both primary large and short lengths of the structure of secondary dendritic are more obvious. the calculations of the structure of dendritic length were performed using the software of Fiji via capturing the images then obtaining the record. the primary length was founded approximately ≈ 1,472 μm, which considered too long.

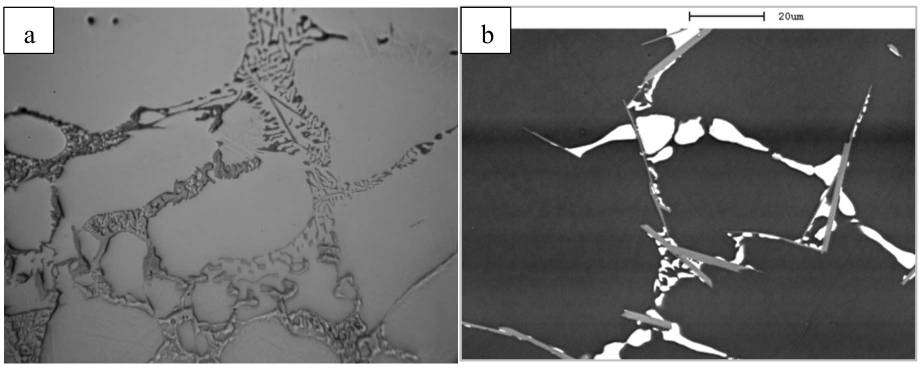

Figure 5. Optical scanning of the control specimen at a) 400x b) 1000X

When the PMF of 40 V was applied, the direct current decreases the convection during the process of solidification. The results of optical scanning and SEM prove the reduction in the dendrite structure that was distributed over the control sample due to the applied PMF which cracked these dendrites. Figures 6 illustrates the results of the SEM and optical scanning, respectively. The outcomes of the SEM are considered more exact illustration of the optical consequences, as it provides a colored representation of different stages distribution over the sample.

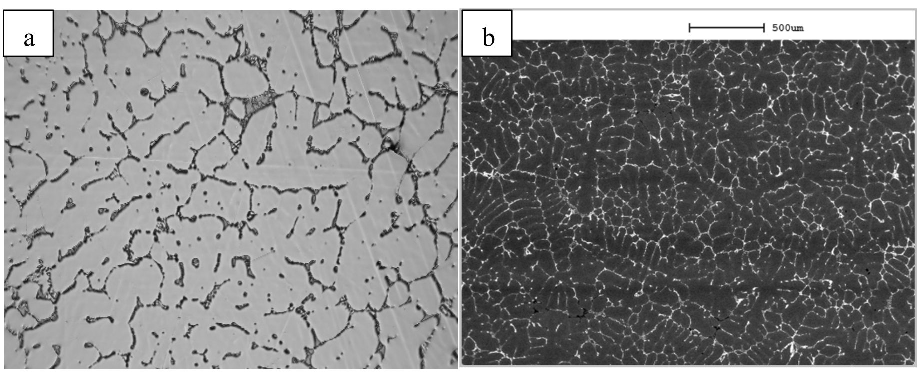

Figure 6. Results when 40 Volt applied a) Optical scanning of the specimen at x100, b) SEM results via 40 volt x100

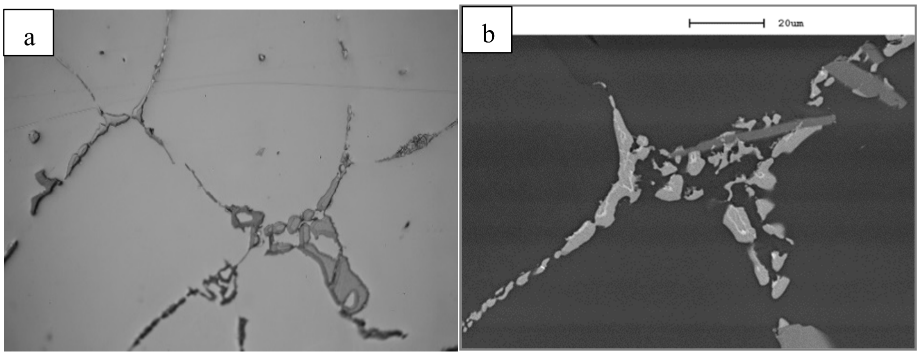

Figure 7. Results when 40 Volt applied a) Optical scanning of the specimen at x400, b)SEM results via 40 volt x1000

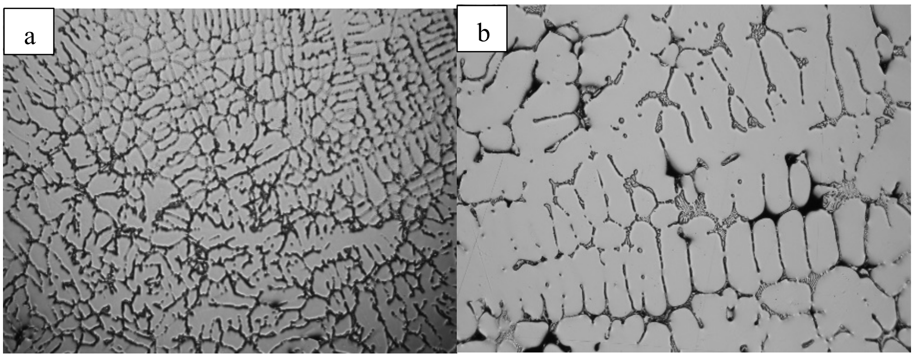

Figure 8. Results when 100 Volt applied using Optical scanning at a) x40, b) x100

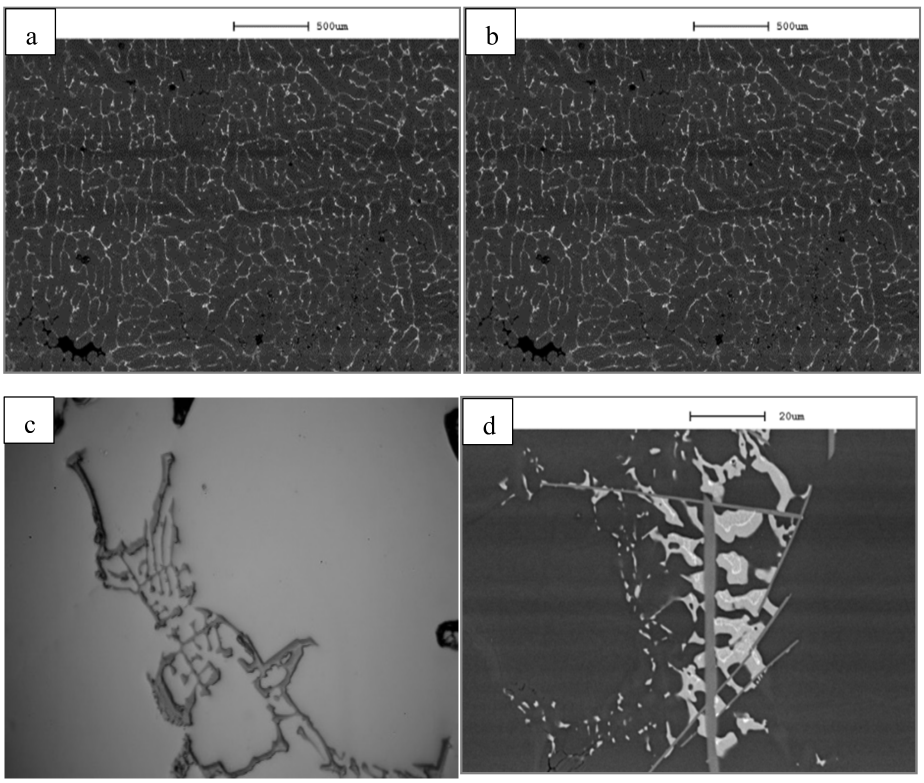

Figure 9. Results a) SEM at 100 Volts x40 b) optical scanning results at 100 Volts x400. c) The optical scanning results at 100 Volts x800. d) The SEM result at 100 volts at x1000

Figure 7 illustrate the dendritic structure both primary and secondary. It has been observed that, The primary length of the control specimen is greater than the primary length when applying the PMF, and the control specimen length is shorter than the secondary length using software of Image J via capturing the images then obtaining the record, the primary length was founded about 1,140 μm while the secondary was about 50 μm.

Changing the voltage of the PMF enable in control and modify the solidification of the alloy of Fe-34Mn-10Al-0.76C and consequently optimizing the alloy microstructural. In order to develop the specimen's microstructure and fulfilling the required refinement of grains. it required applying PMF with a voltage of 100 volts. Under this condition, the SEM and optical results indicate more decrease in the dendrites in comparison with both previously discussed samples with PMF of 40 volts and the control sample. The higher voltage applied, increases the force and consequently, more cracked dendrites are achieved. Figure 8 illustrates the optical scanning and SEM results respectively.

The optical scanning and SEM results at PMF with a voltage of 100 volts are illustrated in Figures 9 (a&b). The SEM analyses presented a more exact illustration of optical scanning result in which the decrease in sizes of grains is clear, the porosity volume fraction additionally to the distribution of stages over the microstructure are represented with several colours. In order to obtain more illustration for the results at 100V figure 9(c &d) were captured, in which the primary dendritic is the lowest in comparison with lower spacing with past records and the secondary is the highest in comparison with the past measurements, the primary length was founded about 780 μm and the secondary was about 52 μm.

In order to adjust and modify the process of solidification of the alloy of Fe-34Mn-10Al-0.76C, extra changes were implemented on the voltage of the PMF to ultimately promote the alloy microstructural and refinement of grains under the voltage applied of 120 V. The consequences of SEM and optical under this condition represented more decrease in the dendrites in comparison with the past two conditions due to the force applied to crack these dendrites is raised when the voltage raised. Figure 10 clarifies the optical scanning results at zooms of 40 and 100.

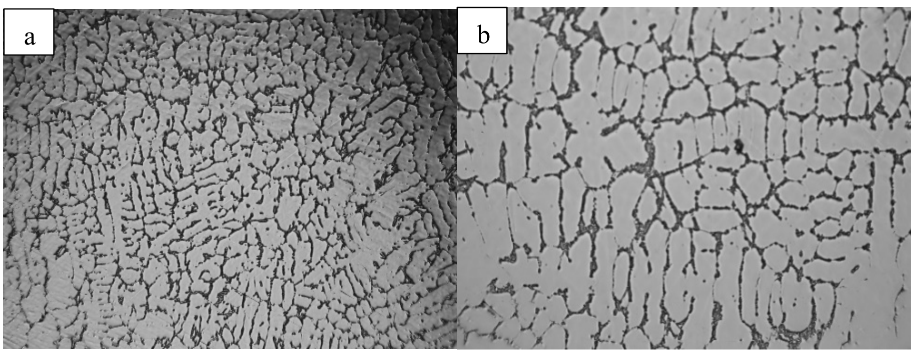

Figure 10. Results for optical scanning results at 120 Volts a) x40 b) x100

The SEM results at zooming of 40 and 100 are illustrated in Figure 11. The refinement of grain and the decrease in the porosity volume fraction are clearly observed. they also represent the distribution of the material stages.

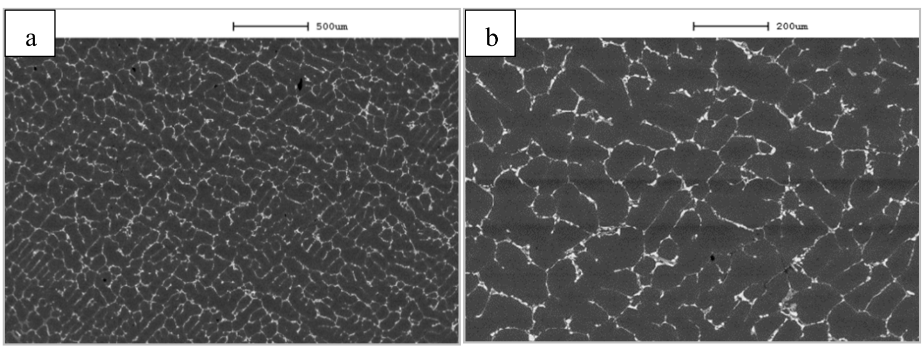

Figure 11. The SEM result at 120 volts at a) x40 b) x100

The length of the primary has an irregular (random) structure while the length of the secondary dendritic arm was observed to be decreased to about 30μm. The results of the voltage of 120 Volts at 400x and 1000x are represented in Figure 12.

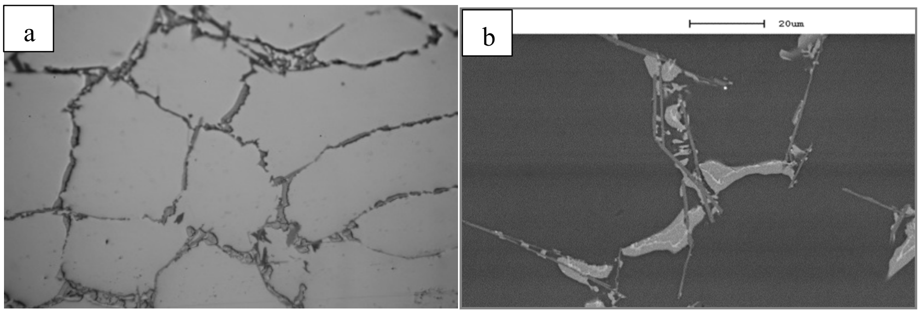

Figure 12. The results of a) optical scanning results at 120 Volts x400. b) The SEM result at 120 volts at x1000

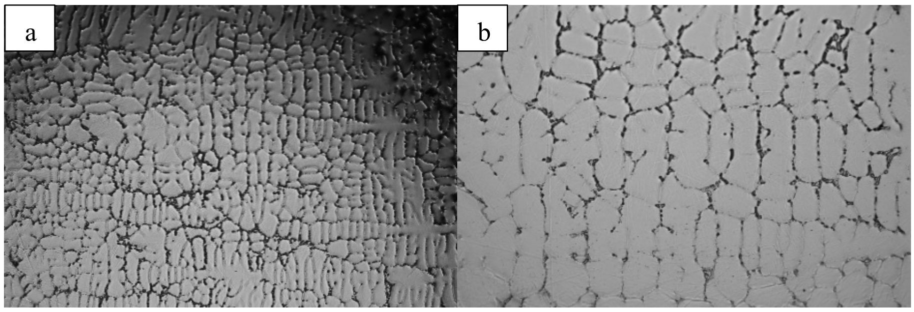

Figure 13. The optical scanning results at 180 Volts a) x40 b) x100

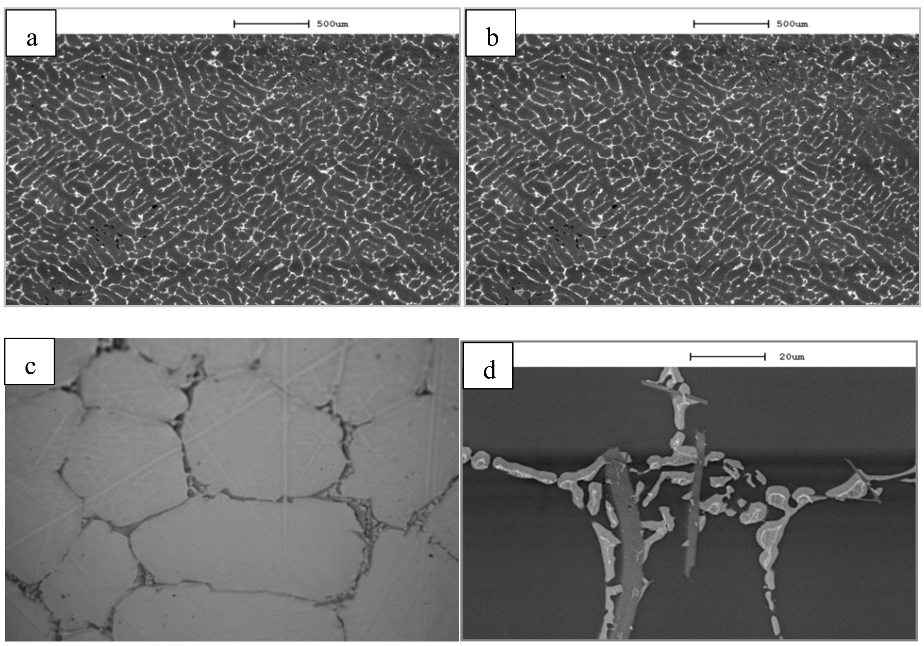

Figure 14. The results a) The SEM result at 180 volts at x40 b) The SEM result at 180 volts at x100. C) optical scanning results at 180 Volts at x400. d) The SEM result at 180 volts at x1000

In the end, the PMF with a voltage of 180 volts was applied to the examined sample. the optical scanning and SEM test were performed, and the results obviously represented an influenced improvement in the microstructure and the grain size. The optical scanning results are presented in Figures13. it was noted that the dendrites didn't occur in the structure, in addition, the sizes of grain are clearly decreased.

The SEM at zooms of 40 and 100 are illustrated respectively in Figure 14. The refinement of grain and the decrease in the porosity volume fraction are clearly illustrated with the stage distribution under this voltage. It was noticed that refinement of the grain increased, and the porosities didn't occur.

The structure of the primary is the lowest in comparison with all past records and the structure of secondary dendritic is the biggest in comparison with all past measurements by the Image J, the primary length was founded to be about 80 μm. figure 35 presents the results of 180 volts a zoom of 1000x.

The control sample under 0 V presented a highly increasing in dendrites that provide bad impact on the structure of the alloy and its mechanical characteristics. It was noticed in this sample a big size of grain and big porosity volume fraction. To improve the microstructure and the performance of the Al alloy, various PMF were implemented and their impact on the refinement of grain, the porosity volume fraction and the microstructure variation were examined by the technology of Optical scanning, EDX and SEM using various analysis techniques.

The tested samples were exposed to PMF. the samples investigation displayed a pressure over dendrites and cracked them whereas such dendrites were eliminated by applying PMF with great voltage (180 Volts). Accordingly, the structure begins to be smoother than that with the refined grains. Consequences of SEM stated that, the composition of chemical of the phases in the microstructural variated wherever the voltage applied raised. The occurred phases were (bulk, matrix, grey and white) phases. Each one stated larger certain materials composition. For instance, the microstructural at the black regions indicates that the matrix stage that includes high rates of Cu and Al. Wherever the copper rates were raised, this stage is known as copper (white) stage. The composition of chemical of every stage was clarified using EDX via the usage of x-rays displayed on the sample. When the voltage is PMF was 180 volts, the refinement of grain was noticed where the removal of the porosities was performed, the fluid rate of feeding developed and the whole microstructural and mechanical characteristics were optimized.

The Fe-34Mn-10Al-0.76C alloy was selected to be investigated in this study. The microstructural solidification was experimentally tested under the impact PMF with various fluxes. The Fe-34Mn-10Al-0.76C alloy has higher conductivity of electric additionally to higher current of inductive which indicates that force of adequate Lorentz can be formed in the material when the field of pulse magnetic is performed for it. The prepared control specimen was tested with no treatment, which stated that, this alloy has a typical eutectic and dendritic stages that are changed according to the applied fluxes of the PMF.

All samples were removed from the tubes of glass and the samples microstructural were described at first by the optical scanning technique and (SEM) technique after solidification. The microstructure of the specimen includes constitutive elements or stages that were analyzed by the EDX technology. The results of the optical scanning and SEM, considering the collected data considering the grain size of the initial dendritic and sizes of intermetallic stages in addition to the estimated growth direction and morphology. It has concluded that, when the flux of the PMF is applied; the initial dendrites growth direction and size were changed. Also, it was noticed that the lengths of the initial dendrites were reduced by increasing the voltage. When the voltage of the PMF increase from 40 volts to 180 volts, the initial dendrites was increased at random that led to the formation of different dendrite equiaxed grains. Moreover, the PMF has a great impact on diffusion of solute through solidification that then influences the formation of eutectic microstructural.

4. Conclusion

The latest engineering trends aimed to specifying methods that inspect the microstructure of the metals along with achieving a refinement of microstructural to optimize the mechanical characteristics of different metals and alloys. The quasi-crystalline structure characteristics are based on the used preparation methods. The fabrication of the most quasicrystal solids can be done in only in an unstable form, such as the thermodynamic metastable stage. Even though this case is not applied for the alloys of Al-Cu-Fe. Producing the Quasi-crystals can be via low temperature solids of amorphous annealing. The crystalline stages of intermetallic heat treating and pure layers of element stacking. The process of mechanical alloying produces the structures of quasi-crystals which the elements of alloying melt more widely in the main metal. Refinement of grain is a significant phenomenon which states the metals mechanical characteristics. PMF gives a strategy in grains refinement and optimizing the microstructural solidification. In this research, by exposing the alloy specimens of Fe-34Mn-10Al-0.76C to the PMF at various conditions, such as control specimen with no treatment (0 volt), Samples under different voltages (40V, 100V, 120V PMF 180V PMF) respectively.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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