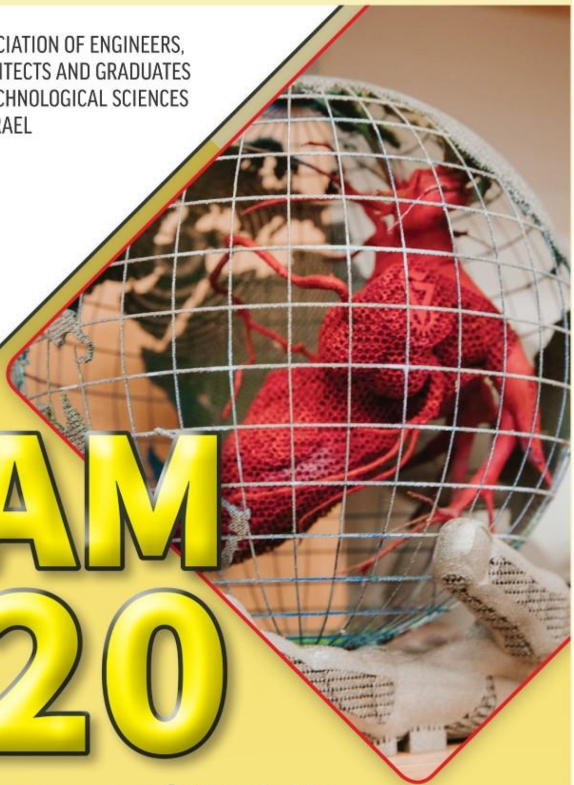
AEAI ASSOCIATION OF ENGINEERS, ARCHITECTS AND GRADUATES IN TECHNOLOGICAL SCIENCES IN ISRAEL



WJAM 2020

International Conference of Welding, Joining and Additive Manufacturing

28 JAN 2020

Table of contents

Welcoming

חברות וחברים יקרים!

כנס ריתוך ותלת מימד המתקיים השנה- 2020 -ייחודי בהיקפו ובשילוב בין תחומים טכנולוגיים משיקים אך שונים.

במובנים רבים הכנס משלב בין תחומי ידע עדכניים, בין מומחים מדיסציפלינות שונות ובהיקף הידע התיאורטי והמעשי המועבר למשתתפיו. הכנס הנוכחי משקף הלכה למעשה את חזונה של הלשכה ואת דרכי הפעולה שלה. לכבוד הוא לי להשתתף בכנס ובהזדמנות זו לברך את ד"ר אמנון שיריזלי ואת מהנדס עמיחי פסח – יו"רי הכנס וכן את חברי ועדות ההיגוי שפעלו להוצאתו לפועל.

הלשכה כארגון גג לאומי יציג, מאגדת בתוכה 14 איגודים מקצועיים בתחומי ידע הנדסי – טכנולוגי שמטרתם לקדם את הידע ההנדסי – טכנולוגי ולהוביל לפיתוח מקצועי של העוסקים בתחום.

האיגודים הללו מאגדים בתוכם עשרות אלפי מהנדסים, אדריכלים ואקדמאים במקצועות הטכנולוגיים על פי תחומי ידע ועשייה. בפעילותם מקשרים בין הלימוד והחשיבה האקדמיים לבין היישום המעשי במפעלי התעשייה וההיי טק בישראל. ביניהם ניתן לציין את איגוד Data Science, איגוד מהנדסי חשמל, איגוד מהנדסי אלקטרוניקה, איגוד מהנדסי הכימיה, סביבה וקיימות, its – מערכות תבוניות בתחבורה , איגוד המהנדסים לבניה ותשתיות, איגוד מהנדסי תעשייה וניהול, איגוד מהנדסי ערים ועמותת האדריכלים, איגוד מהנדסי בטיחות ועוד.

החזון שלנו

- פיתוח מקצועי וטכנולוגי של ציבור המהנדסים בישראל בכל ענפי ההנדסה, האדריכלות והמקצועות הטכנולוגיים מתוך הכרה בחשיבות הפיתוח הטכנולוגי לקידום המשק והחברה בישראל, לפיתוח הדור הצעיר בעידן גלובלי משתנה.
- איגוד כלל ציבור המהנדסים בישראל תחת מטרייה אחת – קהילייה אחת לומדת, משתפת, מפתחת ותורמת.
- יצירת שת"פ למען סיעור מוחין וחשיבה אינטרדיסציפלינרית.
- קידום מעמד המהנדס, האדריכלי והאקדמאי הטכנולוגי בישראל.

הדרך שלנו

- פיתוח תחומי תוכן הנדסיים – טכנולוגים עבור הציבור ההנדסי טכנולוגי בשנות העבודה דרך כנסים מקצועיים , תערוכות, ימי עיון, סיורים מקצועיים במפעלי הנדסה בארץ ובחו"ל, סדנאות, קורסים והסמכות בתחומי הדעת ההנדסיים.
- שיתופי פעולה עם גורמים מרכזיים בקהילה: מפעלי תעשייה וחברות היי טק, פקולטות להנדסה באקדמיה, ציבור הסטודנטים להנדסה, נציגי הרגולטור, הרשות לחדשנות וארגונים בינלאומיים.
- קידום חקיקה ומעורבת בתהליכי קבלת החלטות במערכות הממשל בישראל.
- עידוד חדשנות ויזמות באמצעות פרויקטים.

אנו מזמינים אתכם לקחת חלק בפעילות הענפה שלנו ולתרום מהידע והניסיון שלכם לכלל ציבור המהנדסים והאדריכלים.

אנו תיקווה כי הכנס ישמש עבורכם מקור ידע מעשיר ומהימן ויתרום לכם בעבודתכם ובפיתוח החשיבה בתחומי ההתמחות שלכם.

מכל הלב,

אהוד נוף, יו"ר ארגוני המהנדסים בישראל

Welcome to the International Conference of Welding, Joining and Additive Manufacturing - WJAM2020 .

The history of joining metals goes back several millennia to the days of the Bronze and Iron Ages. The Middle Ages brought advances in forge welding, in which blacksmiths and craftsmen were skilled in the process.

In 1800, the electrical arc was discovered and by the end of the 19^{th} century, arc welding with electrodes was introduced.

WWI and WWII caused a major leap in the use of welding and introduced many new welding methods like: shielding gas, plasma, electroslag, electron beam, laser beam and much more.

The advancement of technology cannot find a replacement to welding. It actually just made welding more accurate with higher quality – Welding is here to stay!

Every 5 years, the Israeli Welding Committee, under the association of engineers and architects in Israel, organize this international welding conference. This is an opportunity to meet with colleagues from around the world and to hear about new developments and discuss the future of our industry.

It is of great honor to have **Mr. Luca Costa**, Chief Executive Officer of IIW, and **Mr. Robert W. Roth**, President of the American Welding Society (AWS), those of which are the two leading welding organization in the world, with us, and I thank them for coming.

This year we joined hands with the Additive Manufacturing Committee, understanding the strong connection between the industries knowledge and the history of welding with the advantages of AM (3D printing) when combined together.

I would like to thank the members of the organizing committee, all of the international participates, the presenters, the amazing staff of the Association of Engineers, Architects and Graduates in Technological Sciences in Israel, and to everyone who has contributed to the success of this conference.

I wish you all an interesting and productive day.

Amichai Pessach

Conference Chair- Welding

It is a great honor to be invited to this forum and a group of dedicated professional people that take care of a very important activity.

As a result of their efforts they became the sole and most important organization in Israel in the field of welding and joining of materials.

I must underline that their activity is done as volunteers and they achieved their important status and authority only through their professional excellence.

On behalf of the industry in Israel and our Society of Engineers we have to thank them.

They succeeded to create close relations with international welding associations whose Chairman honored us to be present at this conference. I am grateful for that.

In recent years we a facing the penetration of new disruptive technology based upon 3D printing.

As any new technology, it will open new horizons for manufacturing and design and it will join and support existing technology, that’s based upon knowledge of people like you that are present in this conference.

Again I want to thank our guests from abroad for their participation and help and I'm looking forward to broaden our relations by cooperation in know- how exchange and Research of Development.

I wish to all of us to enjoy this conference.

Dr. Emanuel Liban- Chairman of The Israeli Society of Mechanical Engineers and Aerospace at AEAI

The International Conference of Welding, Joining and Additive Manufacturing is a part of a collaboration between the welding committee and the Additive manufacturing committee in the Israeli engineering association.

The interest in Additive Manufacturing- AM (3D printing) for industrial applications is growing rapidly. The experience of building a model in a computer and seeing the part printing in and with minimal post-processing operation is still fascinating. It is an interdisciplinary technology, and that fact is well expressed in this conference speakers both cutting edge scientists and industry representatives.   AM opens new ways for design in optimized thermal performance, lightweight designs, complex integrations, etc. The WJAM2020 conference focuses on AM of metals. Aim to create an international platform where knowledge and innovative technology are shared.

I would like to thank everyone who contributes to the success of WJAM2020 conference: To the authors and presenters, to the Organizing committee- Welding, Organizing committee- AM, Scientific Committee-AM, the participants, the hard work of AEAI the Association of Engineers, Architects and Graduates in Technological Sciences in Israel. And last but not least all those who supported and help in the background to organize the WJAM conference.

A. Shirizly

Dr. Amnon Shirizly

Conference Chair- Additive Manufacturing

Dear all

It's my pleasure to welcome you all to the 2020 International Welding & 3D Printing Conference, Kfar Hamaccabia, Ramat Gan, Israel.

I'm happy to welcome our distinguished expert guests from abroad and in particular, the President & the Director general of the American Welding Society (AWS), my dear friend Mr. Robert Roth (Bob) and the Chief Executive Officer of the International Welding Organization (IIW), my dear friend Mr. Luca Costa.

The Israeli National Welding Committee (INWC) as the AWS section in Israel and as a member of the IIW, works consistently, with determination and sensitivity and by looking forward to promote and upgrade the welding level in Israel. This extensive objective is achieved, through monthly meeting, by involvement in the preparation of standards at the Standards Institution of Israel, through seminars, annual conferences, collaboration with the Israeli industry and academy and more.

Moreover, during the last 20 years, the INWC which acts on behalf of the Association of Engineers and architects in Israel to certify more than 130 welding inspectors, based on the mutual recognition agreement signed with the American Welding Society (AWS) years ago.

We must internalize that qualitative welding means safety. On contrary, doubtful and non-reliable welding comes at the expense of workers safety and by endangering the environment.

I must make it clear that it's not just for certifying of Welding Inspectors that we act. In order to create a broader professional platform in the field of welding, I am pleased to announce that we have formulated a course for certifying Welding Engineers through a collaboration with an European organization accredited by the International Institute of Welding. During the seminar scheduled to 29/1/2020 the course program will be presented at the Association of Engineers and Architect's offices in Tel Aviv.

In this way, Certified Welding Engineers will work in Israel alongside with Welding Engineers and together will lead to an upgrading of the welding level in Israel.

Eventually, I would like to use this opportunity to invite you all to join the Israeli National Welding Committee and to contribute to our efforts to create a safer environment for us and for our children.

I wish you all a very fruitful, successful, meaningful and professional conference.

Sincerely yours,

Eng. Adi A. Atsits, Adv.
Chairman- The Israeli National Welding Committee

Opening Lectures:

“Codes, Standards, and Talent". The American Welding Society at 100

Robert W. Roth, President & CEO, American Welding Society (AWS)

The context of the presentation will be the importance of codes, standards, and talent in the welding industry using the American Welding Society’s 100 year history as a framework. Even with the immense change and advancement of technology, process, and materials over the past 100 years, codes, standards and talent have been consistent foundational elements. With this historical perspective, we can be assured that codes, standards, and talent will remain foundational even though we can not imagine all the advances to welding technology, process, and materials that will occur during the next 100 years.

“A mature industrial ecosystem for DED additive manufacturing”

Dr. Filomeno MARTINA,

WAAM3D Limited, Cranfield University, Cranfield, UK

Directed-energy-deposition (DED) Additive manufacturing (AM) has many advantages for production of large scale engineering structures with significantly reduced manufacturing costs and lead times. This has proven particularly true for the Wire + Arc AM (WAAM) process. The presentation will cover how, based on 12 years of intensive world-leading research into all aspects of WAAM, we have printed critical airframe components up to 6m in aluminum and 2m in titanium, by developing a mature industrial ecosystem, which can also be translated to other DED processes. We will present the key elements of this system (software, machines, innovative sensors), and how it has been applied to large scale metallic parts (flanges, wing ribs, pressure vessels, landing gears, etc). The business benefits will be explained, with the support of industrially-relevant metrics, such as reduction of lead times from over a year to a few weeks, and reduction in cost of as much as 60%. A roadmap for future development, including WAAM commercialisation and industrialisation, will be announced.

Welding Session-Hebrew

W1: Welds Repairs of Pressure Vessels based on API Standard 510

by

Jacky Bendayan (M.Sc Eng)

Welding Engineer

ASNT/NAS 410 Level III- VT,MT,PT,UT,RT

API Authorized Inspector 510 and 570

National Board Authorized Pressure Vessel Inspector

API Standard 510- Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair and Alteration of pressure vessels.

API standard 510 Pressure Vessel inspection code is a document that set the rules for inspection, repair, alteration and rerating procedures for in-service pressure vessels systems including pressure relieving devices protecting these vessels for continued safe operation after they have entered service. This code resulted from the need by refineries and petrochemical industry for an in-service inspection code applicable to pressure vessels originally designed and constructed to ASME Code Section VIII Div. 1 and other similar codes such as European Pressure Equipment Directive (PED) , BS PD 5500 Specification for Unfired Fusion Welded Pressure Vessels. API 510 is complimented my many other codes such as API RP 571; API RP 572, API RP 576, API 577, API RP 579, API RP 580 to name a few and many other additional standards.

Repairs of pressure vessels are mainly required in order to restore its original and intended operating condition , safe operation and also to prolong trouble free service life of the vessels. Pressure vessels condition deteriorate due to operating and or environmental conditions due to various factors such as mechanical problems, process related problems and corrosion problems. Repairs based on API 50 are required to be properly and meticulously planned and carried out under strict supervision and control of a competent and authorized API 510 inspector. Repairs of pressure vessels are not always warranted , the decision of welding repairs must be taken with due consideration as far as the location of the defect(s), carefully evaluated an interpreted NDE results, design calculations ad construction conditions such as PWHT and impact tests.

This lecture purpose is to explain the interested audience involved in welding inspection and weld repairs related activities of pressure vessels which can be performed during planned shut-downs within various industries such as Chemical, Refinery, Petrochemical and Fertilizing.

We will discuss weld repair methods allowed by API 510 such as:

- Fillet welded patches requirements commonly used for temporary repairs,
- Overlay and repairs to existing welds with filler/base metals,
- Permanent repairs,
- Preheat or Controlled deposition welding methods as alternatives to PWHT, where impact testing was not performed on the original equipment
- Repair procedure alternative to PWHT, where impact testing was performed on the original equipment
- Repair welding techniques such as Temper bead and Half bead welding techniques.
- Repair to stainless steel overlays and cladding.

I sincerely hope to see you at the 2020 Welding Conference .

W2: Coated Electrodes for Welding of Stainless Steel with reduced emission of hexavalent chromium VI+

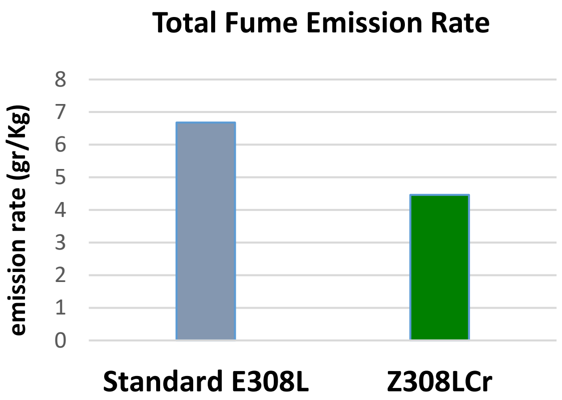
Kiril Kiriyevsky, ZIKA

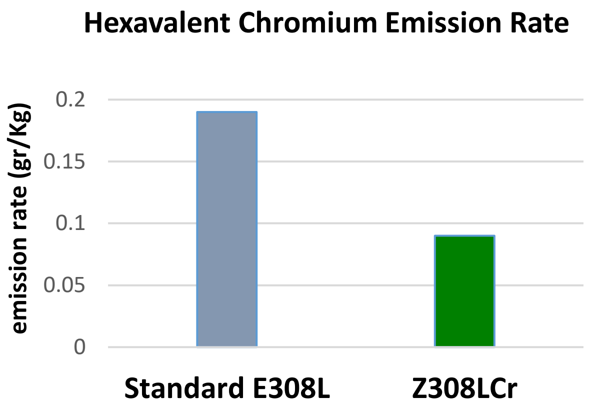
Welding process is accompanied by fume emission. This fume is a complex mixture of tiny particles when their source is mostly an electrode. Existence of such fume in the area of breathing zone causes welders' long-term exposure to hazardous components. One of the most harmful elements, which are emitted during welding, is hexavalent chromium. Hexavalent chromium (Cr VI+) is known as cancerogenic (causes cancer disease) substrate.

Chromium is a main alloying element in stainless steels and it's responsible for corrosion resistance. For instance, chromium content in common austenitic stainless steel AISI 304 is around 18 wt-%. It means that welding consumable must provide a weld metal with at least a such content of chromium. During welding process, neutral chromium passes ionization, evaporation and oxidation. Stable chromium oxides are formed, which are non-toxic Cr III+ within iron based compounds like $FeCr_2O_4$, $Fe_2Cr_2O_4$ and very toxic hexavalent Cr VI+ within alkali based chromates and dichromates like K2CrO4, Na2CrO4, K2Cr2O7 etc.

It means that existence of alkali metals in coating flux causes formation of hexavalent chromium compounds. On the other hand, these alkali metals are essential for stabilization of welding arc and providing of proper weldability. The sources of alkali metals in coated electrodes are mainly in silicate binders and feldspars. Usage of these components is historical and traditional solution for proper welding properties in stainless steel electrodes. Therefore, reduction of hexavalent chromium emission requires cutting down significantly the content of alkali metals in the flux and obviously it needs revolutionary change in recipe of flux preparation. Our talk is about solution of these problems.

Recently developed electrode Z308LCr Zika has a significantly reduced emission of hexavalent chromium. The total fume rate emission is reduced up to 40% and the rate of hexavalent chromium emission is lowered up to 50%.





W3: Inspection of welds by sampling according relevant standards Methodology

Dr. Yossi Shoef/ Gabi Shoef Ltd.

Welding Inspector
ASNT/NAS 410 level III
API certified Inspector

Being experienced welding inspectors or NDT personnel, we often encounter a customer's demand to test 10% of the welds and then he will decide what to do with the results. Is this an acceptable figure by the standards? Is it based on a certain known and bearable jeopardy taken by the customer?

The answer is that 10% is a magic figure in engineering that like all other magic figures does not have any uniqueness. Not only the inspector uses 10% or 20% but the production drawing does that as well. Usually the requirement does not dictate what action should be taken if any defected welds are detected. Should the contractor have to repair all? And what if only one defected weld has been detected? or 50?

The ambiguity is not just a point of conflict between the customer and the contactor but also has supreme importance for the product quality, and in our world it will say if the pipe will leak or the vessel will burst or the crane will collapse.

Most of the building standards for piping and vessels instruct the scope of the tests in full or partial by sampling, and what one must do when he finds defects.

The presentation will discuss these standards and will compare between them. These are our day to day standards that we follow for many years – for Natural Gas piping, petroleum and dangerous gas piping, AST's, pressure vessels, construction and more.

Standards such as: API 1104, ASME VIII, B31.3, ISO 12732, AWS D1.1, API650S

In case no reference to one of these, the discussion of how many the customer likes to examine comes sometimes to an easy end when he has to answer the key question of how many defective welds, he can tolerate in his piping system. If the customer reply NULL than he has to examine all. What happens if he says for example 4%?

When the constructor engineer did not dictate the sampling scheme or forward the parties to a standard, the customer has to find another guide. Such guidance is provided by American, International or Israeli standards that are actually identical.

ASQ/ANSI QUALITY STANDARDS Z1.4, iso 2859-1 or the I.S.2859-1 - Sampling procedures for inspection by attributes.

Experts for Quality Assurance can use part 2 of these standatds for sampling by variables and save examination costs.

An example will be discussed where a bearable risk will be determined and sample numbers will be set with program how to proceed with further examination if needed.

No one can deal with these sampling standards correct without placing more emphasis on ambiguous terms like acceptance number O, double sampling (which means reducing the parts tested) and number of defects for 100 (which is no percent…).

מתודולוגית דגימה של בדיקת ריתוכים לפי תקנים

ד"ר יוסי שואף, חברת גבי שואף בע"מ

לא אחת אנו נתקלים בדרישת מפקח לבדוק ריתוכים. לשאלה כמה, הוא עונה ,איזה 10% ואחר כל נראה מה יהיה". האם דרישה זו תואמת לתקנים? האם היא מבוססת על רמת סיכון מסוימת ידועה ומקובלת על הלקוח?

התשובה היא ש 10% הינו מספר קסום בהנדסה שאינו בו יחוד ממשי. לא רק מפקח שולף מספר קסם זה אלא גם שרטוטי תכנון קובעים מספרים כמו 10% או 20% ולרוב מבלי לקבוע מה קורה אם מתגלים ריתוכים פגומים. האם ממשיכים בעוד 10%? האם מתקנים את כולם? חשוב אם נתגלה פגום אחד או 50?

אי הבהירות אינה רק נושא חוזי בין היצרן ללקוח ומקור לחיכוך מסחרי ביניהם אלא גם בעלת חשיבות לאיכות המוצר או במקרה שלנו האם הצינור ידלוף או המיכל יתפוצץ או המנוף יקרוס.

חלק מתקני הבניה לצנרת ומכלים מגדירים את היקף הבדיקות הנדרשות – 100% או מדגם, מתי המדגם נכשל ואיך ממשיכים כשהוא נכשל.

בהרצאה אנו נזכיר את התקנים האלה, נראה מה הם קובעים ונעמוד על השווה והשונה ביניהם. תקנים אלו יהיו התקנים המוכרים לכולנו – המשמשים לבדיקת צנרת גז טבעי, דלק וגזים מסוכנים, מיכלי דלק עיליים, מיכלי לחץ, קונסטרוקציות ועוד.

API 1104, ASME VIII, B31.3, ISO 12732, AWS D1.1, API650

כאשר אין הפניה לתקן מאלו מעלה, הדיון בצורך לבדיקה 100% או בדיקה מדגמית מסתיים לפעמים כאשר הלקוח מתלבט ואז הוא צריך להחליט את שאלת המפתח –כמה ריתוכים פגומים אתה מוכן לאשר שיהיו במנה ולא יתגלו? אם הוא עונה לא מוכן אף אחד , לא מוכן לקחת סיכון כזה – התשובה תהיה: אם כך תבדוק 100%. אם הוא אומר 4% אז מה עושים?

במקרים בהם המתכנן לא קבע את הדגימה או לא הפנה לתקן המתאים יש למצוא מורה דרך אחר. הוראה זו באה על ידי התקן האמריקאי ASQ/ANSI QUALITY STANDARDS Z1.4, הבינלאומי ISO 2859-1 והישראלי ת.י. 2859 חלק 1 לדגימה לפי תכונות. המומחים להבטחת איכות ודגימה יוכלו לקבוע תוכנית דגימה לפי משתנים ובכך לחסוך בבדיקות.

תוצג דוגמה לקביעת דגימה תוך בחירת הסיכון הקביל והאפשרויות להמשך לאחר דחית מנת הבדיקה. אי אפשר לדבר על תקני דגימה אלו מבלי לתת דגש שבתקנים אלו ישנם מושגים שעלולים להטעות ויש לציין אותם – מספר קבלה 0 שזו איכות גבוהה דווקא, בחינה כפולה שמוזילה את כמות הבדיקות ולא מכפילה אותה כפי שנדמה משמה, פגמים ל100 שאינם אחוז הפגומים ועוד.

שימוש בתקני דגימה יאפשר קבלת סיכונים מושכלים והפחתת כלות הבדיקות או לחילופין עלות באיכות המוצר גם בקבלת מותר פגום וגם בפסילת מוצר תקין.

W15: Cracking mechanisms in weldments

David Kushnir, consultant

A crack is a threatening word in the welding jargon.

This lecture will try to clear some of the mist surrounding the cracking phenomenon in weldments.

The lecture will overview the following topics:

1. What are cracks?
2. How do cracks form?
3. Classification of cracking mechanism groups.
4. Discussion of common cracking mechanisms:
   4.1. Solidification cracking.
   4.2. HAZ and Weld Metal liquation cracking.
   4.3. Ductility dip cracking.
   4.4. Reheat cracking.
   4.5. Strain age cracking.
   4.6. Copper contamination cracking.
   4.7. Hydrogen induced cracking.
5. The influence of cracks on a weldment.
6. Susceptible materials and general prevention methods.
7. summary and questions.

W5: Importance of surface preparation before welding or brazing of aluminum

Dr. Ariel Grinberg

Israel Aerospace Industries Ltd.

Preparation of surfaces before welding or brazing is a critical operation to ensure the integrity of the joint. It is necessary to ensure that the surfaces in and around the joint are clean, free from scale and other heavy oxide coatings, dry and free from organic materials. For example, when welding aluminum and its alloys, surface preparation is very important as this material is extremely sensitive.
The question is how to remove the oxide layer? What are the methods to remove oxides before welding? What is the effect of oxide removal? What is the preferred method?

W6: Flame cutting safety

Amnon Bar Josef, Engineering Services, Safety and Welding LTD

בטיחות בחיתוך בלהבת גז

אמנון בר יוסף

בריתוך או חיתוך בעזרת גזים (אצטילן וחמצן או ג.פ.מ. וחמצן) עלולים להיגרם התלקחויות רבות בגלל טיבם של הגזים שהם בעצמם דלקים ביותר .

<u>להבה חוזרת</u> - אחד מהגורמים להתלקחות אש בעת ריתוך עם גזים היא ה- "להבה החוזרת" . להבה חוזרת נגרמת, בד"כ , בעת ביצוע עבודת חיתוך בלהבת גז- בגלל סיבות שונות הגורמות לסתימת הנחיר שבמבער. הסיבה : אם מחזיקים את הפיה קרוב מדי לחומר אותו חותכים אז הניצוצות שנגרמות בעת העבודה עלולות לסתום את הנחיר שבמבער ; או שבגלל שיטת עבודה לא נכונה הפיה התחממה יותר מהמותר וזה גרם ללהבה "לא לצאת החוצה" אלא לחזור , או שהפח אותו חותכים מונח ממש על החול ואז בגלל זרימת גז דרך החריץ שנוצר בלוח בעת החיתוך גרגירי חול יתעופפו ועלולים לגרום לסתימה , שעל הפח אותו חותכים ישנו בוץ אן אבק , שהפח צבוע והצבע מתפורר מהחום , שמחזיקים את המבער קרוב מדי לחומר הלוהט שנמצא במצב רך או נזיל וזה נכנס לנחיר שבמבער וסותם אותו, שבמצב מסוים מחליט המסגר לנקות את קצה הפיה ע"י שפשוף על החומר אותו חותכים.

כדי למנוע מהלהבה החוזרת לחדור לתוך הזרנוקים , עם אפשרות לחזרה הלאה עד למיכל, יש להתקין "אביזרי בלימה".

<u>עודף חמצן</u> - סיבה נוספת לגרימת סתימה בעת ריתוך/חיתוך היא עודף חמצן בתערובת הבעירה, במיוחד כאשר משתמשים בחמצן לחיתוך . כאשר עושים זאת עם גז אצטילן או ג.פ.מ. וחמצן כשביצוע העבודה בלחץ חמצן גבוה מאוד ומעל למה שדרוש לחיתוך בצורה נכונה. במקרה זה החומר שחותכים אותו למעשה נשרף ולא נחתך ואז נוצרת כמות גדולה מאוד של ניצוצות והסכנה של סתימת החור בפיה גדולה מאוד - ולמעשה חלק גדול מתקלות נגרם בגלל סיבה זו .
יש לכוונן את לחצי הגזים - גז בערה והחמצן בהתאם לעובי של החומר אותו עומדים לחתוך .

יש להקפיד על ניקיון סביבת הפיה וכן הנחיר.

אפשרות להתלקחות שמן /סמרטוט רטוב קיימת כאשר חמצן נפלט מידית של המבער או מחריר הזרנוק ובא במגע עם שמן או פריט המלוכלך בשמן או כאשר מחזיקים במבער עם יד משומנת.

חמצן יכול לדלוף/להיפלט בחיבורים של המרכיבים השונים של ערכת חיתוך בלהבת גז; כאשר משאירים ברז במצב לא סגור לגמרי או כאשר ישנה זרימה מופרזת בגלל לחץ גבוה.

הערה: (במיכל של אצטילן יש גם אצטון ולכן כאשר המיכל עומד ניצב האצטון יורד לתחתית המיכל כך שבעת שפותחים את הברז רק אצטילן יזרום החוצה, באם מיכל אצטילן מושאר "בשכיבה" בעת שפותחים את הברז יזרום יחד עם האצטילן גם אצטון אשר יפריע לבערה נכונה).

צבע הטבעת	צורת הטבעת	שנת בדיקה
לבן		2015
כחול		2016
אדום		2017
ירוק		2018
צהוב		2019

וסתים - על המיכל גז מתקינים ערכת וויסות לחץ כדי לאפשר לווסת את הלחץ הגבוה שבתוך המיכל (125-150 אטמוספרות) ללחץ הדרוש לביצוע הריתוך ובכך גם הלחץ שיהיה בזרנוקים יהיה בגבולות המותר כדי למנוע פיצוץ הזרנוקים . וסתי הלחץ אינם אחידים לכל סוגי הגזים ולכן יש להתאים את סוג הווסת לסוג הגז אין להשתמש בערכת מדי לחץ ובווסתים זולים כי אלה עלולים לגרום לנזקים .

זרנוקים : - בערכת חיתוך בלהבת גז יש להשתמש בזרנוקים (צינורות) מיוחדים , תקינים המיועדים לכך . בכל ערכה לשני הזרנוקים צבעים שונים .

ברזים ואביזרים : - יש להקפיד על תקינות ההברגות ולשמור על ניקיונם ; יש למנוע כל אפשרות של פגיעה בידית **הווסת** או בכל חלק אחר .

W7: Stud welding in civil engineering works

Uri Newman
Architect and a Certified Welding Inspector

Sami Zatout metal works LTD

Stud welding is a process by which a metal stud is joined to a metal workpiece by heating both parts with an arc. A key factor that differentiates stud welding from other fastening processes is that the fastener is attached to the workpiece without marring the other side.

Stud welding has many advantages over other joining processes.

It is fast. Welding a 3/4” fastener will take less than one second.

It is single sided. This means that access to the other side of the work piece is not required.

It is secure. Unlike the peripheral weld that would be used to weld a bolt in place, a stud weld is a full cross sectional weld. This means the full face of the fastener is welded in place providing a strong, worry-free weld.

It is cosmetically superior. As a single sided fastener there are no indicators that a fastener is attached.

It is welded and will not work free like a press-in fastener

Requires no special skills and little training to install.

Hence, Stud welding is common in fields, such as:

Ship Building and Military applications.

Civil engineering works, buildings and bridges.

The purpose of the lecture is to reveal the interested audience to the uses of stud welding in civil engineering works. We will do that by exploring some examples of Stud welding being used at construction site and discuss the advantages and disadvantages of it. Furthermore we will follow the Stud application on site, so we can hopefully give the audience some tools and tips considering using Stud weld, on future works.

We hope you all have an effective 2020 Welding conference.

W8: Metallurgical aspects of laser welding of biomedical devices and implants

Lena Hoffman, Ei-Shar Metallurgical Lab.

1. Laser welding-General
2. Laser welding-for Biomedical materials
3. Laser welding of Ti based alloys-Difficulties in laser welding, Mechanical properties, laser welding parameters
4. Laser welding of Co-Cr based alloys- Mechanical properties, corrosion characteristic and laser welding parameters
5. Laser welding of Stainless steel- Mechanical properties, laser welding parameters

<u>היבטים מטלורגיים של ריתוכי לייזר של חומרים השמים למכשירים ביו-רפואיים ולשתלים</u>

1. ריתוכי לייזר-כללי
2. ריתוכי לייזר-לחומרים ביו-רפואיים
3. ריתוכי לייזר לסגסוגות מבוססות טיטניום-קשיים בריתוכי לייזר, תכונות מכניות, פרמטרים של הריתוך
4. ריתוכי לייזר לסגסוגות מבוססות קובלט-כרום- תכונות מכניות, קורוזיה, פרמטרים של הריתוך
5. ריתוכי לייזר של פלדת אל-חלד- תכונות מכניות, פרמטרים של הריתוך

W9: Presentation Topic: Spot Welding and Other Resistance welding Processes

Itzhak Newman, consultant

The presentation discusses the physical principles of Spot Welding – mechanisms and locations leading to the heat generation necessary for fusion.

Spot welding cycles associated with different materials (steel, aluminum) will be presented, as well as the parameters essential to producing satisfactory results.

This will be followed by an independent and comprehensive presentation of the various parameters – compressive force effect on the lens diameter (nugget size), the mutual relationship between the current intensity and the welding duration, heat input resulting in nugget diameter evolution and more.

Practical/ daily aspects which include cleaning and grinding of the electrode edge, types of copper utilized in electrode production will be discussed.

Standard recommendations for initial parameter selection will be offered along with ways to check the quality of the resulting spot weld.

ריתוך נקודות (SPOT WELDING) ושאר תהליכי ריתוך התנגדות

יצחק נוימן

ההרצאה מציגה את עקרונות תהליך ריתוך ההתנגדות - הפיסיקה שלו ומהלך ההשקעה של של כמות החום הנחוצה להתכה והיווצרות החיבור בהמשך.

יוצגו מחזורי- עבודה של ריתוכי התנגדות האופייניים לסוגי המתכות השונים (פלדה, אלומיניום וכד') וכן יידונו הפרמטרים (עוצמת ומשך הזרם, כוחות וכד') הנחוצים לקבלת ריתוכים תקינים.

ייבחנו ההשפעות והקשרים ההדדיים בין הפרמטרים של התהליך: השפעת כח הלחיצה הסופי על גודל העדשה , רמת עוצמת הזרם כנגד משך זמן הריתוך הנחוץ , השקעת החום כנגד גודל העדשה ועוד.

בנוסף יידונו ענייני התפעול השוטפים : סוגי האלקטרודות , גיאומטריה של קצה האלקטרודה , ניקוי האלקטרודה ועוד .במסגרת זאת יוצגו גם טבלאות תיפעול מומלצות תיקניות. כמו כן יוצגו שיטות בדיקה NDT המקובלות בתהליכים אלו.

W10: Rare welding methods and welding in extreme conditions

Peter Geltser, Metallabs Applied Metallurgy Ltd

ריתוך 10: שיטות ריתוך נדירות וריתוך בתנאים קיצוניים

פיטר גלצר, Metallabs Applied Metallurgy Ltd

הרצאה זו מוקדשת לדר' דוד פוגרביסקי ז"ל, אשר השקיע את רוב חייו בחקר שלל תחומי הריתוך. דר' דוד פוגרביסקי ז"ל עבד רוב חייו בשיתוף עם המכון הבינלאומי לריתוך פאטון (Paton Institute of Electric Welding), הנמצא בקייב שבאוקראינה. בשנת 2016, לאחר שהדר' ניצח את מחלת הסרטן בפעם הראשונה, כתב ספר מפורט ששמו " WELDING OF METALS: CLASSIFICATION, BRIEF HISTORY, DEVELOPMENT". על פי מספר פרקים מהספר שכתב, נדבר על שיטות ריתוך ישנות/עתיקות כמו "Thermite Welding" , "Firecracking Welding", "Gravity Welding" וגם "Forge Welding".

כמו כן נדבר על שיטות ריתוך מתחת למים ועם נספיק גם על ריתוך בחלל.

הספר של הדר' דוד פוגרביסקי ז"ל מוצע למכירה וכל ההכנסות יהוו תרומה לאלמנתו.

W11: Welded assembly Geometric Variation Specifications

Gili Omri,TES-RnD

Welded assembly Geometric Variation Specifications

The world is not perfect, even if it was, we could not measure perfection, since are measurement ability is limited.

Any fabricated part and welded assembly will have some geometric variation in size, Location, Orientation & Form. We handle imperfection by stating variation limits to assure Function.

Plus\Minus Size limits are only one of the Four Geometric variations (Size, Location, Orientation & Form). GD&T (Geometric Dimensioning & Tolerancing) is the only standard tool to fully describe functional limits to assure finished fabrication conforms to the Functional Limits.

Poor geometric specifications lead to large or no gaps between pieces being welded, and might consequent one or more of the following: Need more filler wire, Take longer to make, May need more clean up, Can look unsightly, Can create weak spots in the fabrication.

The lecture will demonstrate the value of GD&T via Real Life cases, in heavy industry and aerospace welded assembly applications.

Presenter: Gili Omri – TES RnD
GD&T\GPS Tolerance and Analysis Expert, ASME Certified Senior / ISO TC213 committee member

Welding Session-English

W12: Welding, a technology joining people

Luca Costa, Incoming Chief Executive Officer, IIW

this goes in to the history of humanity to the modern era and underlines the role of the IIW and its members on building a sustainable world.

W13: Industrial Application of the Impact Welding Process, Magnetic Pulse Welding

V. Shribman

Bmax Srl., Hod Hasharon 4501306, Israel.

Magnetic Pulse Welding (MPW) is one of the family of impact welding processes, which includes Explosive Welding (EXW) and Vapour Foil Actuator Welding (VFAW), Laser Impact Welding (LIW), as well as Water Jet Impact welding (WIJW). All are solid state processes in which a high velocity, oblique angle, impact of two metal surfaces occurs, in which the oxide layers on the surfaces of the two metals are stripped off and ejected by the dynamically closing of this angular impact. These resulting oxide-free metallurgically pure surfaces, under high pressure due to the impact, come into intimate contact undergoing plastic deformation, and allowing valence electron sharing and atomic level bonding.

These solid state processes provides manufacturers with the opportunity to design structures in which a large variety of dissimilar and similar metal combinations may be joined to significantly improve product designs. Of particular industrial interest to the automotive and aerospace fields are the Aluminium to Steel combinations, which are utilised to meet the current emphasis on the fuel efficiency vehicle weight reduction requirements.

The present work provides a short review of the various impact welding processes along with some of the main current range of industrial applications of the MPW process.

Keywords

Impact welding, magnetic pulse welding, dissimilar metal welding, electromagnetic pulse welding

W14: On the Characterisation of Joining of Additively Manufactured AlSi10Mg to Conventionally Manufactured AA6060-T6 Dissimilar Alloys: Using the Magnetic Pulse Welding Approach

M. Nahmany[a,b], V. Shribman[c], S. Levi[b], O. Atiya[c], D. Ashkenazi[d] and A. Stern[a,e]

[a] Department of Materials Engineering, Ben-Gurion University of the Negev, Beer Sheva 8410501, Israel.

[b] Department of Materials, Nuclear Research center - Negev, Beer Sheva 8410900, Israel.

[c] Bmax Srl., Hod Hasharon 4501306, Israel.

[d] School of Mechanical Engineering, Tel Aviv University, Ramat Aviv 6997801, Israel.

[e] Department of Mechanical Engineering, Afeka Academic College of Engineering, Tel Aviv 69107, Israel.

ABSTRACT

The solid-state welding technique of magnetic pulse welding (MPW), known as a clean and green practice, results in continuous metallurgical joints. Joining dissimilar metals, which is hard to achieve in conventional arc welding, is easy to perform, when applying MPW. This feature lead to extensive interest in MPW. MPW is a single shot and high-speed welding technique, and is used, in a lap configuration, to join both cylindrical components as well as flat sheets.

Additive manufacturing by selective laser melting (AM-SLM) is an evolving technology, but so far shows size limitations of the parts. One way to address this challenge is joining AM to AM parts and/or AM to wrought components by welding. The current work investigates the microstructures observed in the bonding zone after magnetic pulse welding of wrought AA6060-T6 and AM-SLM AlSi10Mg. No earlier data has been available in this field, to date.

The current research investigates the origin of MPW morphologies and the distribution of the alloying elements was measured. A continuous ~5 mm joint, free of flaws, was detected, displaying the characteristic wavy interface. The residue of metal jet discharged during MPW was studied and analysed. Leak testing proved that the joint presents a leak rate better than $5 \cdot 10^{-9}$ std-cc·sec^{-1} He.

KEYWORDS: Additive Manufacturing; AlSi10Mg Alloy; Jet; Magnetic Pulse Welding; Microstructure; Tubular Joints; Wrought AA6060-T6;

W17: “From duplex to hyper duplex”

Peter Stones, ESAB, UK

Austenite and ferrite are combined in a duplex steel to create grades that benefit from the properties of both phases. For example there is typically a two fold increase in yield strength in duplex stainless steels when compared to austenitic steels. What is the history of duplex stainless steels? What are the differences between duplex and super duplex stainless steels and what is this grade called *hyper* duplex stainless steel? What were they developed to do and what applications are the most suitable for these grades?

This presentation will answer all of the above and furthermore take the mystery out of how they can be successfully welded with correct filler consumables, technique, parameters and most importantly heat input and interpass temperatures.

W16: Adjustable Ring Mode Laser in the Key e-Mobility Welding Applications

Jarno Kangastupa Coherent Inc., Finland

Typical e-mobility related laser welding processes must fulfill certain requirements which are stricter than typically accepted in the conventional industrial welding processes. These requirements are usually related to the weld penetration depth control, spattering during the welding process, final weld seam porosity and surface quality. With conventional laser techniques some of the new requirements are difficult to achieve. Examples of this kind of welding applications are thin wall battery cell can to lid welding, battery cathode and anode foil welding and electric motor stator hairpin welding.

With the Adjustable Ring Mode laser it is possible to improve and stabilize absorption of bright metals, maintain the keyhole stability and control the meltpool re-soldification more accurately than before. These possibilities are based on the truly independent control of the center and ring mode beams coming out from the laser’s output cable.

The analysis results of the workpieces and the high speed videos show unique performance of the ARM laser in these applications. The e-Mobility industry is adopting the ARM laser technology to various processes already.

AM Session- Morning

AM24: Large-Part Metal Additive Manufacturing: Industrial Adoption Trends and a Technical Overview

John O'Hara, Sciaky, Inc. USA.

Additive Manufacturing (AM) has been continually gaining market share since its emergence over the last few decades. The earliest technologies focused on rapid prototyping, while today industry is benefitting from several AM processes in actual production. Many of today's adopted processes have matured using plastics and metal powders, while the Wire-Fed Directed Energy Deposition (DED) processes have only recently become production viable.

The distinguishing factors that separate the Wire-Fed DED processes from the other technologies is the high deposition rates and the large size of the parts being produced. The large part capability offers solutions and challenges unlike the established processes. The Wire-Fed DED market has recently overcome the challenges, and has positioned these technologies for rapid adoption in several industries.

This paper will discuss details of how these DED technologies can offer benefits to these industries. Examples of adoption are discussed, along with supporting discussions on the technical and economic merits of the examples.

The adoption of Large Part AM will continue to grow at an increasing pace, with early successes in low-risk, non-critical parts made of the most common expensive and difficult to machine alloys. As these first successes enter production, and the benefits are realized, we will see adoption of higher risk, more complex parts.

AM4: The current state of electron beam technology and application in ”additive manufacturing

Eberhard Wagner, pro-beam systems GmbH, GERMANY

Topics:

-Presentation of the company of pro-beam

-Overview about the product range of pro-beam

-EB-Vision the newest software tooling for application

in all branches of industry

-application of additive manufacturing by using

wire feeder technology in vacuum

AM16: General situation of Additive Manufacturing in different industries

p.p. Matthias Müller
Industry Manager Additive Manufacturing Aerospace / Energy

TRUMPF GMBH, GERMANY.

The requirements for Additive Manufacturing in different industries are versatile and the progress of Additive Manufacturing throughout the years showed already which industries benefit the most from the technology even though there are still hurdles left to overcome. This presentation focuses on the road blocks of Additive Manufacturing in regards to the biggest industries. Solutions and approaches e.g. green laser source, high temperature pre heating will be presented that are targeting the root cause of the limitations rather than focusing on workarounds that only partially fulfill the current expectations in the market.”

AM32: Characteristics and advantages of combining 3d-laser printing and mechanical milling in one machine

Dr.-Ing. Roland Mayerhofer, Coherent, Germany

3d-printing of metal parts using laser powder bed fusion is becoming more and more popular in many different industrial and educational sectors, for example, the dental, medical, tool and mold or aerospace industry. Still, there are quite a lot of post processing steps required to turn a raw 3d-printed part into a precise component with narrow tolerances and functional surfaces.

In this presentation, we report first results on a new hybrid process, that combines 3d metal printing with the precision of a computer controlled industrial milling process in a laser system called CREATOR® hybrid. In contrast to pure milling machines, even complex components and structures can be milled, which would otherwise be inaccessible: e.g. inside contours, undercuts or hidden cooling channels.

Among other aspects, the influence of the additional milling process on parts accuracy, surface roughness, process cycle time and recyclability of the powder material will be discussed.

AM9: Modelling and characterization of Pre-heating stage in electron beam additive manufacturing

Eran Landau[1], Eitan Tiferet[2,3], Yaron Ganor[2,3], Michael Chonin[3], Ginadi Ziskind[1]

[1] Dept. of Mechanical Engineering, Ben Gurion University, Beer Sheva, Israel.
e-mail: Landaue@post.bgu.ac.il ; Gziskind@bgu.ac.il

[2] Materials Department, Nuclear Research Center Negev (NRCN), Israel

[3] AM Center, Rotem Industries LTD. Israel.

In electron beam additive manufacturing, the Ti6Al4 powder is pre-heated to 0.5 Tm (were Tm is the homological temperature of the material) followed by a second pre-heat to a higher temperature (0.8Tm) and selective melting. While well below melting temperatures, several thermal and mechanical effects are evident in the powder material during pre-heating, including partial sintering. Furthermore, significant difference in bulk thermal properties is amplified in the presence of many layers of powder and the case-specific solid regions. In this work, a macro-scale simulation model is developed, supported by tailored build chamber characterization experiments, to study the effects of EBM pre-heating and enable better optimization of process design.

Am26: Dimensional Accuracy and Fatigue Strength with Laser Powder Bed Fusion Produced H13 Components

J. Tomas[1], M. Merkel[1]

[1]Aalen University of Applied Science, 73430 Aalen, Germany.

In recent years, additive manufacturing has attracted worldwide attention. In addition, 3D printing is successfully used in industry such as mechanical engineering, plant construction, automotive engineering and aerospace. Many materials have been studied and properties of them investigated, such as hardness, surface quality, material behavior and surface properties. Laser Powder Bed Fusion is a layerwise generation process from metal powder to the components with an anisotropic material behavior. The temperatures during building process and resulting residual stresses are challenges in 3D metal printing.

In this work, powder material 1.2344 (X40CrMoV5-1, H13) manufactured into different components. Substrate plate heating up to 650°C is used to reduce the temperature gradients and with them residual stresses during the printing process. The process is monitored with thermographic imaging system for quality management. The surface quality, hardness and materials density of the printed components are measured after the process. Furthermore, dimensional accuracy is used with other results to optimize the printing process. The optimized parameters used for printing of samples for fatigue strength tests.

AM37: Multi-laser machines ready for Aerospace applications.

Andreas Solbach, SLM Solutions Group AG, Germany

Since more than 6 years, SLM Solutions AG offer multi-laser machines for the production of serial parts in the Aerospace and Space industry. After initial suspecting and doubts about multi-laser processes, the Aerospace and Space industry are now qualifying and using multi-laser machines from SLM Solutions for real applications. For SLM Solutions it was not an easy journey to industrialize multi-laser technology, as more lasers and higher laser powers (e.g. 4x 700W) in one machine, create additional challenges compared to single laser processes. A key element to overcome these challenges is the gas flow system in the process chamber. The right melting conditions need to be created by the gas flow system to translate the full capability of multiple lasers into additional productivity. With the sintered wall gas flow patented in 2016, machines from SLM Solutions achieve homogenous mechanical properties in xy- and z-direction meeting the common aerospace requirements from Aerospace OEMs in Aluminum, Titanium and Nickel-based alloys. Has the tough journey to build reliable and robust multi-laser machines for Aerospace applications has finally come to an end?

AM17: Dream, Think, Make! – How to succeed in Additive Manufacturing

Erwin Schulman M.Sc Head of Optomechanical Department, Head of Additive Manufacturing R&D, IAI, Technologies Division

IAI did it! 3 years ago IAI decided to leverage metal additive manufacturing for products and business purposes, IAI is proud to be the principal player of metal AM in Israel with world class achievements in space (parts on Beresheet). More than 3200 produced parts and implementation of AM serial production. We will share with you what we did and how you can be successfully as well.

Understanding your printing potential is understanding the potential to improve your products by AM. Printing conventionally manufacturing designed part is a frequent mistake. **Profiling your potential** AM parts in terms of complexity, weight, dimensions and quantities.

For IAI, AM is generally effective when the weight is less than 100 g, or with a complexity of more than 17 non coplanar faces, or a batch size of less than 24 parts relative to casting. With those boundaries you can define the effective space of your AM potential. The potential will be increased by: united and/or multifunctional parts, topological optimized and/or lightweighted parts that reduce the cost and increase the reliability of AM process, even if is not necessary by original requirements.

IAI build a **holistic vision** about additive manufacturing process. From design trough preprocessing, processing, post processing, finishing and testing, everything is connected. To produce a performant AM part, the IAI team consider all those stages at-once.

For the **efficient design**, knowing the functionality of the part, the designer must take into account a minimal but process effective supporting structure, optimal process parameters, the post processing effectiveness, the ability of testing, everything together to achieve a cost effective result.

To push forward the AM vision, a winning team needs to be constituted by at least the follow specialists: application engineer, process operator, mechanical designer, stress analysis engineer and material engineer. This is the holistic view. These specialists push forward their domain and share the highest level of their knowledge with all team members, building **multi-domain specialists** in AM that spread and share with all designers the AM acquired knowledge.

Based on specific AM potential of parts, the **effective production cycle** including testing policy and equipment have to be defined. The equipment shall be chosen based on the material, batch size, part size, surface quality etc. A common mistake is to correlate the efficiency of the process only to printing time and to the cost of the printer. Issues such as powder handling, sieving, cleaning, plate dismounting, waste handling, settings, calibrations, quality assurance and especially safety have crucial influence on the cost and ability to increase the potential of printed parts.

In conclusion. For Success in metal AM: understanding and the potential, a holistic view of process and design, multidisciplinary specialized team, effective production cycle and equipment, clear policy of part qualification quality assurance and testing.

AM39: Effect of HIP temperature on microstructure and mechanical properties of EBM produced Ti-6Al-4V.

Denis Zolotaryov, IIM, Technion

Ti-6Al-4V is a wildly used titanium alloy, especially in aerospace industry. In order to meet high requirements of aerospace sector, material must possess the necessary qualities, such as high specific strength, tensile strength, and fatigue limit. For load-carrying parts in the aerospace industry, Hot Isostatic Pressure (HIP) processes are used in order to increase fatigue limit of parts.

A relatively new production process called Additive Manufacturing (AM) has the potential to be a game-changing factor in nearest future for many application in fields like aerospace, automotive industry, microelectronics etc.

This study focuses on investigation effect of HIP temperature on mechanical properties and microstructure of Ti-6Al-4V parts, produced by Electron Beam Melting (EBM) process. The correlation between microstructural characteristic (such as lamella's thickness, phases' fracture) and mechanical properties of AM Ti-6-4 relied on temperature regime changing of HIP was observed and studied.

AM8: Applications of Infra-Red Camera on EBM Processes using Numerical Methods and Algorithms

M. Ezra1, E. Landau2,3, Y. Ganor1,2, M.Chonin1, E. Tiferet1,2, G. Ziskind3
1 AM Center, Rotem Industries LTD
Mishor Yamin D.N. Arava 86800 Israel

[2] Nuclear Research Center Negev (NRCN), Israel

[3] Dept. of Mechanical Engineering, Ben Gurion University of the Negev
P.O.B. 653 Beer-Sheva 8410501 Israel

Electron Beam Additive Manufacturing (EBAM) is one of the methods for 3D printing of metal. In this method, a powder bed of the metal is placed inside a vacuum chamber and an EB is depositing energy in a certain pattern to the bed's upper surface. Then, layer by layer, the 3D object is built.

The thermal behaviour of the 3D printing process is affecting many parameters, such as the mechanical properties, thermal residual stress, forming of cracks in the part, porosity and more. In order to achieve better final parts, the thermal behaviour must be known at all times, using correlations, numerical computations or measurements.

In this work we integrated a dedicated design of a thermal imaging infra-red camera on an electron beam melting machine - ARCAM Q20+. Using the camera data with a simplified numerical code, the camera's thermotopographic maps were extended to get 3D temperature maps of the powder bed and built plate.

Regarding the thermal behaviour of the EBAM process, there are two main approaches: 1) the small scale, which consider the effects surrounding the beam and the melt pool and 2) the large scale, which consider the heat dispersion in the entire environment. Using the IR camera, with some special algorithms, both of the scales were captured and investigated, in order to better understand the EBAM process.

Furthermore, the thermal data from the camera is used as a boundary condition of a simplified numerical model. In this model, it is unnecessary to model the electron beam energy deposition and environmental thermal conditions of the melt surface (radiation mostly), leading to fast calculations times.

This presentation deals with a) the potential of using IR camera in the machine, b) methods for integrating the camera on the machine using some specially designed components, c) the IR camera images for several stages of the process, d) calibration procedures and algorithms [1], [2], e) the numerical model methodology and results, f) some special features of the camera to detect the small scale of the process.

REFERENCES

[1] Dinwiddie et al., "Calibrating IR Cameras for In-Situ Temperature Measurement During the Electron Beam Melting Process using Inconel 718 and Ti-Al6-V4", *Proceedings of SPIE*, doi: 10.1117/12.2229070 (2016)

[2] Raplee et al., "Thermographic Microstructure Monitoring in Electron Beam Additive Manufacturing", *Scientific Reports 7:43554*, doi: 10.1038/srep43554 (2017).

AM34: Deciphering the microstructure and residual stress effects on the mechanical behavior of additively manufactured metals

Y. Morris Wang

Physical and Life Sciences Directorate, Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

Additively manufactured metals and alloys often have unique microstructures and large residual stresses that impact the mechanical behavior. The residual stress issue exacerbates in the case of laser powder-bed-fusion (L-PBF) additive manufacturing. This talk will focus on two parts. In the first part, we show that L-PBF austenitic 316L stainless steels can exhibit a combination of yield strength and tensile ductility that surpasses that of conventional 316L steels. The strength-ductility combination breaks off the strength-ductility trade-off trend in the literature. High strength is attributed to solidification enabled cellular structures, low-angle grain boundaries, and dislocations formed during manufacturing, while high uniform elongation correlates to a steady and progressive work-hardening mechanism regulated by a hierarchically heterogeneous microstructure, with length scales spanning nearly six orders of magnitude. In addition, solute segregation along cellular walls and low-angle grain boundaries can enhance dislocation pinning and promote twinning. We thus demonstrate the potential of additive manufacturing to create alloys with unique microstructures and high performance for structural applications.

To probe the microscale residual stress effects on mechanical properties, in the second half of this talk, we combine in situ synchrotron X-ray diffraction experiments and computational modelling to quantify the lattice strains in different families of grains with specific orientations and associated intergranular residual stresses in an AM 316L stainless steel under uniaxial tension. We measure pronounced tension–compression asymmetries in yield strength and work hardening for as-printed stainless steel, and show they are associated with back stresses originating from heterogeneous dislocation distributions and resultant intragranular residual stresses. We further report that heat treatment relieves microscale residual stresses, thereby reducing the tension–compression asymmetries and altering work-hardening behavior. These results establish the mechanistic connections between the microscale residual stresses and mechanical behavior of AM stainless steel.

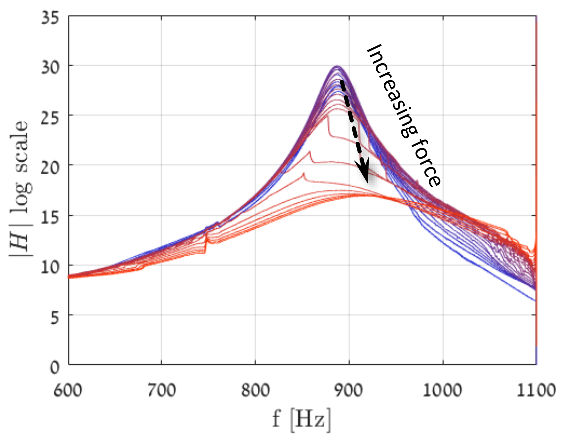
The work was performed under the auspices of the US Department of Energy by LLNL under contract No. DE-AC52-07NA27344.

AM10: Towards optimal dynamic response using AM based granular damping

Yuval Harduf[1], Dr. Eyal Setter[1], Dr. Michael Feldman[2], Prof. Izhak Bucher[2]

[1]RAFAEL – Advanced Defense Systems
[2]Technion, Israel Institute of Technology – Faculty of mechanical engineering

Additive manufacturing (AM) is a relatively modern fabrication process that is quickly progressing. Selective laser melting (SLM) is an AM technique, used mostly for metallic materials, in which powder layers are successively applied and selectively solidified by a laser beam to create a structure layer-by-layer. In the current research, a method of encapsulating unsolidified metallic powder in closed chambers embedded in the solidified structure is proposed, to act as granular dampers. When vibrated, the powder granules collide and rub with one another as well as with the chambers' walls. The inelastic collisions and frictional interfaces act as energy sinks, absorbing vibrational energy. This implementation requires no maintenance, provides high durability and long service life, and of special interest in cases where the design is bound to complex geometries, confined volumes, or where standard dampers cannot be applied. Granular dampers have been a research interest for a long time now and it was already suggested to embed them within a structure. However, the use of AM is highly attractive here as it allows a) to create the granular dampers as part of the fabrication process and b) to control the form, shape and location of the dampers to optimize the structure's effective damping thus minimizing the vibrational response. The behavior of granular dampers has not yet been characterized thoroughly in an analytic model and no design process that optimizes the dampers' topology has been proposed yet. In this lecture the results of experiments on additively manufactured Ti6Al4V beams will be shown. The beams with embedded granular dampers were shown to exhibit high damping ratios relative to fully solidified beams. The damping properties of the beams were found to be highly nonlinear as they increase with the excitation force amplitude. Advanced nonlinear analysis techniques were used to investigate the properties of the beams and initial results show that the damping force exhibits bi-linear behavior, depending on the response amplitude. Initial work towards modelling and a simplified model for the investigation of various damping models will be presented as well.



AM11 :Validation and installation of Additively manufactured parts in the IAF

Cap. Shai Oren, Materials and Process Dept., Depot 22, IAF

The IAF has ever needing growth for replacement parts due to aging platforms in its possession. Most of the parts couldn't be bought or conventionally manufactured in small amounts. 3D printing or additive manufacturing (AM) may aid the IAF to become more independent while minimizing the supply chain.

The IAF maintains constant relations with the Israeli academic boards, industries and other departments of defense in order to embed this beneficial technology to the Air Force. These relations yielded few projects that aid the IAF reach its goal.

Primarily in this early stage the IAF is aiming to manufacture parts via AM technology, these parts shall be non-critical for flight safety and the loads which they carry are negligible.

The concept of this lecture is to introduce 3 of these projects which the IAF is currently involved in.

1. The first demonstrator is a Ti-6Al-4V bracket, additively manufacture via Electron beam melting (EBM) technology for the black hawk.
2. The second demonstrator is a Al-10Si-Mg cowling, additively manufacture via (Selective laser melting) SLM technology for the sea stallion.
3. The third project in collaboration with Tel-Aviv University (TAU) is focused on developing the Direct Energy Deposition (DED) technology in order to refurbish damaged\unusable parts and manufacturing new parts.

The lecture will present the validation, examination and installation process of an additively manufactured part in the IAF.

AM19: Additive Manufacturing – a "Holistic" approach

Eng. Yuval Gale
Head of the AM center & AM Team Leader
MBT Technologies, Israeli Aerospace Industries (IAI).

The MBT AM Center invests many resources for R&D of the Laser Powder bed Fusion (LPBF) technology, the link between all R&D projects is practical application. All current projects are triggered by real life "problems" that were discovered during the manufacturing and the qualification processes. They vary in a wide spectrum; topology optimization, thermal treatment, dynamic properties, surface treatment, welding and more.

In order to benefit from AM to the fullest, the engineer must understand the entire AM processes; design rules for AM, stress/dynamic & thermal requirements, support design & impact, build parameters, post processing, qualifications & testing that are required for the part validation. This type of approach is called a "holistic" view where the engineer is providing a solution free of conventional constraints that obeys the AM guidelines.

In most cases, the production of parts by LPBF that were originally designed for conventional processes, will cause two main issues; degraded part accuracy and a price impact. In order to benefit from this technology, the product must be designed using the AM guidelines or at the least to be revised for AM.

By using this type of approach, the quality of the part can increase while the price of the part may decrease. For example, a short case study ;

An antenna bracket was initially designed for CNC milling. The initial bracket was thought to fit the criteria for AM, therefore the "CNC design" was produced by LPFB. During the build, many support structures were required and later on they had to be removed. These support structures had an impact on the cost (waste, laser exposure time, and post process), on the quality and on the reproducibility (at the interface between the supports and the part) .

The part was redesigned for LPBF by topology optimization and was designed to be self-supporting. Only a few supports were located on un-functional surfaces where high surface roughness is acceptable thus achieving production repeatability, reduction of build time and reduction of post-processing. The outcome was a cost reduction of more than half in respect to the original CNC manufactured part .

The adoption of the design rules by the engineers is one of the most challenging milestones since Additive Manufacturing consists of dozens of different types, each of them have their benefits, limitations and requirements. We believe that the way to

correctly implement the technology is the by giving the designer the right tools for identifying the best possibly AM technology for manufacturing his part.

In conclusion, AM enables us to broaden our engineering possibilities. None the less, one must understand the entire process to identify its strengths and weaknesses. Currently, mistakes and defects are unavoidable, but they are necessary to advance. Recognize that you're facing a learning curve, embrace it and try to make the bend as steep as possible.

AM33: COMPOSITE WIRE FOR WELDING AND ADDITIVE MANUFACTURING: PURPOSE AND PROPERTIES

Ganna STOVPCHENKO[1,2], Ganna POLISHKO[2], Aleksey KOVALEVSKY[3]

[1]*Engineering company "ELMET-ROLL", Kyiv, Ukraine*
[2]*E.O. Paton Electric Welding Institute of National Academy of Science of Ukraine, Kyiv, Ukraine*
[3] *Technion Israel Institute of Technology, Haifa, Israel*
[1]*anna_stovpchenko@ukr.net*, [2]*ganna.polishko@gmail.com*,
[3]*alekseyk@trdf.technion.ac.il*

Keywords: composite (core) wire, active additions, microstructures, deoxidation, microalloying, properties.

Composite ingots/billets with different powder fillers (both metallic, like ferroalloys, and non-metallic, e.g. various oxides and carbon) in a central insert were designed and tested.

The main purpose of developed composite wires is to bring effective deoxidating, microalloying or refining additions in an active state to a pool of molten metal at welding or wire-fed adfitive manufacturing.

Several promising composite wire grades were successfully manufactured by traditional metallurgucal route: ingot casting - rolling for rod wire - drawing. Technical feasibility and efficiency of industrial production of heavy composite-added ingots with additions of deoxidating/microalloying ferroalloys (REE (0,03-0,05%) or zirconium (0,05-0,07%)) in central insert has been validated. 12,5 t composite ingots of SG2 steel were processed to 6,5 mm rod wire and than for the welding type of 2,0 and 0.8 mm in diameter. It was shown that located in the center of the composite ingot/billet powder-filled insert has been deformed congruently to the whole ingot body without sufficient changing of existing processing regimes.

Composite wire was tested at welding of low-alloy structural steels in the environment of protective gases (MIG/MAG) and shown very stable welding process and low degree of splashing of electrode metal droplets (max 2% for REE and 6% for Zr added wires) and high quality of welds. The degree of transition of REE to the welding joint metal makes up to 11% (from solid wire it is traces only), which contributes to weld metal deoxidation and effective modifying of non-metallic inclusion.

Current work presents the microstructure, mechanical and welding properties of the composite wires from SG2 steel with REE.

Several other variants of compositions were designed using a single matrix - ingots of steel SG2 (content of basic elements,%: C - 0,05-0,11; Mn - 1,8-2,1; Si - 0,7-0,95 ; S - max 0.02; P max l0.02). The choice of SG2 steel as a unified matrix is due to the fact that it has the largest output and consumption for mechanized welding of metal structures, but other candidates was also considered (304 for stainless and some others). The convinience of developed method for small lots of diverse wire grades manufacturing and high productivity of composite ingot/billet processing by metallurgical methods as well as due to preventing of active elements dissolving in the wire steel matrix (to save their ability to modify a forming pool due to coming unbonded with admixtures), makes the composite-added wires a promising and competitive material for both welding and wire-fed additive manufacturing processes.

AM28: Manufacturing of Copper with high electrical conductivity by Binder Jetting Printing and Electron Beam Melting

Vladimir Popov [1], Strokin Evgeny [1], Alexander Katz-Demyanetz [1], Aleksey Kovalevsky [1], Gary Muller [1], Menachem Bamberger [2]

The current research present how Powder Bed Fusion (PBF) by Electron Beam Melting (EBM) and by Binder Jetting Printing (BJP) for manufacturing of Copper parts with high electrical conductivity.

The initial feedstock material for the experiments was gas atomized blended powder Cu 99,95% OFHC with two sizes of fraction: 10-38 um and 50-100 um.

The EBM manufacturing has been performed in Arcam EBM A2X machine modified for printing of small amounts of powders from 1 liter of powder.

The BJP has been performed in ExOne M-Flex machine followed by 4 sintering regimes, to find the proper combination for full density parts with better electrical conductivity properties.

PBF techniques were found very prospect for production of high-dense functional Copper parts, however this work requires challenging work with process parameters optimization (for EBM); and development of post-printing sintering parameters (for BJP).

AM5: mobile additive AND subtractive machining solution for fast repair and spare part creation

Dipl.Ing. IWE Marcus Witt, METROM, GERMANY

Innovations can only be achieved by new thinking. On this basis the company METROM has been founded in 2001 and is meanwhile lead by the second generation as a family owned and operated business. METROM stands for parallel kinematic machine systems with 5 struts and an outer structure which is a so called icosaeder. The icosaeder structure is the key to a stiff system that allows withstanding high forces and guiding them from the spindle head till the floor.

New technologies are requested by the customers to be integrated additionally into the machines that started as milling machines first in order to save costs for separate processing stations. Therefore METROM is permanently seeking for interesting technology to extend the machining capability according to the customer's needs.

One example is the combination of 3D-metal printing by wire arc additive manufacturing provided as a module from GEFERTEC in combination to milling for steel molds. These molds get worn out after several months in use and a process to refurbish them in the shortest possible period saves the car manufacturer a lot of manual work as well as time. METROM can provide a mobile 5-axis hybrid machine which is capable of measuring the workpiece, welding the contour as well as machining in one clamping setup. After milling has been finalized a tool to flatten the surface roughness is used for hammer peening which also hardens a small area on the surface. All tools and technologies are available through a direct tool change within the working room so no operator influence is needed besides the programming of the job. The mobile machine can be operated wherever a new plant of the customer is build. Nobody has ever done this before and robots that are used for welding are not accurate and stiff enough for the necessary machining.

As a short outlook we will show one further new technology called SEAM (screw extrusion additive manufacturing) and a new mobile machine that weighs only 90kg for even easier use within production lines.

AM2: Review of Advanced Ti Alloy ALM Process Development

O. Dolev

Rafael ltd. , Haifa, Israel

dolev.ohad@gmail.com

Selective Laser Melting (SLM) is a Powder bed laser beam based additive manufacturing method that is increasingly being adopted throw-out variety of industry sectors.

Although powder bed additive manufacturing is considered to be a low throughput manufacturing and handling sensitive process which is currently limited in its build envelope, it yields high quality process outcome with may include fine features and structures, thin walls, lattice structures, internal channels, cavities etc.

Broadening the Additive Layer Manufacturing (ALM) materials range with new materials may introduce the use of that technology into new and more demanding applications. This, in turn may yield a technological and commercial edge.

In this review, an over view of process development and characterization for a new, high strength specific Titanium alloys is shared. The design considerations and guide lines of this work is described including the Design Of Experiment (DOE) approach used for choosing process parameters, material characterization, post process thermal treatment and test results.

AM38: Simplify the Additive Manufacturing process with a software solution

Maoz Barkai, 3DSYSTEMS

Simplify the Additive Manufacturing process with a software solution

What are the differences between AM for Prototyping and Industrial AM?

What are the pros and cons of an Integrated vs. Best-in-Class solutions for AM

How can we meet the challenges of a print preparation software

איך לפשט את תהליך ההדפסה בתלת מימד בעזרת פתרון תוכנה

מהם ההבדלים בין הדפסה בתלת מימד לצורכי אב-טיפוס לעומת הדפסה תעשייתית?

מהם היתרונות והחסרונות של פיתרון משולב לעומת פתרונות Best in Class לתהליך ההדפסה בתלת מימד?

כיצד עונים על הדרישות המורכבות של מתוכנת הדפסה בתלת מימד?

AM20: Environmental Degradation of AM-fabricated Structural Alloys

Polina Metalnikov[a,b], Prof. Dan Eliezer[a], Dr. Guy Ben-Hamu[b]

[a]Department of Material Engineering, Ben-Gurion University of the Negev,

Beer-Sheva 84105, Israel

[b]Department of Mechanical Engineering, Sami Shamoon College of Engineering,

Ashdod 77245, Israel

Additive manufacturing (AM) technologies enable rapid production of parts with complex geometry which cannot be shaped in other conventional methods. The AM-fabricated parts experience rapid solidification and high cooling rates; this leads to formation of atypical microstructure and directly affects the intrinsic properties of the printed part and on its environmental-assisted degradation. In this research, the environmental degradation by means of corrosion and hydrogen embrittlement (HE) of structural materials produced by AM technologies will be presented.

Hydrogen presence is unavoidable in most manufacturing processes and services. Hydrogen can significantly deteriorate mechanical properties and lead to unexpected failure. The hydrogen interaction with the material is strongly dependent on the type of the metal, microstructure, the amount of adsorbed hydrogen and its location in the material. The aim of the research is to provide detail information about the environmental degradation of AM-produced structural materials in aggressive service conditions for further application of as-printed parts in aircraft, automotive, and marine industries.

AM27: Raising Large Size Copper Parts enabling Advanced AM Applications

Bernhard Kögl
Senior Account Manager, AMCM GmbH, Petersbrunner Str. 1 b, D-82319 Starnberg,GERMANY

Space Tech is currently facing an innovation wave which we have not seen since mankind raced to the moon.
Small launch vehicles for satellites and innovation for heavy payload launchers are the driving forces. Based on this trend aerospace and other industries with AM applications will benefit from the machines and processes developed for the space tech needs.
The AM requirements include very high conductive materials with internal cooling channels in combination with high load bearing and the need for large part sizes. The presentation will give an overview of Copper and Copper alloy (CuCrZr) process development using new laser sources and a unique machine type of 450 x 450 x 1000 mm^3 build envelope enabling many advanced applications!

AM13: Tungsten Additive Manufacturing –Application Success Story

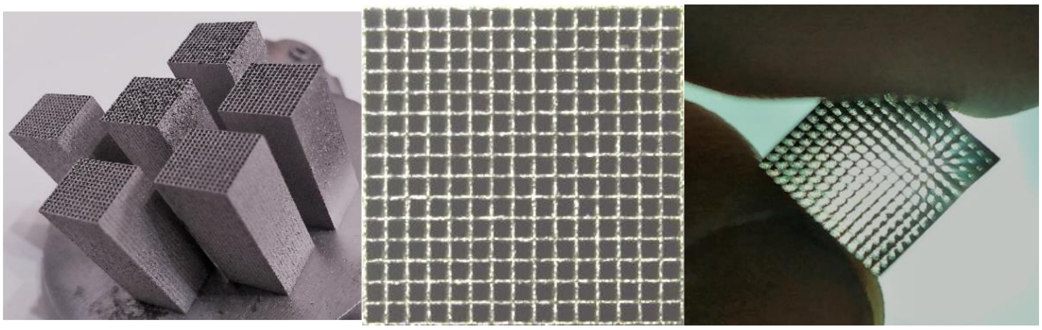
Dov Chaiat
TPT- Tungsten powder Technology

Tungsten (W) high melting point of 3410^{o}C, giving it excellent radiation absorption properties, is ideal for the production of components for X-ray imaging systems. TPT have developed methods to additively manufacture complex tungsten components for high- precision applications such as collimators and radiation shields in CT, SPECT, and X-ray imaging systems. The Selective Laser Melting (SLM) technology enables the development of new parts which could dramatically improve medical imaging technology.
Central to the imaging system's scanner is a collimator. This is a device which aligns the gamma ray beams of radiation emitted from the patient so that they are directed onto a detector. The data received can then be viewed as an image on a computer screen. The most advanced medical machines host new designs of collimators to obtain clear pictures with reduced amount of radiation. Thus advanced collimators geometries will hold small unit cells with minimal wall thickness.

Materials well suited for SLM are regularly adapted by balanced properties of melting point, thermal conductivity, surface tension and viscosity. With state-of-the-art laser based equipment and the so far developed processing strategies/parameters the titanium alloys and stainless steels are defined as "typical easy-to-fabricate materials", whereas tungsten is still considered "difficult-to-fabricate".
Tungsten high melting point means high cohesive energy and high surface tension. This fact drives the shaping of the melted tungsten toward a minimum energy state. It creates a tendency of stopping the merging of melt pools along the scan tracks and forming individual tungsten spherical drops. This result is defined as the "balling phenomenon".

Our experimental tests were carried out to identify critical process parameters effecting the densification of W powders. The effect of various process parameters as laser power, hatch spacing and scan speed on the densification of W powder was analyzed.

We also focused on finding the feasibility of using lower sphericity of W powder as a raw material for manufacturing parts by the SLM technique.



Am14: The Future of Additive Manufacturing in Aerospace - a GE Vision

Pär Arumskog, Application Development Engineer, GE Additive Sweden

Electron Beam Melting (EBM) is an additive manufacturing (AM) technology well established in production, especially in the field of medical implants. Some space-related application has also been manufactured using EBM and in the near future production of safety-critical airplane engine components is expected. EBM is a powder-bed fusion (PBF) process using the electron beam as an energy source. In contrast to laser PBF it is a truly hot process, eliminating the need for post-build stress relief and opening up opportunities for in-situ heat treatment. EBM has for more than 20 years been developed by Arcam in Sweden, now a part of GE Additive. The technology has come a long way and much that was previously impossible is now done on a daily basis by our customers. However, we still see a long way ahead to fully realize the huge potential of EBM.

Focus will be on the technical aspects of EBM and how to utilize the advantages of the technology, such as the possibility to print new difficult-to-manufacture materials, e.g. crack-prone alloys and reflective materials. Examples of applications and different materials will be presented and discussed both from the point of view of what now is possible and what we see in the future. The current limits to the technology will also be discussed and a distinction made between engineering (EBM process and machine) dependent limitations and more fundamental physical ones. Comparison and contrast with laser-PBF and other AM technologies, as well as subtractive technologies, will be made. Business cases for EBM in terms of part design, build design and EBM process parameter development will be presented and discussed. Current challenges, recent developments and visions for the future in terms of new materials and applications will also be touched upon.

AM1: Application Discovery - Evaluating Real Use Cases for In-office Metal 3D Printing

Ilya Mirman, Vice President Marketing, Desktop Metal, USA

Advances in metal 3D printing technologies are enabling engineers and designers to make functional prototypes in the office, on-demand and without the need for special facilities or operators. This session explores the latest advances in office metal 3D printing for prototyping and low volume production through real industry applications. See how Desktop Metal Bound Metal Deposition (BMD^{TM}) process enables AM of wide range of alloys across different material families. The nature of this process eliminates localized melting, rapid solidification and multiple thermal cycles that are common in powder bed fusion systems. It produces isotropic microstructures with grains that form across multiple layer lines and parts that are free of residual stresses. This session will touch the processing of metals using this technology, properties and microstructure. It will also cover a cross-industry view of best-fit applications as a solution to streamline functional part printing for prototyping, jigs and fixtures and tooling. For those evaluating metal 3D printing for on-demand accessibility to part production, this session will enlighten and inspire.

AM7: Engineering Microstructure via Parameter and Beam Manipulation of Electron Beam Melting

Y. I. Ganor(Rotem Israel), D. Braun, M. Chonin, O. Tevet, E. Tiferet

Electron Beam Melting (EBM), is a form of Powder Bed Fusion (PBF) AM that uses an electron beam as the energy source for printing. Many of the governing parameters and algorithms are shrouded 'black boxes' protected by intellectual property (IP), aimed at a defined processes window for a specific material. Research into normalizing beam parameters to metallurgical properties will allow better migration to a new material. Current study aims at developing of optimal printing parameters Ti-6Al-4V alloy by "Arcam Q-20 plus" apparatus, equipped with a developer key, which enables the manipulation of basic and advanced beam parameters. It will be demonstrated that by altering the beam's parameters, it is possible to control the energy deposition and therefore regulate melting regimes, thermal gradients and even engineer the microstructure. Tailored microstructure, in the well-known Ti-6Al-4V alloy, is an essential step towards a new material parameters development. Different tailored microstructures or post processes may allow printed parts to perform better under certain circumstances such as better fatigue resistance, higher yield stresses or better elongation.

AM36: How to ensure reproducible Laser Beam Parameters in SLM, 3D printing & AM systems

Roei Yiftah, MKS Instruments, Inc.

In production systems for selective laser melting (SLM) or 3D printing, several lasers often work simultaneously on one component, or various parts are manufactured simultaneously using several laser sources in a single system. As the productivity of such systems goes up, so do the demands on their availability and the reproducibility of the manufactured parts. To guarantee this in the long run, the technicians and engineers responsible for the system must know its critical parameters such as the focused laser beam and be able to quickly understand any changes they see in it. This is where conventional measurement techniques reach their limits – and where the non-contact approach shines.

The main question is "How can we ensure the reproducibility of 3D printing/SLM system?" between one layer to another, between different lasers on the same system or even between system to system.

To answer it and get the reproducibility needed Ophir introduced the BeamWatch, a laser beam non-contact measurement technology based on Rayleigh scattering that can fast and easy capture the laser shape, and for the first time it was possible to measure the beam profile of high-power lasers without any restrictions on the power. combining it with analyzing software the Technician can monitor all laser critical parameters in live without interfere with the laser.

Physically this can be done by the electric field of the laser radiation that induces oscillation in the dipole molecules of the ambient air (or a process gas) at the laser's frequency, creating a corresponding elastic scattering. This scattered light captures with a camera, and an integrated software calculates the beam and beam-quality parameters according to ISO 13694 and ISO 11146**.**

AM3: Powder-Free Ceramic & Metal AM

Dror Danai, XJet, ISRAEL

This presentation highlights one of the most outstanding ceramic and metal powderless AM technologies.

XJet’s patented NanoParticle Jetting™ (NPJ) technology enables the production of ceramic and metal AM parts of the highest quality – featuring unprecedented levels of detailing, density and design freedom – without compromising on throughput.

With NPJ technology, solid nanoparticles in a liquid suspension are delivered within convenient sealed cartridges. Build and support material cartridges are loaded easily by hand into XJet’s recently launched Carmel AM systems, eliminating the need for hard-to-handle hazardous powders.

XJet’s inkjet technology features:

- **Stochastic nanoparticles** of random size and shape
- **Ultrathin layers**
- **Simultaneous jetting** of build and support materials

These features translate into three types of key advantages:

- **Physical** □ unsurpassed part quality with high density & fully isotropic parts
- **Geometric** □ unprecedented design flexibility, accuracy, smoothness and feature size properties
- **Operational** □ industrialization, operational safety and simplicity

Led by a world-class team of respected industry veterans, XJet has the long-term vision and proven track record to successfully redefine the advanced ceramic and metal AM arenas.

AM12: Applications of Infra-Red Camera on EBM Processes using Numerical Methods and Algorithms

M. Ezra1, E. Landau2,3, Y. Ganor1,2, M.Chonin1, E. Tiferet1,2, G. Ziskind3
1 AM Center, Rotem Industries LTD
Mishor Yamin D.N. Arava 86800 Israel
2 Nuclear Research Center Negev (NRCN), Israel
3 Dept. of Mechanical Engineering, Ben Gurion University of the Negev
P.O.B. 653 Beer-Sheva 8410501 Israel

Electron Beam Additive Manufacturing (EBAM) is one of the methods for 3D printing of metal. In this method, a powder bed of the metal is placed inside a vacuum chamber and an EB is depositing energy in a certain pattern to the bed's upper surface. Then, layer by layer, the 3D object is built.

The thermal behaviour of the 3D printing process is affecting many parameters, such as the mechanical properties, thermal residual stress, forming of cracks in the part, porosity and more. In order to achieve better final parts, the thermal behaviour must be known at all times, using correlations, numerical computations or measurements.

In this work we integrated a dedicated design of a thermal imaging infra-red camera on an electron beam melting machine - ARCAM Q20+. Using the camera data with a simplified numerical code, the camera's thermotopographic maps were extended to get 3D temperature maps of the powder bed and built plate.

Regarding the thermal behaviour of the EBAM process, there are two main approaches: 1) the small scale, which consider the effects surrounding the beam and the melt pool and 2) the large scale, which consider the heat dispersion in the entire environment. Using the IR camera, with some special algorithms, both of the scales were captured and investigated, in order to better understand the EBAM process.

Furthermore, the thermal data from the camera is used as a boundary condition of a simplified numerical model. In this model, it is unnecessary to model the electron beam energy deposition and environmental thermal conditions of the melt surface (radiation mostly), leading to fast calculations times.

This presentation deals with a) the potential of using IR camera in the machine, b) methods for integrating the camera on the machine using some specially designed components, c) the IR camera images for several stages of the process, d) calibration procedures and algorithms [1], [2], e) the numerical model methodology and results, f) some special features of the camera to detect the small scale of the process.

REFERENCES

[3] Dinwiddie et al., "Calibrating IR Cameras for In-Situ Temperature Measurement During the Electron Beam Melting Process using Inconel 718 and Ti-Al6-V4", *Proceedings of SPIE*, doi: 10.1117/12.2229070 (2016)

[4] Raplee et al., "Thermographic Microstructure Monitoring in Electron Beam Additive Manufacturing", *Scientific Reports 7:43554*, doi: 10.1038/srep43554 (2017).

Posters

AM100: Static and dynamic comprehensive response of AM discrete patterns

D. Levy, A. Shirizly and D. Rittel

Additively manufactured (AM) discrete patterns made of Ti6Al4V offer potential energy absorption for engineering applications, including blast and impact protection systems, aircraft structure, automotive, and medical applications. In this study, we compared three different cylindrical printed patterns fabricated by selective laser melting (SLM), patterns sharing similar cross section and mass, in order to identify the "optimal" design of such structures for energy absorption purposes. The specimens consist of one columnar and two tubular patterns. The columnar pattern (8-Column) was constructed out of uniformly distributed columns. The first tubular pattern (Tube I) was constructed with the same outer diameter and tapered inner profile. The second tubular pattern (Tube II) had adjusted internal and external diameters. Quasi-static and impact (dynamic) load tests were performed to investigate the strain rate dependency, compressive response and failure mode of each pattern, including a comparison with a printed solid reference cylinder. Numerical simulations were carried out to complement the experimental work and to develop a generic numerical tool for future structural optimization applications. The results show that the geometry has a strong influence on its overall compressive performance, including energy absorption. The most effective of the patterns investigated was Tube I for both quasi-static and dynamic regimes

AM101: Corrosion characteristics of carbon steel produced by incorporating additive manufacturing and wire arc facility

Tomer Ron*, Ohad Dolev, Avi Leon, Amnon Shirizly and Eli Aghion

Department of Materials Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel

*Corresponding author: toron@post.bgu.ac.il

Practical additive manufacturing (AM) technologies mainly focused on powder bed platforms, such as electron beam melting (EBM) and selective laser melting (SLM). Although powder bed technologies offer inherent advantages such as the ability to produce complex geometrical parts with relatively good surface roughness, their main disadvantages relates to the high cost of metal powder, amount of energy consumption and component's size that are limited by the dimensions of the printing cell. This study aimed at evaluating the corrosion performance of low carbon steel (ER70S-6) produced by a relatively inexpensive AM process using wire feed arc welding. The mechanical properties were examined by tension testing and hardness measurements, while microstructure was assessed by SEM and X-ray diffraction analysis. The corrosion performance was evaluated by salt spray testing, immersion test, potentiodynamic polarization analysis and electrochemical impedance spectroscopy while stress corrosion resistance was examined; by slow strain rate testing (SSRT), all in 3.5% NaCl solution at room temperature. The results obtained indicated that the general corrosion resistance of wire arc additive manufacturing (WAAM) samples was fairly similar to that of the counterpart ST-37 steel and the stress corrosion resistance of both alloys was adequate. Altogether it was clearly evident that the WAAM process did not encounter any deterioration in corrosion performance compared to its conventional counterpart alloy.

AM102: Dynamic strength and failure of additively manufactured Ti-6Al-4V alloy

1V. Paris, P. Fridman, E. Tiferet, S. Samuha,Z. Harpenes, A. Yossef-Hai

[1]Physics dept., NRCN, Israel

Additive manufacturing of metallic alloys (AM) by Electron Beam Melting (EBM) or Selective Laser Melting (SLM) is an emerging field. Understanding the relationships between the AM and post-processing parameters and resulting microstructure and the mechanical (and particularly dynamic) properties is of great practical interest. The Ti-6Al-4V alloy made by EBM has been studied in series of Split Pressure Bar tests (SHPB). The effects of Hot Isostatic Pressing (HIP) and of orientation of loading to build direction on dynamic compressive strength and failure properties were investigated. Stopper rings were employed in the tests to softly recover the specimens for post-mortem characterization. Results indicate that the effect of HIP on flow stress is small. The strain to failure of HIPed alloy is significantly higher than of as-built alloy. Results display small effect of the relation of loading direction with respect to build direction on the flow stress. On the other hand, EBM Ti-6Al-4V demonstrates strong effect of the loading direction on the strain to failure. The fractography images of soft-recovered specimens loaded in or normal to build direction also indicate different fracture characteristics.

AM103: ACOUSTIC ANISOTROPY OF Ti6Al4V ADDITIVELY MANUFACTURED USING ELECTRON BEAM MELTING

Tomer Sol, Prof. Shmuel Hayun, Dr. Eitan Tiferet & Dr. Ofer Tevet

Powder bed additive manufacturing is a promising method for the manufacturing of metals by the selective melting of powder by a high energy beam - an electron beam in the EBM method. Ultrasonic inspection may supply a reliable, quick, non-destructive evaluation of the product made in this developing process. Non-Destructive Evaluation (NDE) based on ultrasound is a well proven and mature technique for quality control in the aerospace and nuclear power industries. In the pulse echo method, an ultrasonic wave is transmitted through a sample and the properties of the wave reflected from the back wall are examined. There are several types of ultrasonic waves, two of which are the longitudinal wave, oscillating parallel to its advancement direction, and the transverse wave, oscillating perpendicular to its advancement direction. Previous research has proven the acoustic anisotropy of selectively laser melted AlSi10Mg caused by the AM texture. In this research, the acoustic anisotropy of Ti6Al4V additively manufactured using the EBM method have been investigated by measuring the sound wave velocity of transverse waves traveling in different orientation, the acoustic results were found to be correlated with the EBSD results.

AM 104: The mechanical behavior of AM Ti6Al4V specimens containing controlled artificial voids under shear-dominant stress state

Rafi Fadida, Amnon Shirizly, Daniel Rittel**,** Technion, ISRAEL

The shear-compression response of additively manufactured Ti6Al4V specimens containing discrete artificial voids was investigated under quasi-static and dynamic loading. Specimens containing spherical voids were designed with one or three voids with variable spacing between the voids. Specimens containing spheroidal prolate void were designed with different void orientations with respect to the shear direction. The total volume fraction of all void configurations was kept equal. For the investigated voids and gauge dimensions, it was found that the very presence of the void or voids reduces the displacement to failure, compared to the dense specimens, in both quasi-static and dynamic regimes. The shape of the void and the number of voids, have a noticeable effect on results, in the quasi-static regime. However, changing the distance between the spherical voids or changing the orientation of the prolate voids did not affect significantly on the load-displacement curves, in both strain rate regimes.

AM106: Incremental solidification (toward 3D printing) of metal powders by a compact microwave applicator

Amir Shelef and Eli Jerby

Faculty of Engineering, Tel Aviv University, Ramat Aviv 6997801, Israel

Incremental solidification (IS) of small batches of metal powders is a fundamental process in various additive-manufacturing (AM) and 3-D printing (3DP) operations. Here we show the feasibility of an IS process implemented by a compact, all-solid-state microwave applicator. In this low-cost compact scheme, the localized microwave-heating (LMH) process is conducted in a nitrogen shielding environment, and hence the microwave power required is relatively small, in the order of only ~0.1 kW. This shielding prevents the plasma excitation (which may otherwise intercept most of the microwave power [1]), and hence significantly improves the efficacy of the LMH-IS process. Here we introduce the compact LMH-AM concept [2], and its novel implementation by a transistor-based microwave system. Experimental and theoretical results of the LMH-AM process applied to bronze-based and iron-based powders are presented. The powder is provided to the LMH interaction region on demand, in small batches. A contactless magnetic confinement is demonstrated for ferromagnetic powder batches. The experimental results of various basic structures obtained, and their mechanical properties are evaluated. The potential applicability of the solid-state LMH technology for AM and 3DP processes is discussed.

References:

1. E. Jerby et al., “Incremental metal-powder solidification by localized microwave-heating and its potential for additive manufacturing”, Additive Manufacturing, Vol. 6, pp. 53–66, 2015
2. E. Jerby et al., “Method and devices for solid structure formation by localized microwaves,” US Patent 9,578,695, filed Sept. 24, 2013, granted Feb. 21, 2017.

AM107: Dimension Extraction from 3D Scanned Hand Model for Prosthesis Design using Deep-Learning Methods

Tzabar dolev, Anath Fischer

Department of Mechanical Engineering, Technion Israel Institute of Technology

Over three million people worldwide are arm amputees, and often need a replacement for the missing arm, such as hand prosthesis. One of the known methods for hand prosthesis design include fitting of a generic prosthesis design to the patient. The fitting process is based on the patient's measurements that engage both him and the designer. Currently, dimension extraction and prosthesis design are processes completed manually. This is tedious, time-consuming, and inaccurate. With the development of imaging tools and advanced scanning technologies, the prosthesis design process can be automated in a more efficient way.

This research proposes a dimension extraction method from 3D hand scans that allows the creation of personalized hand-prosthesis without additional engineering design. This method facilitates the overall procedure of adapting and fitting the prosthesis to the patient. The main stages of the fitting process include: a 3D scan of the healthy hand, processing the scanned data using a deep neural network (DNN) for dimension extraction and adjusting relevant dimensions to a 3D CAD model. The final CAD model can then be 3D printed with accessible and low-cost materials.

The main contribution of this research is a new method for dimension extraction from three-dimensional scans using DNN. This method is used to improve the design process of personalized hand-prosthesis by making it cost-effective, faster, and more accessible for developing regions.

AM108: Electron Beam and Laser Beam Welding of Additive Manufactured Ti6Al4V Products

B. TAVLOVICH, A. SHIRIZLY, AND R. KATZ

Faculty of mechanical Engineering, Technion, Israel

This study investigated the weld joint properties of additive manufactured (AM) titanium parts. The welding experiments were performed using 4-kW fiber laser beam welding (LBW) and 30-kW, 80-kV electron beam welding (EBW). Wrought Ti6Al4V welded parts were compared to AM welded parts. In addition, the combination of welding AM parts to wrought (Ti6Al4V) parts was examined. The welds were analyzed and compared in terms of weld bead profile, tensile strength, microhardness, macro examination, and nondestructive testing. The results revealed certain differences between the welds of AM parts and the welds of wrought parts. Significant differences were found in the weld fusion zone (FZ) and in the material's thermal conductivity below the □ transus. The FZ boundary on the AM side of the joint was wider and had a straight shape versus the neck-shaped FZ boundary on the wrought material side. A thermal finite element model was used to simulate LBW. The simulation supported the experimental observations. The results indicate it is possible to achieve good-quality welds of AM to AM, and of AM to wrought material, for aerospace applications using both EBW and LBW.

AM109: Manufacturing of Copper with high electrical conductivity by Binder Jetting Printing and Electron Beam Melting

Aleksey Kovalevsky[1], Alex Fleisher[1], Denis Zolotarev[1], Gary Muller [1], Michael Kazakin[1].

New combined production technology for SiC components has competitive benefits in realized geometrical shapes and physical properties. It is attractive for many critical fields like high temperature applications, thermal management, and aerospace (like space telescope mirrors). This approach based on Binder Jet 3D Printing (fabrication), phenolic resin binder impregnation (additional carbonization) and capillary liquid silicon infiltration (forming of reaction bonded silicon carbides). It was shown that 50% of the required carbon content can be obtained by this carbonization method in the 3D-printed porous green body before the CLSI.

The effect of additional carbonization by impregnation of BJ 3D printed porous SiC on the residual Si content after the CLSI and on microstructure of secondary SiC has been investigated.

High efficiency of CLSI for full filling of complex geometric thin-walled shapes has been confirmed experimentally. There is a potential and high efficiency of BJ 3D-printing technology specifically for fabricating RBSC complex geometric shapes with wall thickness less than 1 mm and the residual Si less than 10–15%.

As a next step in development of RBSC production, the half of the required amount of carbon could be introduced into the initial powder by mixing before printing.

AM110: ADVANCED COMPOSITE WIRE FOR WELDING AND WIRE-FED ADDITIVE MANUFACTURING

Ganna Stovpchenko [1,2]

1 - E.O. Paton Electric Welding Institute of National Academy of Science of Ukraine, Kyiv, Ukraine

2 Engineering company "ELMET-ROLL", Kyiv, Ukraine

*Corresponding author: anna_stovpchenko@ukr.net

Keywords: composite wire, MIG/MAG welding, wire-fed additive manufacturing, deoxidation, microalloying, modifying, metallurgy of welding bath, quality.

The principles of design and developing a cost-effective, highly efficient technology for metallurgical production and processing of composite-added steel ingots or billets for making advanced welding wires are formulated.

General principles of these wires design consist of enhancing the metallurgical treatment of the liquid metal bath and stabilising the welding arc have been formulated and experimentally validated.

The uniform approach to the welding wire as the key component of the liquid metal bath formation at both wire-fed welding or Additive Manufacturing was proved that ensures the appropriate effects on the composition and properties of welds/parts, and the rational ways for various components adding into the composite wire for microalloying, deoxidizing and fluxing at melting.

Successful tests have been performed for making and processing of composite ingots/billets with central insert filled by various powders (both metallic, like ferroalloys and metals, and nonmetallic, e.g. various oxides and carbon). It was shown that both metal and nonmetal powders in the composite forming part are rolled congruently to the metal of an ingot/billet.

The great potential of the composite method for introduction of numerous additives into steel ingots is demonstrated, thus enabling development of advanced composite welding wire grades of a variety of compositions for different applications, using the same steel grade for the ingot/billet shell. Researches showing the composite wire structure and properties are also presented.

The main results affecting expediency, rational engineering and cost efficiency will be presented to show manufacturing limitations relating to composite insert geometry and filler materials.

AM111: ADDITIVE MANUFACTURING OF MASSIVE PARTS BY THE ESR AND ESR HYBRID PROCESSES

L. Medovar[1,2], G. Stovpchenko[1,2], Ganna Polishko[1], A. Sybir[3], D. Kolomiets[2]

1 - E.O. Paton Electric Welding Institute of NASU, Kyiv-150, Kazimir Malevich Str.11, 03680, Ukraine

2- Engineering company "ELMET-ROLL" Kyiv, 03150, P.o. box 259, Ukraine

3 - Ukrainian National Metallurgical Academy, Gagarin ave. 4, Dnipro, 49600, Ukraine

Keywords: Additive Manufacturing, Drop-By-Drop Formation, Electroslag Remelting, Hollow Ingots, Composite, Heavy Parts.

The most of specialists in Additive manufacturing agree that there are some technical and commercial difficulties restraining the broad industrial use of these technologies, especially for massive parts manufacturing. The most limiting is the feedstocks (powders and wires) of quite a small size and high price that makes techniques of their consolidation low productive ones, and, the final products, as results, is quite expensive. In order to make the AM techniques more suitable for heavy parts fabrication, their hybridisation with productive metallurgical technologies is prospective. The Electroslag remelting way of heavy ingot formation looks a good candidate due to the drop-by-drop filling and layer-by-layer solidification of the liquid metal pool.

The theoretical issues and practical grounds of the efficient technological solutions (both the traditional ESR and family of hybrid ESR technologies with current supplying mould and liquid metal usage) provide the favourable condition of solidification, especially at both the hollow and composite heavy ingots manufacturing.

The electroslag processes provide the favourable rate of heavy parts formation approaching to the solidification rate of a particular cross-section. The minimised volume of liquid bath and mushy zone helps to reduce segregation and suppress a shrinkage formation. At hollow ingots solidification, the conditions become even better due to heat removal increasing by using one more water-cooled mould that reduces the cross-section of solidifying volume at least twice. The same effect is also inherent for a composite multilayer ingot manufacturing with consequent formation of layers from the same or different steel/alloy grades.

The high metallurgical quality of heavy wall pipe used as-cast, as well as the big hollow ingots produced for forging, will be presented as well as the researches of metal structure and chemistry proving low segregation and high density of the metal, because of the shallow liquid metal bath at their formation at the ESR drop-by-drop formation.

The both traditional ESR and ESR hybrid technologies guarantee the much bigger yield in compare with the traditional forging root of shell manufacturing from a solid ingot at due to the high surface and inner quality of the ESR hollow ingots, as well as much smaller top, bottom and piercing discard and lesser losses on scale formation at multistage preheating.

The possibilities to control the liquid bath volume and shape and to adjust the chemical composition of steel/alloy (alloying, modifying) at traditional ESR processes with a consumable electrode and processes in current supplying mould (with solid consumable particles or liquid metal) is estimated and discussed.

The prospects and advantages of the ESR drop-by-drop and layer-by-layer technologies using for the vast assortment of sizes and shapes of hollow ingots and composites as well as other heavy parts manufacturing are clearly demonstrated.

AM112: Monte Carlo Simulations of electron beam's energy deposition during EBM AM processes

Elroei Damri[1,2], Itzhak Orion[2], Eitan Tiferet[1,3]

[1] Nuclear Research Center (NRCN), P.O. Box 9001, Beer-Sheva 84190, Israel

[2] Department of Nuclear Engineering, Ben-Gurion University of the Negev, Beer-Sheva, 84105 Israel

[3] AM R&D Center, AM Center, Rotem Ind. Mishor Yamin 86800, Israel

Abstract

Electron Beam Melting (EBM) is a metal powder bed fusion Additive Manufacturing (AM) technology that allows the fabrication of three-dimensional near-net-shaped parts by spreading successive layers of metal powder on powder bed-chamber and fusing them selectively.

Previous works have reviewed some of the physical transient effects which occur during the AM process. They have assisted to outline certain process procedures, mainly preheating the powder bed in order to reduce the "black smoke" (the effect of sudden powder spreading during beam material interaction) which is the most infamous transient effect caused by the electrostatic charge of the powder particles.

In this study, we tried to further improve the AM process. We examined the mutual influence of the different gas pressures on the energy deposition to the powder in an AM process. Experiments were conducted utilizing the Arcam Q20 machine. The process takes place in 10^{-3} mbar pressure of Helium. The use of Helium in the process improves both the electrical and thermal conductivity of the powder. Furthermore, high vapor pressure of some elements in the printed alloy evolved during the high temperature built processes. Increasing the pressure to the low vacuum regime could reduce these effect. An optimum pressure regime ensures that electrons will not be attenuated significantly along their path to the powder.

This study aims to calculate the electrons' energy deposition to the powder using the EGS5 (Electron-Gamma Shower) Monte Carlo code. The simulations results led to obtain the optimal gas pressure and were supported by an experimental study in which optimization was elucidated.

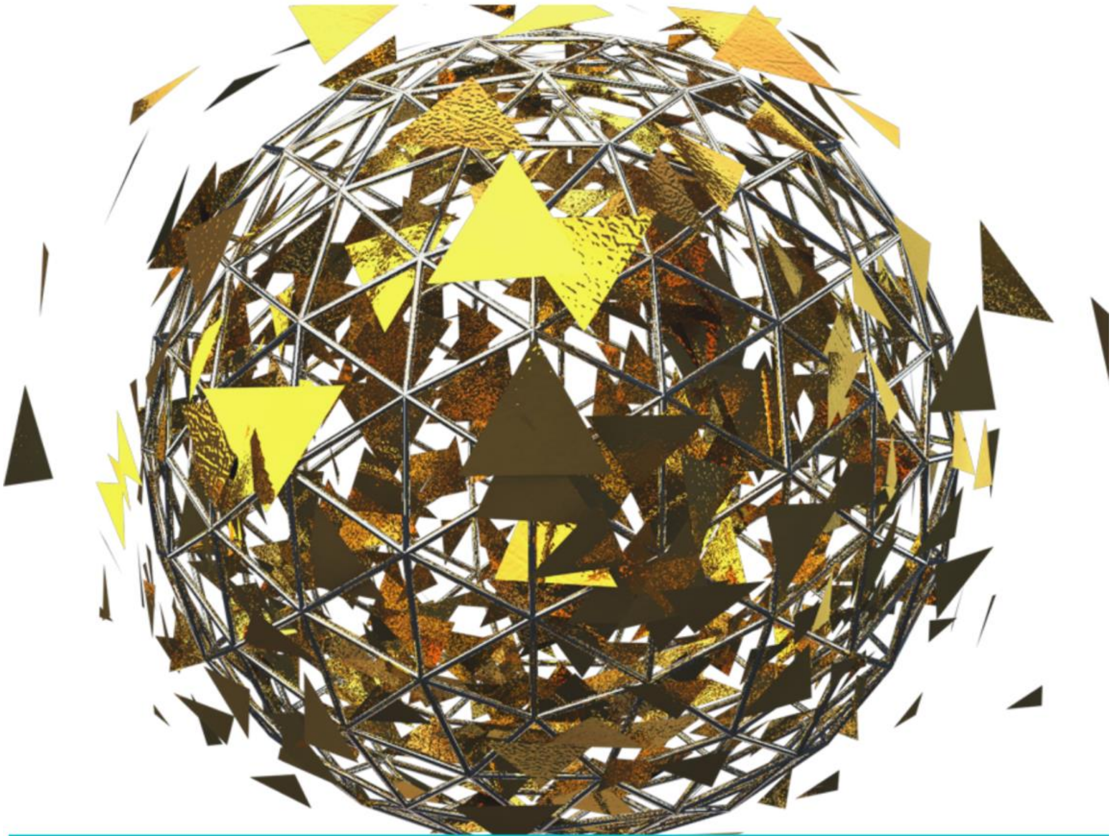
AM35: "Investigation of the Structure and Properties of Products Obtained at Electron xBeam 3D Metal Printer Using Titanium Alloy Wire"

A. Tunik, D. Kovalchuk, L.Adeeva, S.Stepanyuk, S. Grigorenko

The results of investigations of metal structure formation at additive technology method in the electron beam 3D printer with applying the titanium wire are presented. As an initial material for surfacing, the titanium wire of 3 mm diameter of alloy Grade5 was used. The substrate was a plate of 15 mm thickness of the same alloy. The structure formation of the specimens, produced by one, two and three parallel passes were considered. It is shown that in the primary structure of product of a cast type the equiaxial grains are dominated. The secondary structure of grains of an acicular type is presented by two phases: α/ - low-temperature martensitic (FCC is approximately 99.0 wt.%) and β - high-temperature (BCC is 1.0 wt.%). It was found that during the process of wire deposition the aluminium losses are minimum. The heat treatment of products leads to more equilibrium state of the structure. The mechanical tests of specimens showed a good level of main mechanical properties both along and also across the deposited layers

Key words: 3D metal printing; additive technologies; electron beam; titanium alloys; deposited layers; structure; mechanical properties.

לשכת המהנדסים
האדריכלים והאקדמאים
במקצועות הטכנולוגיים
בישראל



לשכת המהנדסים וחברת GE Additive מזמינות אתכם ל -

סדנה בנושא תכן ל- Additive Manufacturing
אבטחת איכות ושילוב בקווי ייצור.

יום רביעי 29.1.2020, בית המהנדס, דיזינגוף 200 ת"א.

הסדנה מיועדת למהנדסי מכונות וחומרים המבקשים להטמיע הדפסת תלת מימד של מתכות במקום עבודתם. נדרשת היכרות בסיסית עם טכנולוגית מצע אבקה (לייזר אן קרן אלקטרונים).
**** הסדנה תועבר בשפה האנגלית**

לפרטים והרשמה

קורסים, סדנאות והסמכות

קורס ציפויי הגנה למניעת קורוזיה ובקרת איכות (52 שעות, 13 מפגשים, תל אביב)
12.02.2020 - 03.06.2020

הקורס מתאים למהנדסים, הנדסאים וטכנאים העוסקים בתחומים הקשורים ל"צביעה תעשייתית", וכן, אנשי טכנולוגיה בתעשיית הצבע, בתחומי האיכות. צביעה איכותית למניעת קורוזיה, מאריכה את חיי הצבע ומונעת הוצאת אחזקה מוקדם מהצפוי. הכשרה מקצועית מוכרת לגמול השתלמות*

https://www.aeai.org.il/activity/corrosion-course/

סדנת טכנולוגיות ייצור מבנים מרוכבים (15 שעות, 3 מפגשים, תל אביב)
12.02.2020 - 26.02.2020

ליאור זילברמן מנהל המו"פ באלביט מערכות – סאיקלון מעביר קורס בנושא טכנולוגיות ייצור של חומרים מרוכבים.

https://www.aeai.org.il/activity/comoposite-materials-workshop/

מסלול להכשרת מנתחי סיכונים בתעשייה התהליכית (40 שעות כל קורס, 5 מפגשים, תל אביב)
החל מ-26.02.2020

כיום אין במדינת ישראל אף גוף המסמיך מנתחי סיכונים תהליכיים. לאור כך, החליטה לשכת המהנדסים להקים מסלול הכשרה שיאפשר למנוע מצב בו מבוצעים ניתוחי סיכונים תהליכיים על ידי אנשים שאין להם את ההכשרה והידע הנדרשים. בוגרי מסלול ההכשרה יירשמו בפנקס מנתחי סיכונים תהליכיים של לשכת המהנדסים. הקורס הראשון במסלול הינו קורס הכשרת משתתפים בישיבות ניתוחי סיכונים במתודולוגיית HAZOP.

https://www.aeai.org.il/activity/risk-analysis-course/

קורס ריענון לקראת מבחני הסמכה למפקחי ריתוך (144 שעות, 18 מפגשים, תל אביב)
25.03.2020 – 12.08.2020

הקורס מאפשר לעוסקים בפיקוח על הריתוך להשלים את ידיעותיהם בנושאי פיקוח האיכות ופיקוח עבודות ריתוך, להתעדכן בדרישות ובתקנים המחייבים, ולהתכונן למבחן ההסמכה בנושא.

https://www.aeai.org.il/activity/welding-course/

סדנת תהליכי NPI - מעבר מפיתוח לייצור (16 שעות, 2 מפגשים, תל אביב)
26.03.2020 - 30.04.2020

סדנת תהליכי NPI נשענת על נסיון רב שנים בתכנון וניהול פרויקטים מורכבים, נותנת כלים מעשיים לתכנון פרויקט יעיל, מצומצם משאבים ובתקציב נתון. במהלך הסדנה יידונו סוגיות שונות וכן, כיצד לגשת לתכנון פרויקט פיתוח ובאילו שיטות פיתוח לבחור, כיצד לבנות ממשק בר-קיימא ליחידות ארגוניות שונות ועוד.

https://www.aeai.org.il/activity/npi-process-workshop/

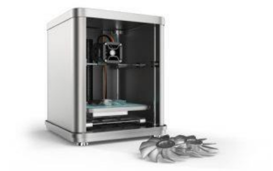
קורס ניהול מו"פ (28 שעות, 7 מפגשים, תל אביב)
04.05.2020-29.06.2020

קורס ייחודי המעניק לבוגריו כלים מעשיים ומתודולוגיות להתמודדות עם אתגרי ניהול המו"פ ושיפור תוצאותיו במישורים שונים בתעשיית הטכנולוגיה. מרצה הקורס, חיים רוסו, כיהן בעבר כמנכ"ל חברת אל-אופ ומשמש כיום כחבר במועצת רשות החדשנות.

https://www.aeai.org.il/activity/r-d-management-course/

סדנת הדפסה תלת ממדית של מתכות (15 שעות, 3 מפגשים, תל אביב)

06.05.2020 – 20.05.2020



ליאור זילברמן מנהל המו"פ באלביט מערכות (סאיקלון) מעביר סדנה מרתקת העוסקת בחידושים ויישומים בהדפסה תלת ממדית של מתכות כולל מפגש מעשי באימפקט-לאבס.
https://www.aeai.org.il/activity/3dprint-workshop/

לפרטים והרשמה: רחלי פפיסמדוב | 03-5205811 | education@aeai.org.il

לשכת המהנדסים
האדריכלים והאקדמאים
במקצועות הטכנולוגיים
בישראל

איגוד מהנדסי תעשייה וניהול
משיק ליין לניהול קריירה

24.02.2020

טיפים מנצחים בתהליך חיפוש העבודה

מרצה מורית דייסי
Talent Acquisition Partner
בחברת EBAY.

21.05.2020

שיפור עמדות בעולם הקריירה: ניוד וקידום בארגון

מרצה דינה בר-אושר
הבעלים והמייסדת של חברת
"קונקט" השמה.

04.06.2020

הצלחה בראיונות, איך עושים את זה?

מרצה סופי שומר
מדריכת קבוצות, בעלת ניסיון
במאות ראיונות עבודה.

עידית שפר I 03-5205818 I Idit@aeai.org.il
בית המהנדס, דיזנגוף 200 תל - אביב.

לשכת המהנדסים האדריכלים והאקדמאים במקצועות הטכנולוגיים בישראל AEAI

יום עיון בנושא מילוי נוזלים דליקים למכלים ניידים

5 במרץ 2020 | 09:00 - 15:00

מנהלי תפעול, מעבדות, אחזקה ובטיחות במפעלי תעשייה ואקדמיה

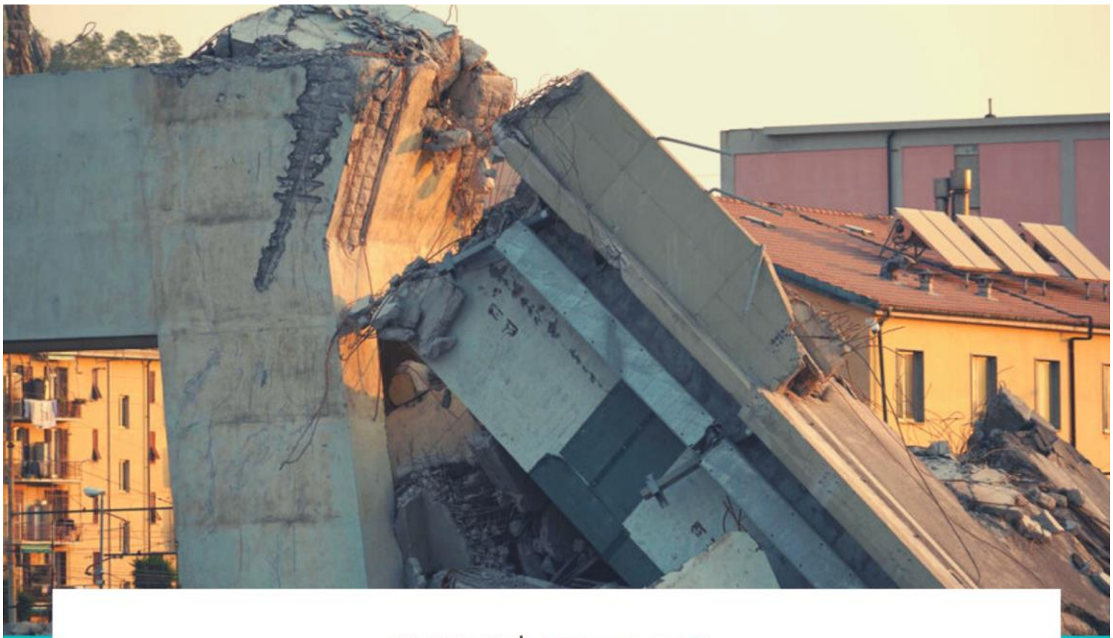
כך תמנעו את התאונה הבאה!

היום יעסוק בהתפתחות מצבי סיכון שעלולים להוביל להתלקחות ופיצוץ בעת מילוי מכלים ניידים בנוזל דליק (עד 1000 ליטר). כמו כן, יוצגו אמצעי הגנה למניעת התלקחות מחשמל סטטי וההנחיות הקיימות בתקנים הישראלים, המיועדות למנוע מראש את מצבי הסיכון.

בית המהנדס, דיזינגוף 200 תל - אביב.

עידית שפר | 03-5205818 | Idit@aeai.org.il

לפרטים והרשמה



לשכת המהנדסים
האדריכלים והאקדמאים
במקצועות הטכנולוגיים
בישראל

יום עיון בנושא
קורוזיה מזרמים תועים והשפעות הדדיות
19.2.2020

באירוע חד פעמי עם מרצים מובילים בתחום נדבר על בעיית הקורוזיה כתוצאה מזרמים תועים Stray Currents והשפעות הדדיות, הניטור שלה, דרכי התמודדות ומניעה.
על הפרק נושאים של קורוזיה במתקני התפלה, קורוזיה של גשרים ורכבות, ניטור צנרת גז ונפט, קורוזיה בגופי תשתית לשדות סולארים ועוד.

בית המהנדס, דיזינגוף 200 תל - אביב.
עידית שפר I 03-5205818 I Idit@aeai.org.il

לפרטים והרשמה

לשכת המהנדסים
האדריכלים והאקדמאים
במקצועות הטכנולוגיים
בישראל

AEAi

WJAM 2020

International Conference of Welding, Joining and Additive Manufacturing

28 JAN 2020