metals industry
TRENDS & EVENTS
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TÜV Reaffirms MIRDC's Certification to ISO 9001:2000

In a surveillance audit conducted on 04 February 2008 by TÜV SÜD Management Service GmbH auditors—Mr. Cloyd Jones Unson, lead auditor and auditors Mr. Elmer Cruz and Ms. Eunice Diamante—the Center's quality management system (QMS) was assessed, evaluated, and still found to be in compliance with ISO 9001:2000.

The process owners of the organization were audited and asked to show documents and records as objective evidences that all the activities done by them follow the established Procedures Manuals (PMs) and Work Instructions (WIs).

The top management was also interviewed and asked to provide records on their conformity and commitment to clause 5, Management Responsibility, of ISO 9001:2000.

After the gruelling 10-hour interview and leafing through of the auditors on the Center's various papers, the TÜV auditors unanimously recommend the MIRDC to another year of certification. The Center is certified in the following areas: Industrial Training and Staff Development; Promotions, Consultancy and Technical Assistance for Metallurgical Technologies; Design and manufacture of moulds for plastic and metal casting; Design and manufacture of fabricated and machined metal products.

With this, the Center's customers will continuously enjoy the benefits of availing consistent quality products and services at MIRDC.

The MIRDC is one of the first government agency to have been certified to ISO. The Center first had its analysis and testing Laboratories accredited to ISO/IEC Guide 25 in 1996, the Metalcasting Technology Division certified to ISO 9002:1994 (1998), the Industrial Training and Staff Development Section to ISO 9001:1994 (2000), and centerwide certification on ISO 14001-Environmental Management System (EMS) and ISO 9001:2000 in the succeeding years. Since then, the Center consistently maintains its certification and accreditation. The ISO certification initiative of the Center also dovetails with EO 605—mandating all departments and government agencies including GOCCs and government financial institutions (GFIs) to be certified to ISO 9001:2000.


ZERTIFIKAT ◆ CERTIFICATE ◆ 認証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

TÜV SÜD Management Service

CERTIFICATE

The Certification Body
of TÜV SÜD Management Service GmbH
certifies that

METAL INDUSTRY RESARCH AND DEVELOPMENT CENTER
General Santos Avenue, Bicutan
1631 Taguig

has established and applies
a Quality Management System for

Provision of Industrial Training and Staff Development ; Promotions, Consultancy and Technical Assistance for Metallurgical Technologies; Design and manufacture of moulds for plastic and metal casting; Design and manufacture of fabricated and machined metal products

An audit was performed, Report No. 70014292
Proof has been furnished that the requirements
according to

ISO 9001: 2000

are fulfilled. The certificate is valid until 2009-07-17
Certificate Registration No. 12 100 14621 TMS

Munich, 2006-08-16

QMS-TGA-ZM-07-02

TÜV SÜD Management Service GmbH • Zertifizierstelle • Ridlerstraße 65 • 80339 München • Germany

From the Executive Director.....

"Very warm greetings to our readers!"

Starting this year, our Metals Industry Trends and Events will take on some notable changes. Firstly, this section will be a regular portion starting this 2008 issue. As much as possible, we will try to provide insightful commentaries or statements on general and technical issues and concerns that influence our players in the metals and engineering industries. Secondly, we have made drastic makeover on the design of the Trends and Events to make it enjoyable to read. The said change would not have been made possible without the acquisition of our new duplicating machine funded by one of the projects of the DOST. And lastly, we hope to provide and attract more technical article contributions not only from the MIRDC personnel but also from our partners in the industry.

In the process of doing so, we re-affirm our commitment in providing our stakeholders with a quarterly newsletter publication that has more substance, timely, newsworthy, and most importantly, a paper that provide information that is useful to all.

Likewise, we are happy to report to you that last year, we conducted our strategic planning and reviewed our performances against the emerging requirements of the domestic metals and engineering sector. In the succeeding months, we hope to finalize these plans and implement them despite our challenging timetable.

Rolando T. Viloria, CEO III
Executive Director

Metals Industry Trends and Events is a quarterly newsletter of the Metals Industry Research and Development Center (MIRDC), an agency of the Department of Science and Technology (DOST).

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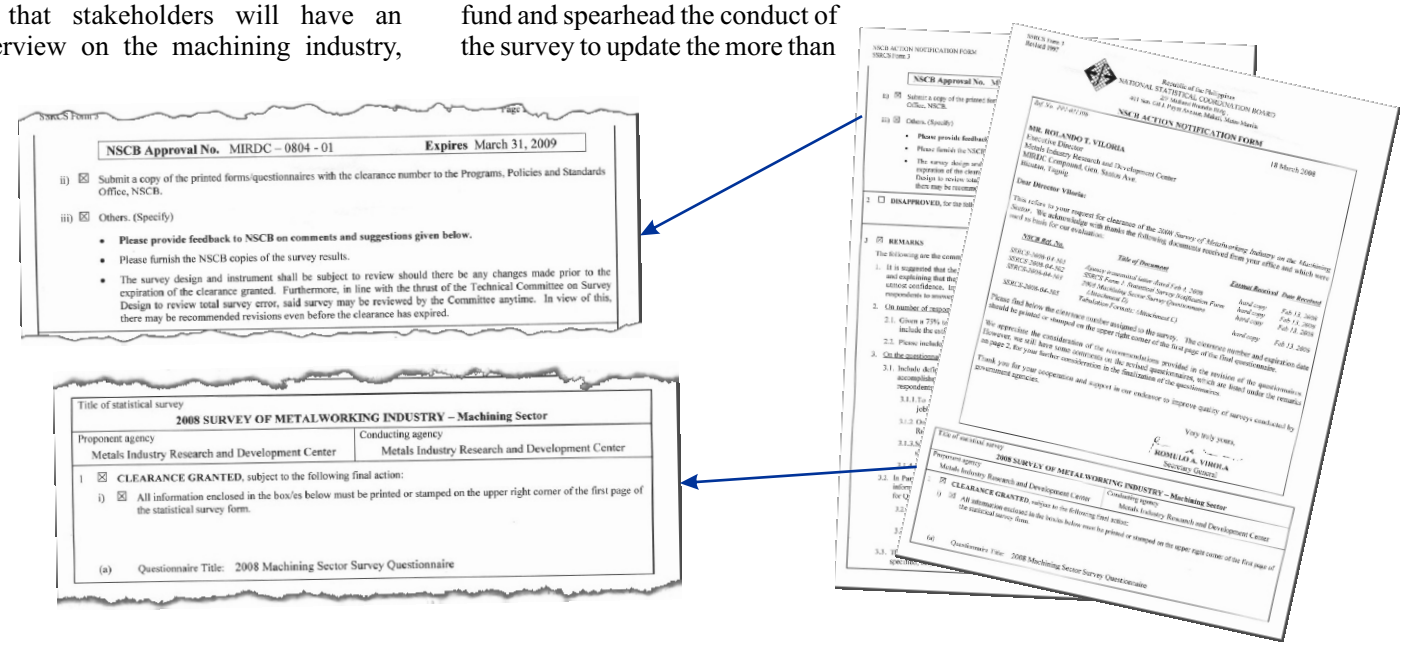
NSCB approves survey on machining

The National Statistical Coordination Board (NSCB) recently approved the conduct of survey on machining industry nationwide per NSCB Approval No.: MIRDC-0804-01. The MIRDC hopes to achieve keen participation of the industry players considering that the survey is endorsed by no less than the national president of the Metalworking Industries Association of the Philippines (MIAP), Mr. Almarco C. Brito. Mr. Brito stressed that vital information about the industry is necessary to be disseminated so that stakeholders will have an overview on the machining industry, their production and technical capabilities, and have a better understanding about the recent growth trends which may serve as a guide for policy reforms and even to attract more local and foreign investors.

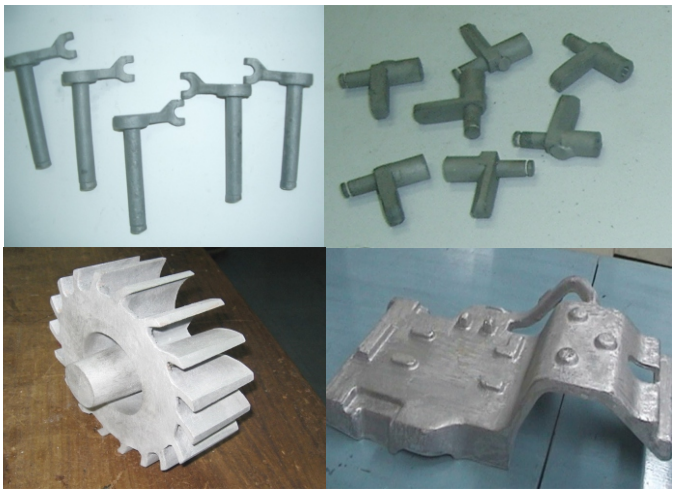
The conduct of the survey is aligned to the mandate of the Center to provide/release vital information necessary in promoting investment opportunities and bring to light the issues and concerns that, if properly addressed, will help boost the Philippine economy. The MIRDC will fund and spearhead the conduct of the survey to update the more than a decade data collected in 1993. Gathering of data starts from April to November 2008 and is expected to be completed by the end of the last quarter of 2008. The survey will cover the majority of the MIAP members throughout its 16 chapters in different regions, and other machine shops identified by MIRDC based from data provided by the Local Government Units (LGUs) and the Department of Trade and Industry (DTI) estimated to total 2,500 potential respondent-shops.



MIRDC Reports a Record High Completed Contract Researches in 2007

For MIRDC, 2007 was a very demanding year as the number of contract research arrangements of the Center with private firms and individuals rose sharply to 174. The figure denotes a growing number of companies that seek the expertise of the Center when it comes to equipment development, parts and components localization, tool, dies and molds fabrication, and casting.

Among the highest contract researches paid to MIRDC last year were the projects entered by the Philippine Coconut Authority (PCA) and the Department of Agrarian Reform (DAR) on the development of coco-coir decorticating machines; Blue Rock Aggregates for the development of stainless steel impeller; and Lamon Bay for decorative castings for furniture beds. Other researches include localization and development of various dies, molds, orthopedic



Continuation on p7

EnerCon Program takes center stage

JETRO Manila concludes dispatch program for the metal casting industry

With the continuous sharp hikes and shortages of fuels, as well as the instability of regional economic conditions, the industrial sector has been vulnerable to these threats thus significantly affected in their business operations.

The industrial sector accounts for the biggest share of the country's energy demand. It consumes about 30 to 40 percent of the energy used in the country. While there is a general awareness of the opportunities in reducing energy consumption in the industry, progress in implementation remains to be slow. Part of this slow progress is the lack of information on methodologies for energy management and conservation.

Hence, designed on the heels of energy crisis, the Japan External Trade Organization (JETRO) started its Energy Conservation project under the Green Aid Plan (GAP) of Japan in 2001. This aims the promotion of energy conservation practices in the various manufacturing sectors in the Philippines. The project was first implemented in the food industry then replicated to the iron and steel industry—a sector known to be energy-intensive.

Realizing the significance and the economic benefit that will be derived from this project, it was then applied to the metalcasting sector in collaboration with the Philippine Metalcasting Association, Inc. (PMAI) and the Philippine Council for Industry and Energy Research and Development (PCIERD-DOST).

It is a tripartite initiative between the Philippines and Japanese governments including the local industrial sector which started in 2006. The objective of the project was to promote adoption of energy-efficient technologies in the industrial and commercial sectors that are large consumers of energy and primary generators of carbon dioxide (Co_2) emissions. Energy conservation is important because the price of fuel and coke continuously increases and the Philippines depends on imported oil as source of its energy. Widespread replication of energy-efficient technologies is expected to reduce fuel and coke consumption and improve the competitiveness of the local casting industry.

> Japanese experts were dispatched to the Philippines to assess and evaluate foundry operations and recommend some countermeasures for existing predicaments in foundries.

The dispatch program involved capacity-building of the local candidates in the field of energy conservation and management. Japanese experts were dispatched to the Philippines to assess and evaluate foundry operations and recommend some countermeasures for existing predicaments in foundries. Moreover, the Japanese experts together with the local counterparts conducted a series of energy audits and identified specific areas for reducing energy consumption and possible energy efficient technology intervention in the plant operations.

Recently, a whole-day seminar was conducted by JETRO Manila in Makati City. The event was well participated by the Philippine Iron and Steel Institute (PISI) and the Philippine Metalcasting Association, Inc. (PMAI) as well as representatives from the Departments of Energy (DOE) and Science and Technology (DOST). It served as a venue for the local counterparts to present their accomplishments and action plans for the continuance of this energy conservation project among the steel and casting industries.

In addition, a ten-day training and study tour in Japan was organized through the Association for Overseas Technical Scholarship (AOTS). This activity aims to provide the local candidates from DOST and PMAI the technical know-how with regard to Japan's expertise on the field of energy conservation and management. Ultimately, the energy conservation dispatch program for the metal casting industry in the Philippines has been a success. With the technology transfer that has been provided by the Japanese experts, recipient companies were able to realize big savings and reduction on their carbon gas emissions.

For this coming fiscal year, JETRO Manila in partnership with the DOST, through the PCIERD, plans to conduct an energy conservation program for the cement industry in the country. This is in line with the objective of both governments in building the capabilities of local industries towards energy efficiency.

Source: Dateline JETRO Jan-Feb 2008 Volume 9 Number 1

Japanese expert renders free technical assistance to local companies

As part of the JETRO Expert Service Abroad for Improving Business Environments (JEXSA) program for the metalcasting industry, another Japanese expert was dispatched to the Philippines early this year to provide technical assistance to the local industry. Mr. Junichi Take-uchi, technical expert on casting and also a foundry man, conducted a series of workshops last 07 - 09 January 2008 at JETRO Manila.

Latest trends on melting technology as well as data gathering techniques were the foci of discussion during the three-day workshop. According to the expert, there is a need to re-examine new technologies (environment, energy, recycling, computerization, etc.) to be able to respond to the changing social demands and overcome the limitations on environment and energy conservation. In other words, it is necessary to promote the development of individual technology under the Metalcasting Technology Base considering the resources, energy and environmental burdens, in order to promote a "Recycling Society" which prioritizes the resource productivity. Moreover, some of the best practices in Japan with regard to the casting techniques and processes were also discussed.

Participants in this activity consisted of selected member companies from the Philippine Metalcasting Association, Inc. (PMAI) and representatives from the Department of Science and Technology (DOST) and Department of Energy (DOE). The recipient companies for the metalcasting sector include Acetech Metal Industries Corporation, Progressive Metals Resources, Inc., Tiger Machinery & Industrial Corporation, SOH Technologies, Miyano Machinery, and Supercast Foundry & Machinery Corporation.

Consequently, the Philippine Council for Industry and Energy Research and Development (PCIERD) in collaboration with the Metals Industry Research and Development Center (MIRDC) and the Industrial Technology Development Institute (ITDI) presented their plan of coming up with a guidebook containing the best practices as well as casting techniques within the local casting industry. This would be made available for all foundries in the country by second quarter of this year.

As part of the JETRO Expert Service Abroad for Improving Business Environments (JEXSA) program for the metalcasting industry, another Japanese expert was dispatched to the Philippines early this year to provide technical assistance to the local industry.

Source: Dateline JETRO Jan–Feb 2008 Volume 9 Number 1

Mr. Junichi Take-uchi, one of the technical experts on casting technology, discusses the method of data gathering for the local foundries in the country

PDMA launches PDMAEC 2009

The Philippine Die and Mold Association (PDMA) recently launched PDMAEC 2009, the 4th exhibition and conference which features the latest technologies on die and mold, machine tools, metalworking machinery, equipment, accessories, hardware and other related products and services. The launching was held in conjunction with the PDMA's general membership meeting on 07 March 2008 at the Legend Villas' Banahaw Ballroom.

The PDMAEC 2009 is being organized by the PDMA and managed by the MAI Management Philippines. The signing of the Memorandum of Understanding (MOU) by the PDMA and MAI Management Philippines which took place on 31 January 2008 at the Café Caruzo, Makati City signaled the preparation of the holding of the PDMAEC 2009 scheduled from 27-30 August 2009 at the World Trade Center Metro Manila. PDMA president Gregorio A. Oliveros signed the MOU for PDMA while Marketing Director Ma. Angelica P. Barrios signed for MAI. Some directors witnessed the MOU signing.

The PDMAEC 2009 launching and general membership meeting was attended by 38 representatives from among 27 member companies. Mr. Oliveros welcomed the participants and each was asked to tell something about their company, products, and services. Three companies, namely:

Seated (r to l): PDMA president Gregorio A. Oliveros, MAI director Angelica P. Barrios and vice president Louie T. Fuster ink the MOU together with PDMA directors (l - r standing) Messrs. Domingo I. Bagaporo, Jimmy T. Chan, and Philip C. Ang

Ito Seisakusho Philippines Corp.; Gerbag Industrial Technologies; and Cenel Development Corporation were acknowledged as new members and given Certificate of Membership to the Association. Highlighting the program was the launching of the PDMAEC 2009 as vice president Louie T. Fuster announced the upcoming event. He enthusiastically invited everyone to participate in the show.

Ms. Barrios likewise gave updates on the information about the activities of the Federation of Asian Die and Mould Associations (FADMA). She encouraged all members to actively support the Federation in which the PDMA is currently serving as the secretariat. Finally, the other plans and programs of the Association were made known to the members, among which, the proposal of sponsoring scholarship and/or on-the-job training program for technical students.

The PDMA organizes exhibitions biennially. The PDMAEC 2009 is among the lined-up activities to be undertaken by the Association in its effort to help the Government in promoting the country's die and mold industry. For inquiries, interested participants may contact MAI Management Philippines through telephone no. (632) 898-2198, fax no. (632) 890-1087, email: www.mai_mgt@compass.com.ph or PDMA Secretariat through telephone nos. (632) 837-0431 to 38 loc. 463 and telefax no. (632) 837-0764.

Launching of PDMAEC 2009 cum PDMA general membership meeting on 07 March 2008 at the Banahaw Ballroom of the Legend Villas

21st MIAP Convention Held

The Metalworking Industries Association of the Philippines, Inc. (MIAP) held its 21st National Convention from 28 February–01 March 2008 at the Garden Oases Resort and Restaurant, Davao City. This year's theme is "Metalworking: In Support to Agriculture and Mass Transport Towards Economic Growth."

Undersecretary Jesus Emmanuel M. Paras of the Department of Agriculture (DA) graced the affair as keynote speaker in lieu of Senator Juan Miguel Zubiri. Other guest speakers were Hon. Rodrigo R. Duterte–city mayor of Davao, Mr. Pastor Z. Guiao–deputy director general of the Technical Education and Skills Development Authority (TESDA)-Communities Local Government Services and Unit, and Mr. Teodoro Sanico–executive director of TESDA Office of Technology Institute.

Concurrently, MIAP elected its officers and trustees for CY 2008-2009. Mr. Almarco C. Brito was once again made president of the association. The rest of the positions were designated to the following: Mr. Jose Y. Mateo as executive vice president, Mr. Joseph Alan T. Abrenica as vice president–Luzon, Mr. Nelson Lopez as vice president–Visayas, Mr. Dominador Lanoy as vice president-Mindanao, Mr. Leonardo B. Sinangote as secretary, Mr. Francis Celis as treasurer, Mr. Samuel Sia as auditor, Messrs. Hector D. Molonzo, Jose Bernas, and Jacinto Buenaflor as trustees.

A plant tour to HOLCIM Phil., Inc. was conducted and everyone enjoyed the tourist spots of Davao. Also, the participants joined golf tournament and gun shooting competition as well as the fellowship night at Garden Oases Resort.

The event was attended by the representatives of MIAP chapters throughout the Philippines, i.e., Bohol, Butuan, Cagayan de Oro, Camarines Sur, Cordillera, Dagupan Region I, Davao, General Santos, Iligan City, Iloilo City, Kidapawan, Metro Cebu, Metro Manila, Negros Occidental, Surigao del Sur, and Zamboanga City.

Headed by chapter president Lorenzo A. Cristobal, the MIAP Davao Chapter hosted well the event.

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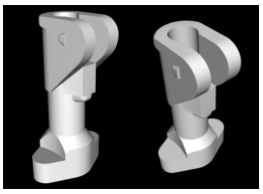
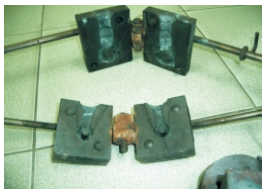
items, ornamental articles, among others.

Income receipts for the said projects totaled to a little over PhP 2.79 million. Thirty-two percent of the total number of researches implemented cost over PhP 10,000.00 each.

MIRDC expects contract researches to continue increasing specially that the Center has been given the opportunity to upgrade and rehabilitate some of its defective equipment at the production areas through the financial support of the DOST.



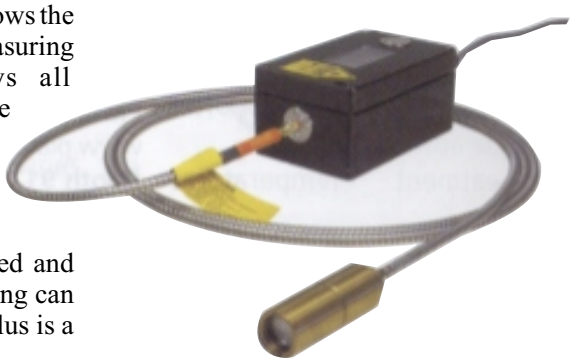


Some of the contract projects done by MIRDC in 2007

New pyrometers with fiber optics for non-contact measurement on metals

The instruments IS 50-LO plus and IGA 50-LO plus are digital pyrometers with fiber optics for non-contact temperature measurements on metals, ceramics, graphite, etc. between 250 and 2500 ºC. The optical fiber as the exchangeable optical head are unaffected by electromagnetic interferences (e.g., induction) and can be used in high ambient temperature up to 250 ºC. Two different types of optical heads for different measuring distances and very small spot sizes (min. 0.45 mm) are available. A laser targeting light enables the exact alignment into the measuring object. Due to their short response time of less than 1 ms, these pyrometers are ideal for measure of fast heating processes. The pyrometers are equipped with a display which shows the current temperature, when in measuring mode. Moreover, it displays all instrument parameters if there are changes via the integrated keys at the instrument. Via servial interface and the provided software InfraWin, the temperature can also be displayed and stored in a PC where parametrizing can also be done. The IS 50/67-LO plus is a special version with an extremely short wavelength for the measurement of molten metals with a very high emissivity.

Source: Heat Processing. 3 (2007): 264



C-Detect shim stock carbon analysis

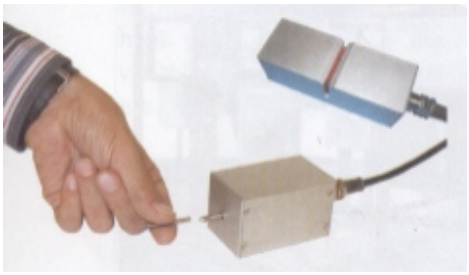
C-Detect is a highly reliable measuring system that determines the carbon content in iron foils for calibrating carburizing atmospheres.

An indispensable tool for heat treating shops, C-Detect does not require specialized personnel; and contrary to typical carbon foil tests, where surface imperfections of the shim stock will negatively impact readings, the C-Detect is more forgiving. C-Detect measures the carbon content within a shim stock using an electromagnetic multi-frequency method followed by a multi-parameter analysis.

Key benefits are:

- ➔ problem-oriented hardware and software;
- ➔ easy operations, no specialized personnel required;
- ➔ cost-effective and user-friendly;
- ➔ solid construction for shop environment;
- ➔ accurate readings, regardless of shim handling and its surface conditions fast and easy measurement;
- ➔ easy handling of shims; and
- ➔ measuring heads available for rolled or flat shims

Source: Heat Processing. 3 (2007): 266



Special heat treatment furnace for aluminum parts

The furnace plant serves for solution annealing, approximately 525 ºC/max. 600 ºC, and aging heat treatment, approximately 160 ºC/max. 250 ºC, for automotive parts made out of aluminum. The cycle times of the solution annealing and aging heat treatment furnace are variable. The aluminum parts are loaded into transport frames and in this way fed into the furnaces. For the transport of the transport frames, roller conveyors are used. To be able to use the furnace plant very flexible and hence, in an optimum way the roller conveyors are divided in several single conveyors. Hence, we are able to use the options "fast-in," "fast-out," "closing gaps," and "reversing mode." The entire plant management is done in U-shape. For the solution furnace the manufacturer designed the heating with gas burners in on-off mode using natural gas. The furnace plant is equipped with hot gas redial circulation fans, and hence achieving a guaranteed temperature uniformity of ± 2.5 ºC for the aging heat treatment furnace heating is done using electric cage heating elements. Also, this furnace is done with the solution furnace equipped with an intense circulation system of the furnace atmosphere.

Source: Heat Processing. 3 (2007): 264

Plasma nitriding treatments for modified characteristics of metal surfaces

Plasma nitriding treatments for the purposeful change of the surface properties of tools, work pieces, and wearing parts are used in the metalworking industry for many years. PlaTeG develops PulsPlasma®-Technologie which makes it possible by means of unipolar or bipolar pulsed DC-plasma to improve the wear and corrosion resistance of surfaces and simultaneously affect the materials fatigue strength positively.

Unipolar, respectively, bipolar pulsed PulsPlasma®-Plants makes the following applications possible:

- nitriding/nitrocarburizng;
- oxidation;
- CVD coating; and
- ultra-fine cleaning of metal surfaces

PulsPlasma®-Treatments offer unique advantages:

- treatment temperatures starting from 300 ºC;
- small power consumption, little losses of energy;
- warm wall technology, excellent temperature distribution in the load;
- high loading density possible; and
- high surface quality of the treated parts (no arcing during treatment)

A further main focus of PlaTeG's activities are low pressure plasma plants, which can modify the characteristics of metal surfaces by means of medium frequency, high frequency and/or microwave plasma purposefully.

Source: Heat Processing. 3 (2007): 262

Rotary tube furnace with integrated cooling channel

Linn High Therm is presenting a high quality rotary tube furnace with controlled atmosphere for special heat treatment with metal rotary tube (dimensions 400 x 380 x 5,000 mm). Specific features are:

- adjustable speed rotation (from 0.5 up to 5 rpm) of the tube;
- adjustment of inclination via spindle-type mechanism (up to 10 degrees);
- 4-zone heating: fibrothal half-shells with embedded heating coil;
- T max. 950 ºC;
- rotary tube and cooling channel with nitrogen flushing;
- output and cooling channel with integrated water cooling; and
- options: Thermal post-combustion, multideck screen, water cooling, vibrating chut

Source: Heat Processing. 3 (2007): 265

New recorder targets aerospace heat treatment shops

The latest addition to Eurotherm's 6000 Series family of paperless graphic recorders is aimed at heat treatment shops that supply the aerospace industry. Called the 6180 AeroDAQ, this new recorder makes it easier for heat treatment shops to comply with AMS2750 Revision D, a subsection of the AS7102 audit that concerns pyrometry. AS7102 accreditation must be achieved in order for heat treatment shops to qualify for the performance Review Institute's Qualified Manufacturers List (QML) under the Nadcap accreditation scheme. Membership of the QML is essential for any company that wants to supply major aerospace customers such as Boeing, Airbus, and Rolls-Royce. Eurotherm's 6180 AeroDAQ comes with a number of specialized mathematical routines that carry out calculations critical for heat treatment shops hoping to gain AS7102 accreditation. These include calculating due dates for system accuracy tests, temperature uniformity surveys and calibration, and providing warnings to ensure that critical dates are met. AMS2750D also specifies the number of uses and days of life for load thermocouples. 6180 AeroDAQ includes routines that calculate thermocouple usage and set off alarms if they are in danger of going out of specification, as well as allowing the user to validate that all load thermocouples meet the usage specification prior to starting a treatment. Both the due date calculation and the thermocouple monitoring features, together with their respective alarms, come preconfigured to allow the customer to meet the requirement of ASS2750D. An optional batch reporting package fully automates the recording of each job, making it simple to generate the paperwork required by customers in the aerospace industry. It also does away with the traditional risks associated with mechanical recorders.

Source: Heat Processing. 3 (2007): 265

Highly Efficient and Accurate Machining Using Five- and Six-Axis Control

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Abstract

5-axis control machining can create work pieces with complicated shapes that are difficult to machine through 3-axis control. Moreover, 6-axis control machining can cope with work pieces impossible to machine by rotational tools since it can control the direction of non-rotational tool. Though 5-axis control machining which uses rotational tools is advantageous in terms of the machining efficiency, the cutting remainings peculiar to the rotational tool take place at the corner part of workpiece shape. On the other hand, 6-axis control machining can machine the corner part, which cannot be removed with the rotational tool, though it has the low machining efficiency. The use of two machining methods together seems to be very effective to improve the machining efficiency. This research investigates the highly efficient and accurate machining method using 6-axis control machining together with 5-axis control one. The algorithm to generate the cutter location data is developed in consideration of the use of control machining, and it is implemented to the integrated CAM software for control machining. As a result, it is experimentally found that the system enables the effective and accurate machining.

Keywords : CAD, CAM, Machining

1 INTRODUCTION

In recent years, the shape of industrial products tends to be complicated and diversified, remarkably. On the other hand, the reduction of cost in design and production processes is increasingly requested. Therefore, it is strongly required to establish efficient machining methods, which can cope with shapes impossible to machine using conventional methods.

As an example, let us explain the character line, which consists of an intersection line with two or more curved surfaces, as shown in Fig. 1, and cannot be normally machined with conventional rotational tools. Though such part has been removed by electrical discharge machining, it causes the increase in the set-up process by moving work pieces from machining center to electrical discharge machine, the occurrence of installation error and so on. Moreover, it is also disadvantageous to prepare a special electrode in terms of the running cost.

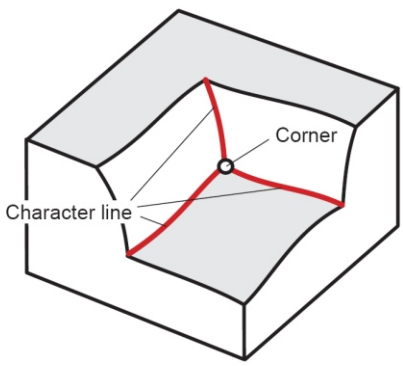


Figure 1. Character line and corner part

Here, if the replacement of electrical discharge machining with cutting is realized by solving the restriction of cutting with rotational tools and expanding the applicability of cutting, it is possible to greatly contribute to shortening the leadtime.

Based on the background, 6-axis control machining which simultaneously controls the nonrotational tool by 6 axes is proposed, aiming at its practical uses [1, 2]. The simultaneous 6-axis control machining had the problem with regard to the accuracy and appearance of the machined surface. It is due to the low cutting speed equals to the feed rate. The introduction of the vibration cutting solves the problem on low cutting speed [3-6]. However, since an excessive load cannot be applied to the tool in the vibrational cutting, the depth of cut par one path should be small.

It is said that 6-axis control machining has a variety of cutting possibility, but is not necessarily efficient due to the low removal rate of machining. Thus, it is desirable to make the most of machining with rotational tools as much as possible from the view point of machining efficiency.

The study aims at establishing an efficient machining method to obtain a clear character line by removing the cutting remainings in the vicinity of the character lines with 6-axis control vibration cutting together with 5-axis control efficient machining. After explaining the method of generating the cutter location (CL) data, based on 3-dimensional CAD data of the machining object shape, the result of the machining experiment is described, which was performed by using the cutter location data generated with the CAM system intended for the proposed technique.

2 CHARACTER LINE MACHINING USING CONTROL

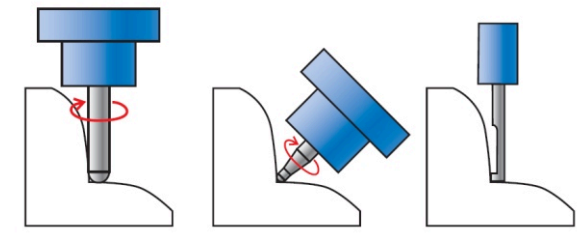


Figure 2. Machining method proposed in this research

2.1 Proposed machining method

Figure 2 shows the procedure of the character line machining proposed in the study. First of all, the finishing is done with the ball end mill with an appropriate diameter after rough cutting, as shown in Fig. 2(a). Though it is possible to machine the work piece directly by using 6-axis control, it should be removed first with a small ball end mill as much as possible because 6-axis control machining takes a lot of time. However, since the projection length of small tools may be short, the holder part will interfere easily, and possible parts to be machined are severely limited. For this case, the machining with the simultaneous 5-axis control is extraordinarily effective, as shown in Fig. 2(b). Finally, the residual part is removed by applying the vibration cutting with the simultaneous 6-axis control, as shown in Fig. 2(c). In order to achieve the machining method, it is important to efficiently generate the best cutter location data for each machining.

2.2 Format of cutting point data

The system calculates CL data for both 5- and 6-axis control machining, based on the cutting point data expressed in the same format. Figure 3 shows the composition of the cutting point data.

The data of one cutting point consists of three elements of coordinates value **P** at the cutting point, where the tool touches the work piece surface, the normal vector **N** to the machined surface at the cutting point, and the tool feed direction vector **F**. This cutting point data is called **PNF** data.

2.3 Generation of cutting point

Here, let us explain the method that calculates cutting point information for machining a target character line.

First of all, the system has to generate dividing points on the character line to be machined, as shown in Fig. 4(a). Then, the system generates perpendicular planes at each dividing point. Further, the intersection curves of the plane and two surfaces composing the edge are calculated, as shown in Fig. 4(b). When the intersection curve is too short, as shown in Fig.4(c), the system extends the curve to its tangent direction at the end point of the intersection curve with a straight line.

In case that the intersection curve is not obtained at the end point of the edge, as shown in Fig. 5(a), the intersection curve is virtually defined as the straight line. Moreover, if the number of intersection curve is insufficient, the edge is extended to the tangent direction at the end point, as shown in Fig. 5(b), and the last curve generated at the end point of the edge is copied on the extended edge, as shown in Fig. 5(c).

Cutting point **P** of **PNF** data is generated on each intersection curve in consideration of a character line machining. At this time, over-cutting and under-cutting might take place in the machining because **P** obtained from the copied curve is not strictly a point on the machined surface. Therefore, each point **P** is corrected by projecting it onto the machined surface, as shown in Fig.6. Normal vector **N** is also calculated at each point **P**. Tool feed direction vector **F** at each point **P** is a correction of the tangent vector at the corresponding dividing point to orthogonalize to **N**.

3 DATA GENERATION FOR 5-AXIS CONTROL MACHINING

3.1 Generation of PNF data

The system calculates contact points of large and small radius ball end mill with two intersection curves at each dividing point, as shown in Fig.7. Cutting points **P** are arranged between two obtained contact points with equal intervals. At this time, the number of **P** is automatically decided so as the cusp height becomes below the fixed one. Successively, **PNF** data such as the normal vector, etc. is calculated at each cutting point. Here, the **PNF** data for machining the left and right surfaces are called **L-PNF** and **R-PNF**, respectively.

Moreover, in order to reduce the cutting load, **PNF** data is added between the residual part before 5-axis machining and that one after 5-axis machining, as shown in Fig. 8. First of all, **L-PNF** and the **R-PNF** data are offset by the radius of the small ball end mill in the normal

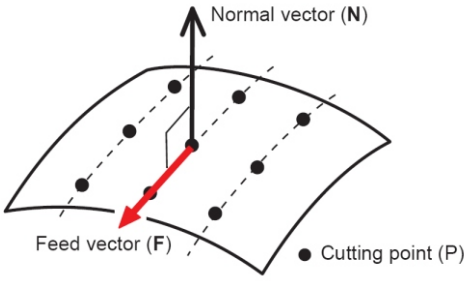


Figure 3. Composition of PNF data

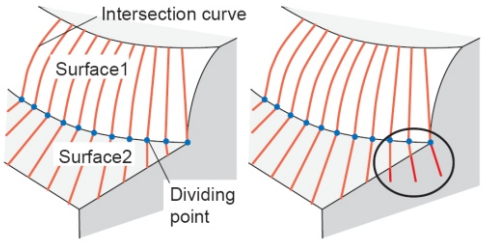


Figure 4. Generation of intersection curves

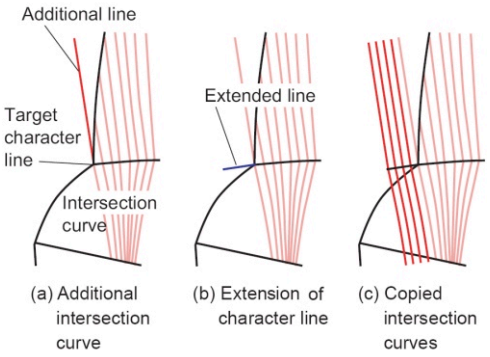


Figure 5. Treatment of intersection curves at the end of target edge

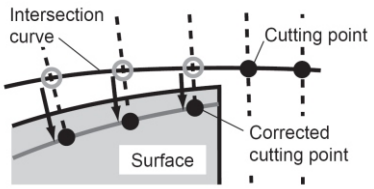


Figure 6. Correction of cutting points

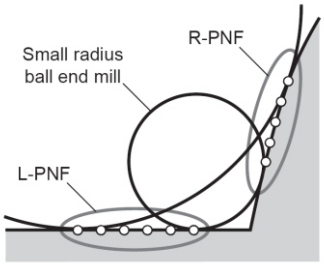


Figure 7. Arrangement of cutting points

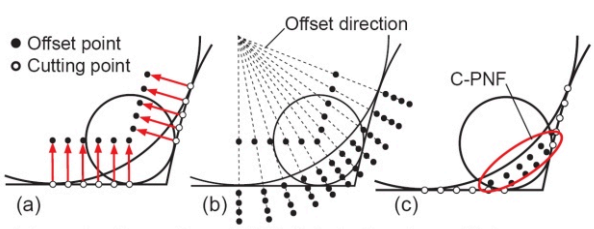
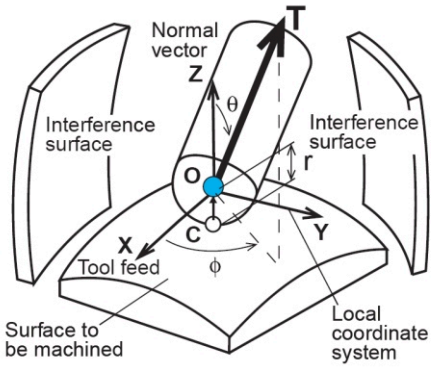
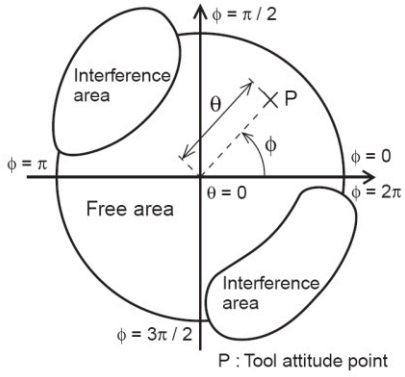


Figure 8. Generation of PNF data for 5-axis machining
(a) Offset of PNF data in the direction of normal vector
(b) Offset of PNF data for circular part
(c) Generation of C-PNF data



T : Tool axis vector O : Tool center point
C : Cutting point r : Offset radius

(a) Definition of tool attitude in real space



P : Tool attitude point

(b) 2-dimensional configuration space

Figure 9: Concept of 2-dimensional configuration space

direction of each **PNF** data, as shown in Fig. 8(a). Then, the system calculates vectors directing from the center of the large ball end mill to each offset point. Afterwards, the offset data is again offset in the direction of the calculated vector, taking account of the fixed depth of cut, as shown in Fig. 8(b). Finally, the system deletes unnecessary data, based on the positional relation between each generated **PNF** data and target shape, as shown in Fig. 8(c). Thereafter, the **PNF** data generated like the circular arc is called **C-PNF**.

3.2 Generation of CL data

In order to generate **CL** data for 5-axis control machining, the tool center point **O** is firstly decided by shifting the cutting point **P** by the tool radius in the direction of **N**, as shown in Fig. 9(a). Here, it is important how to decide the tool axis **T** corresponding the tool attitude without interfering with the workpiece surface. In order to generate the interference-free 5-axis **CL** data in the study, the original 2-dimensional configuration space (C-Space) [7] is applied, which was proposed by us [8-10].

Figure 9(b) shows the composition of proposed 2-dimensional C-Space. It is determined by two parameters; the tilting angle **θ**

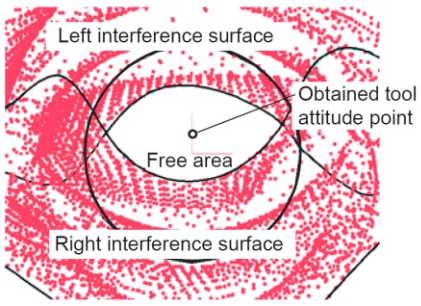


Figure 10: Determination of tool attitude using 2-diminsional configuration space

between the normal and the tool axis and the rotating angle **φ** around the vector **N**, which decide the tool attitude at each cutting point. The relationship between the tool attitude and the interference at each cutting point can be clearly understood by mapping the obstacle around the tool into the definition area of this space. Thus, the space can classify the definition area into the "interference area" corresponding to tool attitudes with interference and the "free area" corresponding to interference-free tool attitudes.

Figure 10 shows an example of the tool attitude determination process using C-Space. The left and right machined surfaces against the tool feed direction are mapped on C-Space as the interference area. As shown in the figure, one tool attitude point is selected from the free area corresponding to the interference-free tool attitude, and the interference-free tool attitude is determined on the basis of parameters of the selected attitude point.

Continuation on next issue...

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