出國報告（出國類別：研討會）

ICACME Notification of Acceptance 研討會

服務機關：高雄應用科技大學

姓名職稱： 王嘉男 副教授

派赴國家：泰國

出國期間：102 年 6 月 20~102 年 6 月 24

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摘　要

自動控制和機電工程國際會議是國際機電學門的重要會議，是國際相關領域學者交流學問的好機會，本人投稿一文「The Experiment Improvement of Alloy Power Spraying for Steeling Manufacturing」，及錄取在由自動控制和機電工程國際學議所主辦的International Conference on Automatic Control and Mechatronic Engineering (ICACME)中！此次研討會約收錄 140 篇文章，約有 200 多位學者參與，在參與會議中與多國同領域、同研究的學者交流，對學術研究上，有很大的幫助！此外，本人的文章在大會中因內容和品質都達到適當的水平，因而被選錄到可刊登到 Journal of Applied Mechanics and Materials 之中，此為 EI 等級的期刊，除了學術中同業的交流之外，對研究成果受到肯定，亦是值得可喜之事！

目　的

一、會議簡介

2012 年自動控制和機電工程國際會議(ICACME2012)已於 2012 年 12 月 20 日-21 日在杜拜成功召開，有来自阿拉伯聯合大公國，中國，日本，韓國，馬來西亞，英國，加拿大等十多個國家和地區的學者參加會議流。ICACME 组委會感謝各位專家、學者和專業技術人員對 2012 年自動控制和機電工程國際會議的關注與支持。

2013 年第二屆自動控制和機電工程國際會議(ICACME2013)於 2013 年 6 月 21 日—22 日在泰國首都曼谷召開。會議主題包括自動控制技術、自動控制理論及應用、机械設計、機電工程、机械制造技術、電子學学和自動化等。

作為 TTP 官方列表的正式會議，ICACME 經同行專家評審錄用的論文將全部出版在《Applied Mechanics and Materials》[ISSN:1660-9336, Trans Tech Publications]上，目前，該刊物上發表的論文全部被 EI Compendex 和 ISTP 收錄。該刊物檢索情况請參閱該刊物官方網站：http://www.ttp.net/1660-9336.html 。

二、會議內容

會議內容涵蓋了自動控制與機電工程領域的主要研究方向，旨在為全世界自動控制与機電工程領域的專家、學者和專業技術人員提供一個交流最新研究成果的機會。熱忱歡迎從事相關技術研究的專家、學者和專業技術人員踴躍投稿並參加大會。

主要研討領域如下：

T1 Automatic Control and Technology

Linear, Nonlinear and Fuzzy Systems and Control

Predictive Control, Intelligent Control and Servo Control

Electronics Automation and Electrical Engineering

Networked Control Systems

Hybrid Systems and Control

Stochastic Systems Control and Remote Supervisory Control

Automation instrument and device

Guidance, Navigation and Control

Simulation technology of control system

Electronic, communication and automatic control technology

Signal Processing Systems for Control

Power machinery engineering

PLC and Micro-controllers

T2 Control Theory and Application

Cybernetics

Control System Modeling

Control Theory and Methodologies

Process Control and automatic control theory

Simulation Techniques and Methodologies

System Engineering Theory and Practice

Intelligent Optimization Algorithm and Application

Circuits and Electronics for Control

Automotive Control Systems and Autonomous Vehicles

Automation technology application

Signal Processing Systems for Control

Automation in Chemical Engineering

Machines and Mechanical Engineering

Optimization Problems in Control Engineering

Manufacturing Systems Control

Man-Machine Interaction

T3 Mechatronic Engineering

Theory and technology of optical-mechanical-electrical integration

Theory, technology and equipment of precision forming and special machining

Advanced manufacturing technology

Manufacturing Process Simulation

CIMS and Manufacturing System

Mechanical and Liquid Flow Dynamic

Applications of Micro and Nano Systems

Image recognition and intelligent control

Development and Applications of Micro Manufacturing Equipment

Miniaturization of Molding and Casting Processes

Hybrid Macro/Meso/Micro Manufacturing Processes

CAD, CAM & CAE

Hydraulic servo system

Laser processing technology and system

Complex mechanical-electro-liquid System

Design and Operations of Manufacturing Systems for Responsiveness

Collaborative and Digital Manufacturing for Advancing Product Quality

Diagnostics, Performance Prediction and Decision Making for Intelligent Maintenance of Manufacturing Systems

三、會議議程如下：

Conference Schedule June 21, 2013(Friday)

13:00-17:00	Registration at the Hotel

June 22, 2013(Saturday) in the meeting room Gamma on the 2nd Floor

08:00—08:30	Keynote Speech
08:30—09:00	Keynote Speech
09:00—10:00	Session 1
10:00—10:15	Coffee Break
10:15—12:00	Session 2
12:00—13:00	Lunch at Cuisine Unplugged Restaurant on the Ground Floor
13:00—15:00	Session 3
15:00—15:15	Coffee Break

心得及建議

自動控制和機電工程國際會議是國際機電學門的重要會議，是國際相關領域學者交流學問的好機會，錄取的文章會刊登在 EI 中，本人投稿一文「The Experiment Improvement of Alloy Power Spraying for Steeling Manufacturing」，有機會與國際相關領域學者共襄盛舉並互相切磋，在學術的交流和研究的精進上，有者莫大的幫助！

本人

附件一　接受發表內容

The Experiment Improvement of Alloy Power Spraying for Steeling Manufacturing

Chia-Nan Wang[1, a], Wen-Chang Lin[1,b] and Phung Duc Tung[1]

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Keywords: molten steel corrosion test, abrasion test, adhesive test, HVOF, TRIZ

Abstract. Copper tundish is used widely in continuous casting in steel production line. Tundish is coated by a special coating in the steel manufacturing. A coating experiment was developed to study the resistant of the copper material against the molten steel corrosion. High velocity oxygen fuel (HVOF) method was used to spray the alloy powder on the copper surface to form an alloy coating. However, the experiments are unreliability, waste of material and low efficiency. These would affect to the quality of the samples and spend more time and money to perform the experiment. Base on Teoriya Resheniya Izobretatelskikh Zadatch (TRIZ), this study improved the design of the experiment. After improvment, the average of alloy powder consumed per sample reduces 23.8%, and samples produced in this experiment are twice more than before. This improving will also be applied in other spraying processes.

1. Introduction

Nowadays, continuous casting is used commonly in the steel industry. Continuous casting is a process which turns liquid steel into slab or bloom. Liquid steel is filled in ladle and transferred to turret from upstream plant by crane, charged to a tundish, then distributed and flew into several molds which circulated by cooling water. Liquid steel starts cooling down, solidifying and forming a shell outside in, pulled into arc-shape strands, through secondary cooling sprays to a complete solidification, then straightened, and cut into pieces according to each order. This semi product called slab (rectangular type) or bloom (square type) is conditioned if necessary then shipped to downstream for further treatment.

The tundish in this production line is made from copper material. The tundish operates in a severe condition because it touches the liquid steel at very high temperature (1450-1500^{o}C) for a long time during the production process. The molten steel corrosion may occur on the tundish surface and affect to the quality of the tundish surface and therefore impact on the

steel product. In order to increase the higher resistant of the tundish against molten steel corrosion so as to extend the service life of the tundish and to guarantee the quality of the product, an experiment was set up to study the resistant of the copper material against the molten steel corrosion. By spraying an alloy powder to create a thin alloy layer on the copper surface, the resistant of the copper against molten steel corrosion was improved.

In order to improve the resistant of the copper material against the molten steel corrosion, the coating experiment was set up to create an alloy coating onto the copper samples. These samples, then supply to the abrasion test and adhesive test. In coating experiment, 16 pieces of copper sample were fixed on the steel board. The dimension of the sample is 2.5x5x0.5cm. The composition of these samples are whether identical or not, it depends on each order. These samples were separated into two rows, each row includes eight samples. Each row of samples was fixed by two steel bars with four bolts. High velocity oxygen fuel (HVOF) coating was used to spray alloy powder on the samples surface. The composition of the alloy powder is WC CrC Ni 73-20-7 Aggl. Sint. (Tungsten Carbide (12070-12-1); Chromium Carbide (12012-35-0); Nikel (Ni) (7440-02-0)). The HVOF gun is hung on an automatic robot arm. The HVOF gun sprayed the alloy powder on to the samples surface to create a thin alloy coating. The thickness of the alloy coating for each spraying is about 25~33.25um. therefore as an example, if the thickness of the alloy coating required is 130um, then the coating experiment needs to spray for 4 or 5 times. Each spraying will take 42 seconds and the temperature of samples after spraying is 140^{o}C. One compressed air pipe is hung on the HVOF gun to blow compressed air to cool these samples. The cooling process will take 5 minutes to wait for the temperature of sample reduce to 70^{o}C, then the next spraying process will start.

However, some problems occurred during the coating experiment. First, sample fixed on the steel board was not stable. Because the dimension of these samples is not exactly the same, therefore some samples are clamped tightly while some samples are not clamped tightly. Besides, the velocity of the flame sprays out from the HVOF gun is 1350 m/s, it is strong enough to make samples which are not tightened firmly to fall down easily. This problem affects the quality and the continuity of the experiment. Second, the alloy powder waste in this experiment is too much. The alloy powder coated on the sample surface is covered all the samples' area and extend 2.5 cm around the samples. The extended area is necessary to guarantee the quality of the alloy coating on the samples surface. Third, the number of the sample produced in the coating experiment is so small, 16 pieces. These samples are not enough to serve for the abrasion test and the adhesive test. In other word, the experiment efficiency is low. These problems are shown in Fig. 3.

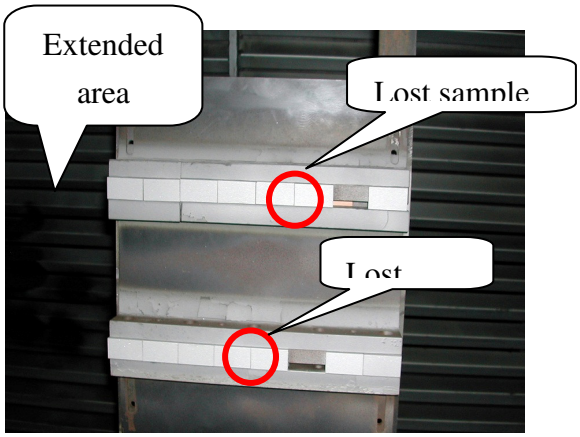

Fig. 1 Samples fixed on the steel board

The goals of this study are to prevent the interruption occur during performing the coating experiment, to reduce the waste material and to improve the efficiency of coating experiment. In this study, TRIZ was used to look at the problems of the coating experiment. TRIZ is a widely used problem solving method. TRIZ provides a unique approach for structuring the development of innovative solutions for technical and nontechnical problems and has the potential for substantial results in construction innovation if used properly [2]. TRIZ includes different problem solving tools, such as Contradiction Matrix, Inventive Principles, Trends of Technology Evolution, IFR (Ideal Final Result), S-Field (Substance-Field) analysis, ARIZ (Algorithm for Inventive Problem Solving), Trimming Rules, Psychological Inertia Tools and Subversion Analysis [3]. These tools can be used to generate conceptual solution to the problem.

The structure of this paper is divided into 3 sections. The rest of sections are listed as follows. Session II describes how to use TRIZ method to deal with the coating experiment problems. Session III is conclusion including results of this study, contributions and future work.

2. Case Study

In this study, S-Field analysis was used to generate the solution to solve the problems of the coating experiment. The S-Field Model was applied to analyze the system, as show in Fig. 13 and Fig. 14. In the S-Field model, continued line denotes “useful”, waved line denotes “harmful”, dashed line denotes “insufficient”.

In Fig. 6, samples S1 are fixed by using bolts F1 to tighten the steel bars S2. Sample falling down during performing experiment will cause a harmful reaction exists between samples S1 and steel bars S2. The coating samples S1 are not enough to supply to the Abrasion test and Adhesive test F2, therefore an insufficient reaction exists between sample S1 and Abrasion and adhesive test F2.

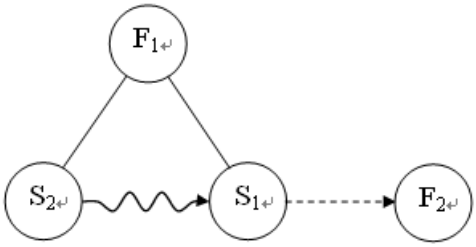

Fig. 2 S-Field Model 1

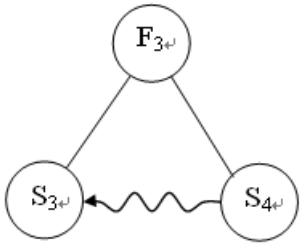

Fig. 3 S-Field Model 2

In Fig. 7, HVOF gun F3 sprays alloy powder S3 on to the sample surface and the expanded area S4. The alloy powder coated on the expanded area means alloy powder waste in this experiment. Therefore, there is a harmful reaction exists between S3 and S4.

According to TRIZ, when a system appears harmful effect, there are seven directions to solve the problem. They are (a) modify exist substance, (b) modify the Field, (c) add a new substance (d) add a new field, (e) add a new substance and field, (f) transition to the super-system, and (g) transition to the sub-system [3]. “Modify exist substance” was used in this study.

As similarity, when a system appears insufficient/excessive relationship, there are nine directions to solve the problem. They are (a) modify an existing substance, (b) phase transitions, (c) modify the field, (d) add a new substance, (e) add a new field, (f) add a new substance and field, (g) ferro-magnetics, (h) transition to sub-system, (i) transition to the super-system [3]. “Modify exist substance” was used in this study. For these problems in the coating experiment, S-Fields also suggests “Modify exist substance”. By using this direction these problems may be removed from the experiment.

It was found that #1 Segmentation, #5 Merging and #26 Copying in the 40 Inventive Principles are possible solutions to these problems.

In the first problem we need to answer the question “How can we fix samples stable during the coating experiment?”.

The #1 Segmentation principle in the 40 Inventive Principles gives us a suggestion that we can use short pair of steel bar to fix copper sample. According this way, two steel bars are separated into eight pairs of short bar as shows in Fig. 8.

By using this way, each sample is fixed by one pair of steel bar as show in Fig. 9. Each sample is fixed independently and clamped tightly, therefore the unstable problem of fixing sample will not affect to the experiment. The unstable problem is avoidable, the first problem is solved.

The second problem occurred during the coating experiment is the waste of alloy powder. We need to answer the question “How can we maintain the quality of the alloy coating on the sample surface while we can reduce the waste of alloy powder in the coating experiment?”. The #5 Merging principle gives us a suggestion that we can merge two rows of samples into one row.

By using this way we can decrease the expanded area around the samples, thus we can reduce the alloy powder waste in this coating experiment. Two pieces of copper sample are fixed by one pair of short steel bars, as show in Fig. 11.

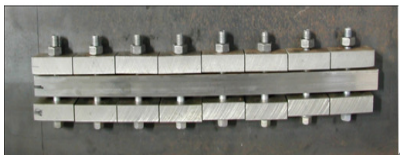

Fig. 4 Applying # 1 principle

Fig. 5 Applying # 5 principle

Fig. 6 Applying # 26 principle

In the third problem occurred in coating experiment, we need to answer the question "How can we increase the number of copper sample in the coating experiment while we do not need to repeat the coating experiment?". The #26 Copying principle suggests that we can increase the amount of the samples in this experiment by copying another row of samples, as shows in Fig. 12. By using this way, we can increase the amount of the copper samples producing in the coating experiment to thirty two pieces. In other words we increase the efficiency of the experiment. The third problem is solved.

Fig. 13 shows the complete coating experiment after applying TRIZ to solve the problems.

Fig. 7 Final coating experiment

After these Inventive principles were applied, the problems of the coating experiment are solved. Table 1 shows the parameters of coating experiment before and after improving by TRIZ.

Table 1. Parameters of coating experiment before and after improving by TRIZ

Item	**Before improving by TRIZ**	**After improving by TRIZ**
Time for each spraying	42 (s)	64 (s)
The number of spraying to complete the coating experiment	4 (times)	4 (times)
Alloy powder rate	(90 g/min)	90 (g/min)
The total alloy powder consumed	252 (g)	384 (g)

In Table 1, the total alloy powder consumed in the coating experiment is calculated by multiply the number of spraying to complete the coating experiment and the time for each spraying and the alloy powder rate. From Table 5 we can calculate the average of alloy powder consumed per sample by the total alloy powder consumed divides by the quantity of sample producing in the coating experiment. Table 2 shows the comparison between the coating experiment before and after improving by TRIZ. The average of alloy powder consumed per sample before applying TRIZ is 15.75 g/piece and after applying TRIZ is 12 g/piece. The average of alloy powder consumed per sample after improving by TRIZ reduces

23.8% than before.

Table 2. Comparison between the coating experiment before and after improving by TRIZ

Item	Before improving by TRIZ	After improving by TRIZ
Quantity of sample	16 (pieces)	32 (pieces)
The average of alloy powder consumed per sample	15.75 (g/piece)	12 (g/piece)

3. Conclusion

By applying TRIZ methodology, the coating experiment is a lot of improved. Experiment is performed reliably without interruption, as a result, the quality of sample is guaranteed. This study can save the alloy powder used in the coating experiment. The average of alloy powder consumed per sample after improving by TRIZ reduces 23.8% than before. Besides, the amount of sample produced in this experiment after improving is thirty two pieces, more than two times than before. The objective of this study is achieved and the coating experiment is running more efficiently. In the coating experiment, an alloy coating is coated on the copper surface. The resistant of the copper against the molten steel corrosion is improved more significantly.

Future research is required in solving the waste of alloy powder in the coating experiment. It will also possible to look at the problems of the coating experiment from different angle, such as using technical contradiction for the significant improvement and stainable development.

References

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[4] D. Mann, *Hands-On Systematic Innovation*, ifr Press, England, (2007).

附件二　大會接受函

ICACME2013 Notification of Acceptance

http://www.icacme.org/

Dear Chia-Nan Wang,Wen-Chang Lin,Phung Duc Tung

Paper ID: K040

Paper Title:The Experiment Improvement of Alloy Power Spraying for Steeling Manufacturing

The review processes of your paper for 2013 the 2nd International Conference on Automatic Control and Mechatronic Engineering (ICACME 2013) has been completed. We are pleased to inform you that your paper has been accepted for presentation. You are cordially invited to present the paper at ICACME 2013 held on 21 - 22 June 2013, in Bangkok, Thailand.

This notification serves as our formal acceptance of your paper as well as an invitation to present your work at ICACME 2013. Please note that this NOTIFICATION will be sent to your co-author(s) (if any), as well.

Important Note:

Please kindly notice that the paper will not be published in the proceedings unless the author pays the registration fee. In order to register the conference successfully, you must finish the following FOUR processes and register by Email. (Before April 3, 2013).

1. Finish the payment of Registration fee according to the Registration Form)
2. Format your paper according to the Template http://www.icacme.org/downloads/AuthorInstructions.rtf
3. Send your (1) filled Registration Form (You can download Registration Form from the website http://www.icacme.org/registration.html), (2) Final Paper (BOTH MS Word file and PDF), (3) the Scanned Payment Proof (in jpg format), (4) Scanned Student Card (in jpg format if any) and (5) COPYRIGHT Agreement FORM (.pdf) to us by email cfp@icacme.org.
4. Submit Final Paper (BOTH MS Word file and PDF) and Copyright Form via TTP online submission and editing tool in late June 2013. Note that we will send your personal login and password information via TTP new online tool in late June.

Please strictly adhere to the format specified in the conference template while preparing your final paper. If you have any problem when preparing the final paper, please feel free to contact us via cfp@icacme.org.

If the above requirements are met by the set deadlines, the paper will be published in Applied Mechanics and Materials [ISSN:1660-9336, Trans Tech Publications].Applied Mechanics and Materials is indexed by Elsevier: SCOPUS www.scopus.com and Ei Compendex (CPX) www.ei.org/. Cambridge Scientific Abstracts (CSA) www.csa.com,Chemical Abstracts (CA) www.cas.org, Google and Google Scholar google.com, ISI (ISTP, CPCI, Web of Science)www.isinet.com, Institution of Electrical Engineers (IEE) www.iee.org, etc. http://www.ttp.net/1660-9336.html

Please kindly notice that the Conference Program will be available at the website in June, 2013. The CD-ROM Proceedings will be available at the conference and online version should be available within 8-10 weeks after receiving the manuscript in full text via TTP platform. Authors will receive free online "author access" via your email address (as it appears in the paper) and from us supplied password. Via this access you will be able to download your papers as PDF and order reprints online. In addition participants will receive full online access to the entire proceedings via TTP platform http://www.scientific.net.

Maybe some unforeseeable events could prevent a few authors attending the conference to present their papers, if so, please inform us. And we will send you the official receipt and proceeding after ICACME2013.

Finally, we would like to further extend our congratulations to you and we are looking forward to meeting you in Bangkok, Thailand.

Yours sincerely,

ICACME2013