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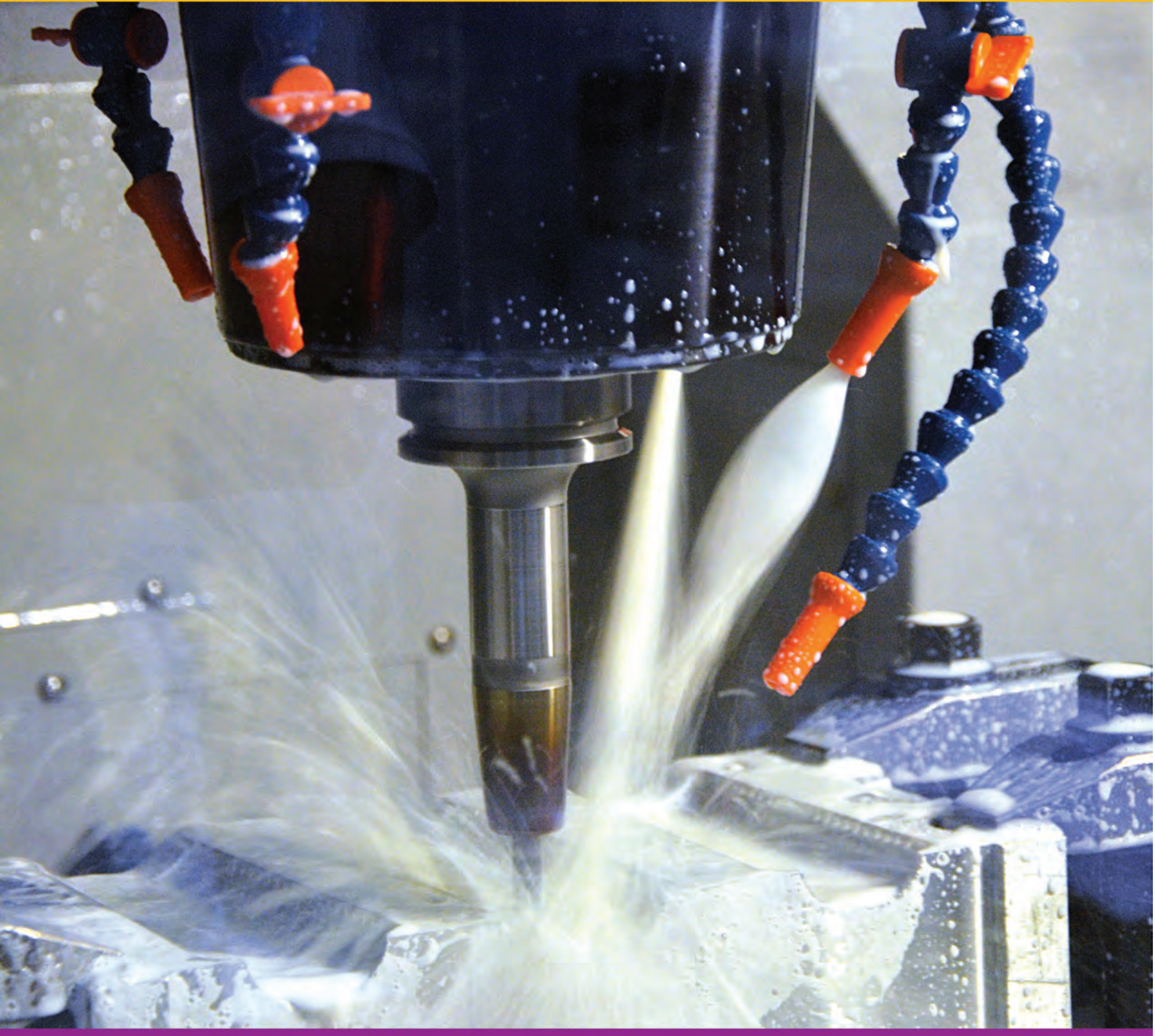

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Philippine Metals

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Preface

We are proud to present to you the Philippine Metals Volume 5. Here, we provide you with a report on the status of the metalcasting industry, and a glimpse of outputs of projects that we engaged ourselves in, with the purpose of providing technology-based interventions and services most needed by the metals and engineering industries.

Volume 5 of the Phil Metals also features the Metalworking Industries Association of the Philippines, Inc. (MIAP), one of our industry partners for many years now. Also in Volume 5 is a feature article on Mr. Ruperto C. Magno, in the segment entitled, 'Men in the M&E Industries.' Both of these feature articles are our ways of sharing with the entire M&E industries our support and gratitude to organizations and individuals who are focused on propelling the country towards higher levels of productivity and competitiveness.

I wish to acknowledge key members of various teams who actively carried out tasks for their project's completion and took the lead in authoring the technical papers. May this publication serve to motivate researchers, both internal and external, to further enhance technical paper writing capabilities, and to stir up the local M&E industries to pursue publication as a means to create lasting and relevant impact to other sectors of the economy in particular, and to the entire Filipino nation as a whole.

Robert O. Dizon
Executive Director

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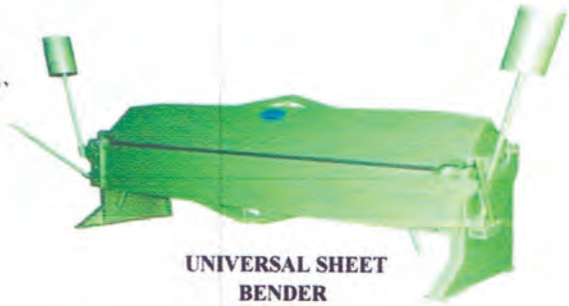

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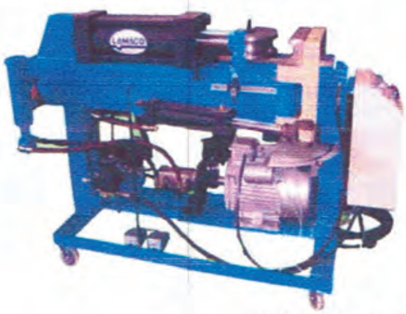
Length: 12ft

STIRRED TANK BIROREACTOR
Capacity: 500 kgs. / 1000 kgs



HYDRAULIC PIPE BENDER

ORGANIC WASTE SHREDDER

PLASTIC/STYRO DENSIFIER

PLASTIC/STYRO SHREDDER

PRODUCTS LINE

METAL WORKING MACHINERIES
*SHEET BENDER *SHEARING MACHINE
*SLITTING MACHINE *ROLLER BENDER
*BURRJNG MACHINE *LOCK FORMING MACHINE
*ROLL FORMING MACHINE

HYDRAULIC & PNEUMATIC MACHINERIES
*SHEET BENDER *SHEARING MACHINE *SLITTING MACHINE
*ROLLER BENDER *BURRING MACHINE
*ROLL FORMING MACHINE

WOODWORKING MACHINERIES
*BAND SAW *CIRCULAR SAW

MATERIALS RECOVERY EQUIPMENT
*BIOREACTOR CMPOSTER *PLASTIC DENSIFIER
*PLASTIC SHREDDER *ORGANIC SHREDDER

MATERIALS HANDLING
*CONVEYOR SYSTEM *PACKAGING MACHINE

ENGINEERING FARICATION
*GENERAL MACHINING WORKS *METAL FABRICATION
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- To lead in certifying mechatronics and automation professionals, technicians and practitioners which will complement globally recognized national certification.

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Philippine Metalcasting Industry 2017: A Status Report

Alexander P. GONZALES*[1]

Abstract

The metalcasting industry plays a vital role in today's modern economy. The metalcasting industry is currently dominated by China, which produced 46.2 million metric tons in 2014 and this accounts for more than 40% of the global casting production while Germany leads the per-plant production with 8,818 metric tons per-plant output. The scale of production of the Philippine metalcasting industry is nowhere near the level of the current global players. This study aims to determine the status of the Philippine metalcasting industry for 2017. This study utilized a descriptive survey research method. The process includes the preparation of the survey questionnaire and submission to the Philippine Statistics Authority (PSA) for approval, conduct of the survey proper with industry interviews, and a focus group discussion for confirmation of collected and processed data. The Philippine metalcasting industry is in its critical stage. Several micro and small metalcasting shops in the country have closed down due primarily to its incapability to compete in the Philippine market as well as globally. About 71% of the metalcasting workforce is concentrated in the medium and large metalcasting companies. The medium and large metalcasting companies are also responsible for 97.1% of the casting production in the country. Government intervention is essential for the survival of the industry.

Keywords: MIRDC, metalcasting, casting, metals industry, foundry, PMAI

Metalcasting is a 6000-year-old process which was mentioned in several ancient texts found in India and Mesopotamia. One of the earliest artifacts is an eleven centimeter (11 cm) bronze dancing girl found in Mohenjo-Daro dated 3500 – 3000 BC.[1] Metalcasting played a significant role in the development of human civilization. In history, two metallurgical periods marked the advancement of humans, the Bronze Age (4000 – 2000 BC) and the Iron Age (1500 – 1000 BC), where human civilization learned to work with natural metals, melt ores, and cast alloys of different composition and properties.[2]

The metalcasting industry still plays a vital role in today's modern economy. According to the 49th Census of World Casting Production, [3] the worldwide metalcasting industry production was more than 105 million metric tons in 2014. The metalcasting industry is currently dominated by China which produced 46.2 million metric tons in 2014, and this accounts for more than 40% of the global casting production. In far second is the United States which produced a little short of 12 million metric tons in 2014. In third is India with a production of 10 million metric tons in 2014.

Though China seems to dominate the world casting production, its per-plant production of 1,777 metric tons is relatively low compared to Germany's 8,818 metric tons per-plant production[3]. Even though China has more than 30,000 reported foundries in 2008, the average foundry in China is relatively very small and labor intensive.[4]

The metalcasting sector is an essential component of the Philippine metals and engineering industries. Metalcasting is an upstream industry following the primary process of mining mineral ores and extracting the metal from it. Casting is a method where solid material is dissolved, heated to a suitable temperature (generally treated to change its chemical structure), and is then added into a mold or cavity, which keeps it in a proper form during solidification. As a result, in just one step, complex or simple designs can be created from any material that can be dissolved. The end product can have nearly any setting the designer needs.[5]

Metalcasting serves as the source of raw materials within the engineering industry and provides machinery, tooling, and parts used in other industries such as agriculture, housewares, chemical/petrochemical,

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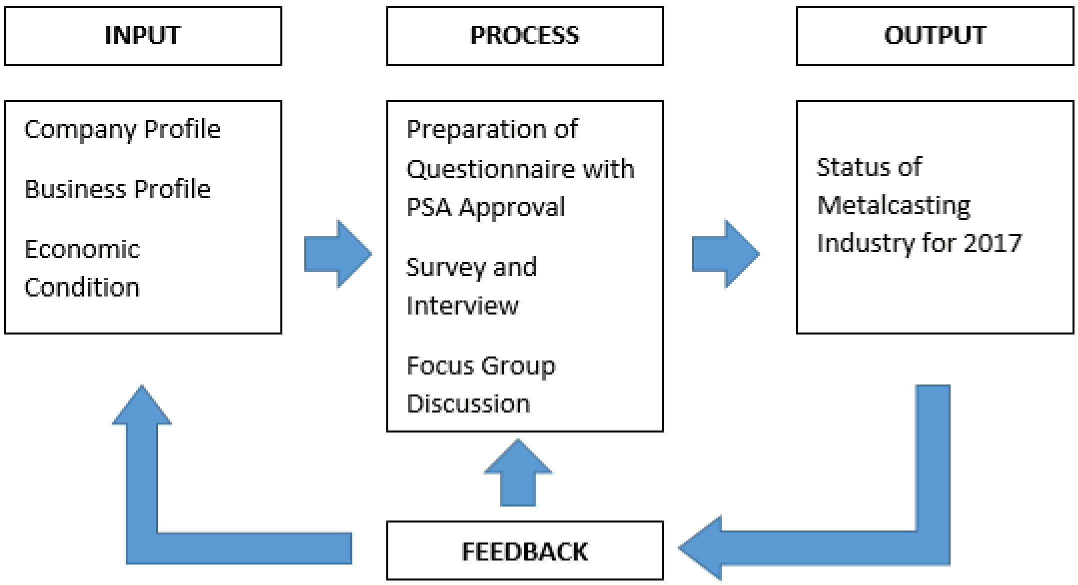

Figure 1. Conceptual Framework

water/sewerage, machinery, mining, cement, electronics, automotive, defense/armaments, and medical/dental.

At present, the scale of production of the Philippine metalcasting industry is nowhere near the level of the current global players in the casting market. In the 2003 study conducted by the Metals Industry Research and Development Center (MIRDC), 195 metalcasting companies were maintaining 295 foundries in the Philippines. Majority of the micro and small category metalcasting companies identified in 2003 are now closed due to bankruptcy, while some shifted to other industries. In 2012, the identified metalcasting companies decreased to 102, and in 2017, the year covered by this study, the number further drops to 85 metalcasting companies.

This necessitates an in-depth study of the current status of the domestic metalcasting industry to identify possible measures to revive and assist the metalcasting industry to become a global player in the future.

Figure 1 shows the conceptual framework of the study. The inputs of the study are the metalcasting industry's company profile, business profile, and economic condition. The process includes the preparation of the survey questionnaire and submission to the Philippine Statistics Authority (PSA) for approval, conduct of the survey proper and industry interview, and conduct of focus group discussion (FGD) after the consolidation of data. The output of the study is the status of the Philippine metalcasting industry for 2017 which will be the basis of programs, projects, and activities (PPA) of the government.

Objective of the Study

This study aims to determine the status of the Philippine metalcasting industry for 2017. Specifically, it aims to:

1. Determine the business profile and classification of the metalcasting companies;
2. Identify the conditions of the metalcasting companies in terms of production, workforce, industries served, and raw material; and
3. Examine the business outlook, concerns, and problems of the existing metalcasting companies.

Method

This study utilized a descriptive survey research method, which is often used to capture data from business organizations.[6]

The survey questionnaires were formulated to elicit responses that would reflect the existing profile of the industry, its structure, nature of business activity, market served, level of production and consumption, its technology and workers' training requirements, and issues and concerns that the government could intervene. Once finalized and approved by the MIRDC management, the questionnaire was submitted to the Philippine Statistics Authority (PSA) for suggestions and approval. The survey questionnaire utilized in this study acquired a PSA Approval Number of MIRDC-1703 with expiration on 28 January 2018.

The MIRDC conducted the survey among 46 respondent metalcasting companies in 2017 from six (6) regions of the country. The data were obtained through filled-out survey questionnaires, personal interviews, and actual plant visits. Secondary sources were also considered in the study, such as import and export statistics of the metalcasting products from the PSA.

In verifying the result of the study, an FGD was conducted with industry players on October 19, 2017. Additional inputs were also extracted from the FGD conducted on May 29, 2018 under the MIRDC project entitled, "Design and Optimization of Austenitic Manganese Steel Liners for Philippine Aggregates and Mineral Processing."

Table 1. Economic Classification of Metalcasting Companies in 2017

Categories	Classification Based on Capitalization	Classification Based on Employment	Workforce Distribution Percentage
Micro	11%	7%	0.4%
Small	37%	59%	28.5%
Medium	37%	17%	31.0%
Large	15%	17%	40.1%
Total	100%	100%	100%

Table 2. Cost of Local Production of Metalcasting Companies in 2017

Categories	Average Annual Cost of Local Production in 2017
Micro	P1,352,086.95
Small	P6,825,796.43
Medium	P49,048,883.10
Large	P223,557,500.00
Overall Average	P61,400,429.41

Table 3. Workforce Employed in the Metalcasting Industry in 2017

Categories	Workforce	Percentage
Production	2663	75%
Support Services	470	25%
Total	3546	100%

Table 4. Industries Served by the Metalcasting Industry in 2017

Industries	Frequency	%	Rank
Industrial and Agricultural Machineries and Equipment	24	54%	1
Automotive	14	30%	2
Construction Machineries and Equipment	10	22%	3
Metalworkings	7	15%	4
Cement and Concrete Works	6	13%	5

Table 5. Raw Materials Used by the Metalcasting Industry in 2017

Raw Materials	Quantity, in kgs
Silica Sand	111,153.26
Coke	35,614.29
Green Sand	21,400.00
Reclaimed Sand	18,833.33
CO_2 and Other Gases	9,764.95
Metals	
Mild Steel Scrap	367,780.00
Aluminum	346,888.63
Pig Iron	242,833.33
Ductile Iron	78,000.00
Stainless Steel	45,730.00
Bronze	9,030.53

Results

This study assessed the current condition of the metalcasting industry in the Philippines for the year 2017.

Concerning business registration, this study finds that 89% of the metalcasting companies in the Philippines are registered as corporations, while 7% are partnerships and 4% are single proprietorships. In terms of operations, 98% are independent, and 2% are captive or in-house. In terms of services offered, 57% are engaged in manufacturing, and 5% are accepting only jobbing works, while 33% are accepting both manufacturing and jobbing works services.

Table 1 shows that majority of the metalcasting companies are classified as small based on employment capabilities. As observed, a combined total of 71.1% of the workforce in the metalcasting industry are employed in medium and large metalcasting companies.

The average annual cost of local production in 2017 is shown in Table 2. The overall average annual cost of local-production in 2017 is P61,400,429.41.

Based on the study, the total number of human resource involved in the metalcasting industry from 46 respondent metalcasting companies in 2017 is 3546. Table 3 presents that 75% of the human resource are engaged in production, while 25% are part of support services.

The study also identified that 63% of the metalcasting workforce involved in production have formal training, while 37% acquired their skill through actual work experience and in-house training.

The metalcasting industry in the Philippines serves various other industries. Presented in Table 4 is the top 5 industries served by the sector in 2017.

Table 5 summarizes the most common raw materials used by the respondent metalcasting companies in 2017.

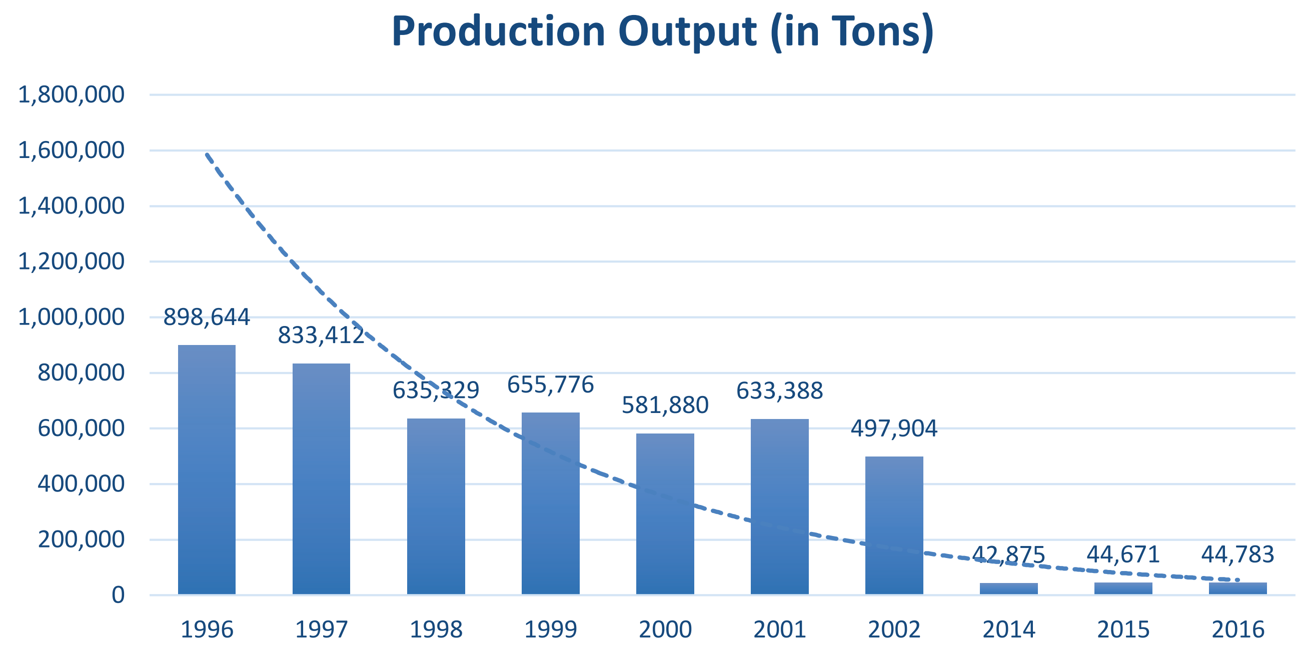

Figure 2. Philippine Metalcasting Industry: Production Output Trend

As far as business outlook is concerned, 72% of the respondent metalcasting companies believe that there is stiff competition in the metalcasting industry taking into account the influx of imported casting products specifically from China. Nevertheless, 50% of the respondent metalcasting companies believed that their company is improving.

Based on the study, the Philippine metalcasting industry is vouching primarily on the quality of products and services they provide and their company's good reputation, which is viewed as their strengths, while maintaining a stable financial resource is considered to be their weakness. The pressing concerns of the metalcasting industry are the high cost of production which is in the increasing trend, and the stiff foreign and local competition for market.

Discussion

The Philippine metalcasting industry is just a shadow of its former glory in terms of production and number of existing companies and foundries. Presented in Figure 2 is the declining production output of the metalcasting industry from 1996 to 2016.

This data reveals that the metalcasting industry is in its critical stage and interventions must be immediately done to revitalize it.

Based on previous studies conducted by the MIRDC, most of the micro and small metalcasting shops in the country opted to close due primarily to their incapability to compete in both local and global market. With the influx of imported casting products especially from China, faced with concerns on the high production expenses attributed to the high-energy cost in the Philippines, and a labor-intensive production process, micro and small metalcasting shops have no choice but to close down.

Demand for casting products is still high since they are viewed as the cheapest source of replaceable parts for industrial and agricultural machinery and equipment, automotive, construction machinery and equipment, metalworking, and cement and concrete works. Castings are essential building blocks of the Philippine industry. They are present in 90% of all manufactured and durable goods and 100% of all manufactured machinery. It is already a known fact that industrialized countries have strong manufacturing industries fueled by a vibrant metals and engineering industries in which metalcasting is a significant component.[7] This fact serves to emphasize the country's need for the resurgence of the metalcasting industry.

Based on the FGD conducted in 2017 by the MIRDC, for micro and small metalcasting companies to survive and grow, they have to take all possible vantage points. Being near to the industries in need of cast products gives the advantage of delivering the product faster than any other sources. On the part of its customers, the availability of replacement parts will, lessen the downtime of machines and equipment and in turn, maximize the output of industries served by the metalcasting companies. Metalcasting firms can also venture into specialized areas and establish their niches, such as in arts and decorative products, jewelry, and ornaments. In these areas, the design will hype up the value of casting products and those who could release an interesting design first will command the market.

For medium and large metalcasting companies, bringing down the cost of production might be futile if we look at inputs such as high energy and labor costs. At the moment, the focus of the energy sector is not on how to bring down the energy cost. Instead, their focus is how to meet the country's increasing demand for energy and devise a way for energy efficiency and conservation.[8] It means that all sectors need to reduce their energy consumption by implementing schemes to conserve energy whenever possible. Foundries are energy-intensive.[9] Currently, the most commonly used metalcasting equipment is the induction furnace and it needs a high amount of energy to produce the desired heat. It means that the metalcasting industry still has to endure the increasing cost of energy in the near future. On the labor component, the Philippines is experiencing a downtrend concerning people who are willing to learn the art of metalcasting as shared by key informants during MIRDC's 2018 FGD. There are limited foundries in the country for students and trainees to acquire this skills, and those who gain sufficient training are enticed to go overseas for greener pasture.

Conclusion

The micro and small metalcasting companies need all the assistance they can get to survive. Their primary concerns are access to financial resource and assistance, technology upgrade, and compliance with product standards and regulations.[7] The Philippine government through the Department of Trade and Industries (DTI) should formulate an incentive program to make the metalcasting business profitable for those who wish to engage in it. The issue on the deflating availability of metalcasters in the Philippines should also be addressed by developing programs that will produce world-class and globally competitive metalcasters in the Philippines.

Metalcasting companies should focus more on their process and business model rather than on inputs such as energy and labor cost. Metalcasting industries from countries such as Germany and the United States are utilizing developed and advanced processes with minimum labor and maximum production output. Research can be conducted on the most energy efficient foundry procedure.[10][11] The MIRDC is the primary government agency that can assist metalcasting companies in this area.

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Acknowledgment to the efforts of the MIRDC-TIPS Metalcasting Industry Survey Team 2017 for their diligence in data gathering headed by Mrs. Lina B. Afable

Ironmaking of Magnetite Sand Concentrates through the Rotary Kiln- Electric Arc Furnace (RKEF) Process

Agustin M. FUDOLIG[*1], Carla Joyce C. NOCHESEDA[*2], Bernardo V. BITANGA[*3], Juancho Pablo S. CALVEZ[*4], Dionisio R. RIVERAL[*5]

Abstract

This paper investigates the suitability of magnetite sand concentrate from Leyte, Philippines as feed material in the RKEF process for pig iron production. The pre-reduction stage follows the SL/RN process making use of coal from Semirara Island, Philippines as reductant. The charge materials are fed into an electrically heated laboratory rotary kiln at a magnetite sand:coal ratio of 1:0.8 and heated at 950 ^{o}C aiming for 80% metallization. An 80% metallized pre-reduced magnetite sand is smelted in an induction furnace wherein the resulting pig iron and slag were analyzed. Leyte magnetite sand's composition and particle size distribution approximates that used by the New Zealand Steel. An 80% metallization was achieved in 90 minutes' reduction while smelting behavior of reduced magnetite sand resulted to a pig iron which contained most of the Vanadium and a slag that captured most of the Titanium.

Keywords: Ironmaking, Magnetite sand, Rotary Kiln, Electric Arc Furnace, SL/RN

1. Introduction

The Philippines is rich in iron ore, particularly in the form of magnetite sand, and exports them after minimal value adding operations. Based on the Metallic Resource/Reserve Inventory of the Philippines, 2015,[1] the Philippines has around 1.56 Billion MT of iron ore with %Fe ranging from 5.7 to 64.4%. A significant inventory of magnetite sand deposits is found in Leyte amounting to 1.1 Billion MT which are present in the towns of MacArthur, Mayorga, Dulag, Javier, Tolosa, Abuyog, and La Paz.

The magnetite sand from Leyte contains titanium oxide[2] which may be detrimental as a blast furnace charge due to its low reducibility and fusibility.[3] Titanium-bearing minerals, however, have found use in blast furnaces where they protect the hearth and consequently, extend the blast furnace's campaign life.[4,5] Blast furnace burden consisting of sinters and pellets must contain less than 2.3%TiO_2 to have a manageable slag.[6] Charging of titanomagnetite in a blast furnace in Panzhihua, China is made possible with dilution of hematite from Australia.[7]

There is only one ironmaking facility in the world that makes use entirely of magnetite sand for its raw material source of iron: the New Zealand Steel (NZS) plant in Glenbrook, New Zealand. The magnetite sand used by the NZS mill also contains considerable amount of vanadium, which warrants their recovery. The ironmaking process employed at the NZS involves direct reduction of the magnetite sand without need for prior pelletization. Direct reduction follows the SL/RN process where magnetite sand together with coal and limestone are charged in a rotary kiln and heated up by a countercurrent gas flow targeting for at least 80% metallization of the iron. The hot reduced titanomagnetite, together with char, are fed into submerged arc furnaces forming two layers: the molten iron at the bottom which also contains the vanadium, and the upper slag layer containing the titanium and other oxides. The molten iron is first subjected to vanadium recovery prior to the steelmaking process.

The objective of this study is to investigate the suitability of the RKEF process to turn Leyte-sourced magnetite sand concentrates into pig iron.

2. Methodology

2.1 Materials

The magnetite sample used in this study was taken from the mining operations of Northern Access Mining, Inc. (NAMI) in Barangay Capangihan, Tolosa, Leyte [11°02′N 125°01′E]. Samples were gathered from around 60 cm deep from the surface and subjected to magnetic concentration using hand magnets on-site producing roughing magnetic concentrates. These roughing concentrates were transported to the

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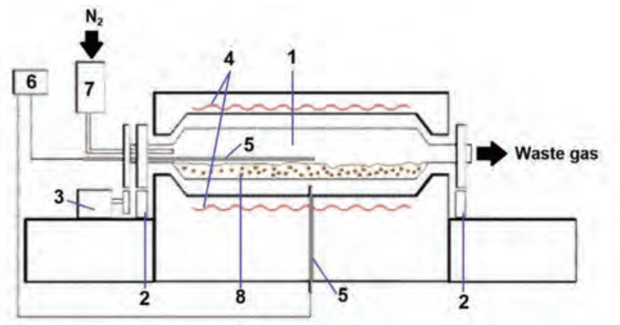

1 Rotary kiln
2 Roller bearing
3 Motor
4 Heating coils
5 Thermocouple
6 Temperature Controller
7 Flow meter
8 Charge

Figure 1. Experimental Setup for Reduction Tests

Mines and Geosciences Bureaus' (MGB) Metallurgical Research Laboratory and subjected to tabling to produce the final concentrates for reduction tests. Coal samples used in this study were supplied by the Semirara Mining and Power Corporation from its coal mining operations in Semirara Island, Antique, Philippines.

The final concentrate was analyzed for its chemical content by XRF/XRD, and for its particle size distribution by laser diffractometry. Coal samples underwent proximate and ash fusion analysis for comparison with the NZS's charge materials. The coal sample acquired from Semirara for the SL/RN process must be of the sub-bituminous type having 45% Volatile matters, 45% Fixed Carbon, and 10% Ash and meeting a minimum Initial Deformation Temperature (IDT) of 1150 °C.

2.2 Reduction Tests

The reduction tests for SL/RN process were carried out in a Salvis rotary kiln represented in Figure 1 at the Frankfurt Research Center of Outotec GmbH in Frankfurt, Germany. This stage aims at producing pre-reduced magnetite sand with a metallization degree, M°, of 80%, where M° is defined by

$$M^{o} = Fe_{metallic} / Fe_{total}$$

Where Fe_{total} is the total iron in a sample, including metallic iron and iron chemically combined with other elements such as oxygen, and $Fe_{metallic}$ is iron chemically uncombined and as cementite (Fe_3C). Reduction is caused by the carbon monoxide (CO) formed in the material charge of the SL/RN kiln by the Boudouard reaction of CO_2 from the reduction reaction with coal in the charge.

The experimental parameters made use of the NZS operating conditions. The charge to the rotary kiln is composed of 2.5 kg magnetite sand (as delivered) mixed with 2.0 kg of coal. The temperature inside the kiln is kept at 950 °C. Intermediate sampling at 15, 30, 45, 60, 90, and 120 minutes were conducted and the samples analyzed for Fe_{total} and $Fe_{metallic}$ content to determine the metallization profile. Nitrogen gas was passed through the kiln throughout the experiment, including the cooling down stage to 50 °C, to prevent re-oxidation of the reduced ore and to remove all product gases.

2.3 Smelting Tests

A second reduction batch consisting of 2.5 kg magnetite sand and 2.0 kg coal was conducted using the Salvis rotary kiln operating at 950 °C and processed for 90 minutes to produce 80% metallized pre-reduced magnetite sand. The reduced kiln discharge was magnetically separated and subjected to smelting tests at the Outotec Pori Research Center in Pori, Finland.

Smelting tests are carried out in an induction furnace using an MgO crucible as shown in Figure 2. A batch of feed material was made by combining the magnetic and non-magnetic fractions of the reduced magnetite sand and then mixed with Anthracite coal containing Fixed C of 83.4% at 1.1% of the feed and fluxed with $CaCO_3$ at 3.6% by weight of the charge. The charge is heated and kept for 10 minutes at 1650 °C. After cooling, the slag and pig iron are separated, weighed, and analyzed.

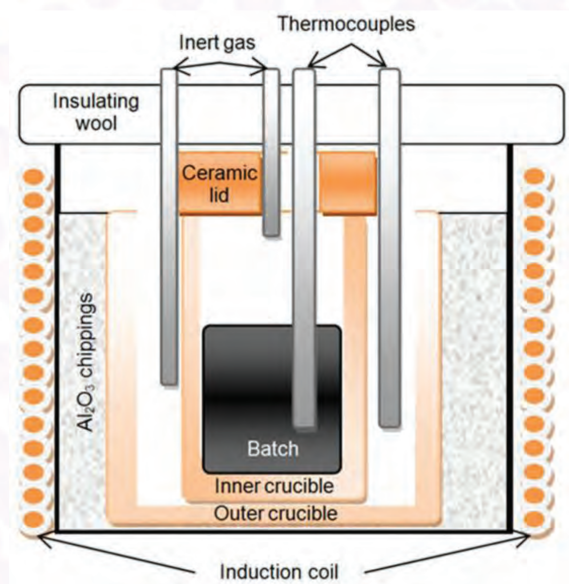

Figure 2. Experimental Setup for Smelting Tests

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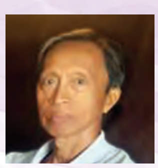

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3. Results And Discussions

3.1 Charge Material Characterization

The chemical analysis of the magnetite concentrate when pitted against typical feed charge for the NZS rotary kiln[8] is shown in Table 1. The total iron content of the magnetite sand from Leyte is about the same as that of NZS which is sourced from the Waikato river. Vanadium content of the Leyte magnetite sand is also high which may warrant its economic recovery, as is the case of the NZS. Titanium is also high which makes it not suitable to comprise 100% of the burden in blast furnace operations. All other mineral contents are generally the same except for Phosphorous, which is quite high for the Leyte magnetite and may pose some problems in processing the resulting pig iron into steel.

The particle size distribution of the Leyte magnetite sand is shown in Table 2. This particle size distribution would result to the following d-values: d20=118 µm, d50=163 µm and d80=230 µm. At the NZS SL/RN processing, the charge is not pelletized, thus particle size distribution is important since fine materials can cause accretion in the rotary kiln, impairing kiln productivity. Ideally, the particle size of magnetite sand feed in SL/RN rotary kiln should be 100% 100 µm or larger. The particle size distribution of Leyte magnetite sand would be around 90% 100 µm or larger and still meets the requirement for SL/RN process.

Analysis of the coal from Semirara is shown in Table 3 together with the coal from Rotowaro, New Zealand which is being used by the NZS. The initial deformation temperature (IDT) and Swelling index are important coal characteristics for the SL/RN process, in which Semirara coal meets the requirements. Semirara coal, however, has lower Fixed Carbon which may affect the reduction time or reduction temperature in the rotary kiln.

Table 1. Chemical composition of final magnetite (wt%)

	Fe tot	Fe^{2+}	TiO_2	SiO_2	Al_2O_3	MgO	CaO	Mn	P	V
Leyte	60.4	21.5	6.4	4.2	1.5	0.9	1.2	0.53	0.19	0.27
NZS[8]	58-59.5	24.0	7.7-8.1	2.0-3.0	3.8-4.8	2.8-3.2	0.4-1.3	0.49	0.06	0.31

Table 2. Particle size distribution of the final Leyte magnetite sand concentrate

microns	-63	63-90	90-100	100-125	125-150	150-200	200-315	315-400
fraction, %	2	3.32	4.06	14.74	17.12	28.43	24.74	5.59
% passing	2	5.32	9.38	24.12	41.24	69.67	94.41	100

Table 3. Analysis of Semirara coal samples (wt%)

	Water*	Volatile Matter**	Ash**	Fixed Carbon**	Sulfur	Initial Deformation Temperature	Swelling Index
Semirara Coal	34.9	47.1	5.8	47.1	0.64	1194 °C	0
Rotowaro Coal[8]	22.5	43.0	5.7	51.3	0.24-0.40	1120 °C	0

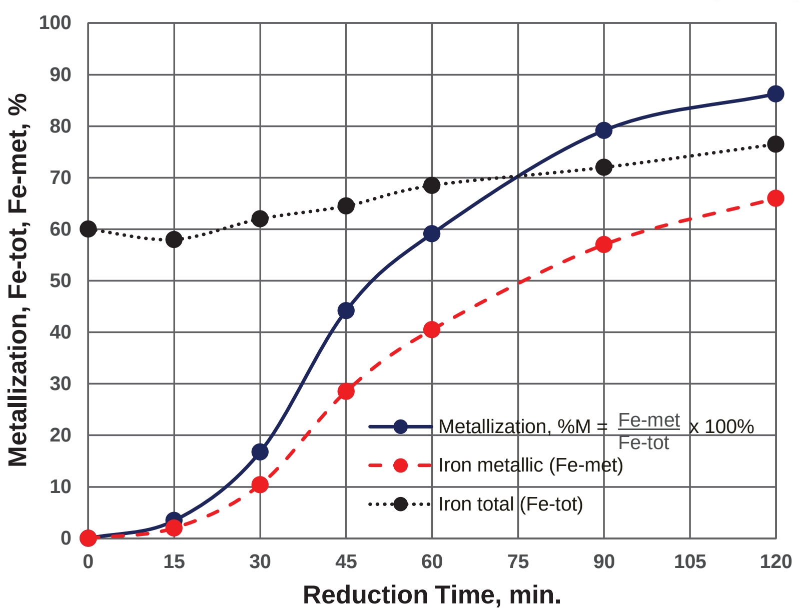

Figure 3. Metallization profile of Leyte magnetite sand

3.2 Reduction behavior

The metallization profile of the Leyte magnetite sand as a function of reduction time is shown in Figure 3. The formation of metallic iron (Fe-met) increases with reduction time achieving 80% metallization after 90 minutes of reduction. This behavior is typical of the NZS operations. It is important to note that the 80% metallized product, referred to as RPCC (reduced primary concentrate and reduced char) by the NZS, does not qualify for CDRI or HBI production for merchant DRI trade and must be processed further within the metallurgical plant.

Observation of rotary kiln discharge showed some small soft aggregates have formed. This may indicate potential problems of accretion due to the magnetite fines (around 10% of <100 µm) in the charge or due to the ash fusion temperature of the coal used. Nevertheless, the NZS operations also produce small and large lump accretions in its rotary kiln discharge. [8]

3.3 Smelting behavior of reduced magnetite sand

The composition of the reduced magnetite discharge fed to the induction furnace, the resulting pig iron and slag are shown in Tables 4 to 6.

As shown in Table 4, the reduced magnetite discharge still con-

Table 4. Composition of reduced magnetite discharge

Fe	FeO	TiO_2	SiO_2	Al_2O_3	MgO	CaO	MnO	P_2O_5	V_2O_5	C	S
60.8	19.5	7.5	3.5	3.4	1.7	0.99	0.79	0.50	0.48	0.23	0.10

Table 5. Composition of pig iron resulting from smelting

Fe	Ti	Si	Mn	P	V	C	S
Balance	0.10	0.10	0.61	0.28	0.36	1.4	0.05

Table 6. Composition of slag resulting from smelting

FeO	TiO_2	SiO_2	Al_2O_3	MgO	CaO	MnO	P	V	S
0.62	37.30	16.10	18.20	8.60	17.10	0.95	<0.01	0.06	0.09

tains iron oxides which indicates that these may be bound to titanium oxides and can only be reduced at much higher temperatures.

The smelting test using NZS parameters resulted to products with compositions which mirror those of NZS. As indicated in Table 5, a high percentage of the FeO in the charge has been reduced to metallic iron. Vanadium was mostly recovered in the pig iron wherein the yield is as high as 95%. Carbon in the pig iron is quite low, although 3% is expected in an industrial scale. The pig iron, however, needs to undergo dephosphorization in view of the high amount of Phosphorous.

As depicted in Table 6, the slag captured most of the Titanium, which is the same as that of NZS. This is a potential source of Titanium or Titanium oxides for use in some industries. The MgO in the slag may include those coming from the ore and a contribution of the MgO crucible being used, but is still less than that of NZS operations which stands at around 13-14%.[8] This may require fluxing strategy in order to produce slag with manageable viscosity since increasing the MgO decreases the viscosity of titanium oxide-rich slag.[9] As expected, the residual Vanadium in the slag is also very low which is not already feasible for further recovery.

Conclusions

The magnetite sand from Leyte responded well to the RKEF process, where reduction through the SL/RN process and its subsequent smelting produced pig iron. The resulting pig iron contains most of the Vanadium from the ore but is low in Carbon and high in Phosphorous, which may require subsequent dephosphorization during steelmaking. The slag captured most of the Titanium from the charge, but contains lower MgO which may warrant additional studies to ensure that proper slag viscosity is met. The coal from Semirara Island was also found to be suitable as a reductant in the SL/RN process.

Acknowledgment

This study is a collaborative research between the DOST-MIRDC and the MGB, and financially supported by the DOST-Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD) and the Board of Investments (BOI) of the Department of Trade and Industry (DTI). The authors express their deepest appreciation to the management and staff of the ECA Philippines, Inc. for the magnetite sand samples used in this study and to the Semirara Mining and Power Corporation for the coal used as reductant. We are grateful to Mr. Andre De Jong, Mr. Max-Dieter Laumann, and other personnel and staff of Outotec GmbH Oberursel, Germany, and Outotec Frankfurt Research Centre in Frankfurt, Germany for their valuable assistance and helpful discussions on the RKEF process.

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Design and Development of a Five-Coach Hybrid Electric Train

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Abstract

The crisis being faced by the Philippine transportation system is very evident in heavily congested traffic that results to a significant economic loss. A railway system is considered a robust solution to this crisis. The Department of Science and Technology-Metals Industry Research and Development Center (DOST-MIRDC) ventured in the local design and development of a five-coach Hybrid Electric Train (HET) to augment the number of train sets presently in service at the Philippine National Railways (PNR). The development centered mainly on two primary assemblies – the bogie and the coach. The specifications of the bogie assembly, which is manufactured abroad, was based on the results of the X-Ray Fluorescence Analysis, Chemical Analysis, and Hardness Test conducted on the existing PNR rolling stocks. The coach assembly, on the other hand, was locally made with design verification via computer-aided Stress Analysis. The coach dimension, 12 x 2.85 x 4.432 (LxWxH) in meters, can accommodate a crush load capacity of 220 passengers per coach. The hybrid train set runs on either diesel or electricity. It offers a wide range of benefits, including significantly lower emissions, increased efficiency, and decreased maintenance costs. To establish interface and interaction among the systems making up the train set, a control system utilizing Programmable Logic Controller (PLC) and Human Machine Interface (HMI) was installed. Testing in component and assembly level wrapped up the development securing the trainset functionality, but more performance tests and system certification should be done to assure its commercial viability and public safety.

1. Introduction

The Philippines, at present, is facing problems on worsening traffic congestion, air pollution, and unsafe roads and vehicles. In the report made by the Japan International Cooperation Agency (JICA) in partnership with the National Economic and Development Authority (NEDA), the daily losses caused by heavy vehicle congestion alone was estimated at Php 2.4 billion in 2014, a figure which is more than 10% of the gross regional domestic product [1]. It continuously grew to Php 3.5 billion in 2017 and would intermittently inflate to Php 5.4 billion come 2035 if it remains unchecked [2]. The World Bank has even supported these figures after vetting the Philippine infrastructures and noting these crises have collectively reduced the efficiency of the road sector in promoting economic growth and providing safe access in the country [3].

A railway system is considered a remarkable solution to this crisis with its roster of advantages, which include: safety, speed, capacity, comfort, environmental protection, traffic jam reduction, and economic feasibility. The claim is further supported by the continuous global growth of the rail market which is predicted to grow by 2.3% per year until 2020 [4] according to a study by the International Railway Journal (IRJ).

Currently, the country has a railway footprint of only 77 kilometers through the following lines: Manila Light Rail Transit System Line 1 and 2 (LRT-1 and LRT-2); the Manila Metro Rail Transit System (MRT-3); and the PNR. These rail lines can only serve roughly a combined total of 1.3 million passengers daily, just 9% of the total 15 million commuters in Metro Manila [5]. The insufficiency of active trainsets seems accountable for this problem, stretching even more in PNR where trains are inadequate, restricting them to one-hour interval trips. Importation has always been the country's resolve to this crisis, but with tight national budget, this outsourcing practice has become impractical and risky.

The DOST-MIRDC's project entitled, 'Development of a Prototype Trainset' aims to design and develop a local trainset for public use via the PNR. It is envisioned to improve the current operations of the PNR by raising the efficiency of its services while trimming the production and operational cost. This also aims to utilize and maximize the capabilities of local industries in the fields of metals and engineering by means of coming up with its own technology to address the needs of the transportation sector.

Upon project commencement in 2013, the DOST-MIRDC, together with the DOST-Project Management and Engineering Design Services Office (PMEDSO), be-

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Figure 1. Current situation of railway lines in the Philippines

Figure 2. MIRDC team visits South Korea for the bogie assembly

gan active coordination with the Department of Transportation (DOTr) through the PNR. The DOST–Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST–PCIEERD) monitored the over-all progress of the project until its completion in 2016

2. Methodology

The HET development has three stages: (1) systems assembly; (2) systems integration; and (3) testing and evaluation. The first stage mainly covered the identification of the bogie assembly suitable on Philippine rail tracks, as well as the development of coach assembly. The bogie assembly was manufactured abroad and procured in the light that its local fabrication requires intrinsic design and approval from an internationally-recognized certifying body. In aid of proper material identification, testing procedures, such as X-Ray Fluorescence Analysis, Chemical Analysis, and Hardness Test on PNR's existing rolling stock were conducted. The design of the coach assembly, on the other hand, underwent computer-aided stress analysis to verify its compactness and credibility. Actual testing of plates was also conducted to confirm if the material can withstand load acting on the bogie frame.

The second stage was the system integration aimed to establish interface and interaction among the systems making up the trainset. The electrical and control system to power and direct each trainset assembly was developed at this stage. The trainset utilizes both diesel-fueled generator set and battery to set up the hybrid energy system. This provides increased system efficiency, as well as greater balance in energy supply. For the control system, the trainset was automated through a Programmable Logic Controller (PLC) and Human Machine Interface (HMI). With the priority given to reducing downtime, the system includes CC-Link Central System for ease of maintenance and troubleshooting.

The third stage, i.e., functional testing and evaluation, covered component level and assembly level. Component level testing was conducted on every part of the equipment and system, whereas assembly level testing was performed after integration. A functional and safety test protocol was drafted to guide the engineers and technicians in conducting the tests.

3. Results and Discussion

3.1 Bogie Assembly

Based on the chemical analysis, the chemical composition of the sample rolling stock falls within Material No. 1.0601 with Symbol C60 as specified in STAHLSCHLUSSEL KEY TO STEEL, 2010, classified under Non-Alloy Quality Steels: Steels with average C > 0.55%. Test was conducted for Hardness using Wolpert Wilson M-295 Portable Hardness Tester. Figure 3 shows the location of the ten (10) hardness points.

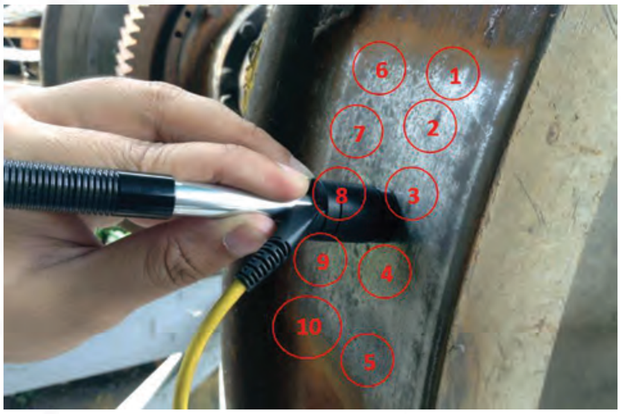

Figure 3. Hardness testing points on PNR's rolling stock

Table 1. Hardness test result for the PNR's existing rolling stock

Test Points	Wheel (outer steel rim)
1	40.80 HRC
2	41.10 HRC
3	39.60 HRC
4	41.80 HRC
5	41.80 HRC
6	36.80 HRC
7	37.70 HRC
8	39.20 HRC
9	39.30 HRC
10	38.80 HRC

The bogie assembly shown in Figure 4 was procured from Sung-Shin Rolling Stock Technology Ltd based in South Korea. The assembly consists of four (4) main parts: bogie frame, power and non-powered wheelsets, gears, and brakes.

The bogie is an H-frame type where the main frame and bearings are outside the wheels. Chevron spring and coil spring are used as the primary and secondary suspension, respectively. It is connected to the main chassis of the coach through a king pin, allowing the coach chassis to pivot to the bogie when running along a curvature. The bogie has a maximum loading capacity of 20 tons and a minimum turning radius of 50 meters.

3.2 Coach Assembly

The carbody structure utilizes mild steel hollow rectangular tubes, having the capability to withstand the loading without any permanent deformation. Jacking points are provided on the longitudinal members of each vehicle section at under frame. The inside of the frame uses galvanneal steel for the side and fiberglass reinforced plastic (FRP) paneling for the front, rear, and roof parts. The roof is slightly convex with an edge to the sides and forms a part of the steel frame

Floor construction is designed with fire retardant quality. It is made from marine plywood with rubberized matting to prevent slips.

The interior of the vehicle is fitted with accessories required for the comfort and the safety of the passengers. The interior architecture is of adequate strength and rigidity for their applications and has surfaces resistant to wear and rust. The interior panels are a combination of aluminum composite material and versa board. There are also spaces for wheelchairs in the passengers' compartment of the vehicles. Perimeter seats with reinforcements are installed on both sides of the car.

Each coach has one (1) passenger door opening per side, double-sliding, clear open width of 1000 mm on each door. The door system uses the electric/pneumatic door engine which is mounted under the door. The doors are controlled from the driver's cabin. When the doors open and close, the buzzer at the driver cab and passenger compartment are on. Above each door cover is mounted a signaling device indicating door closing and lights to automatically illuminate the door area when the door opens. The vehicle's movement may be prevented through interlocking when a door is not completely closed.

Windows are tempered flat glass equipped with wire mesh. Windows are normally closed. A driver's cab is located at the Pilot Coach. It is equipped with programmed HMI and equipment with various buttons to facilitate control of train operation.

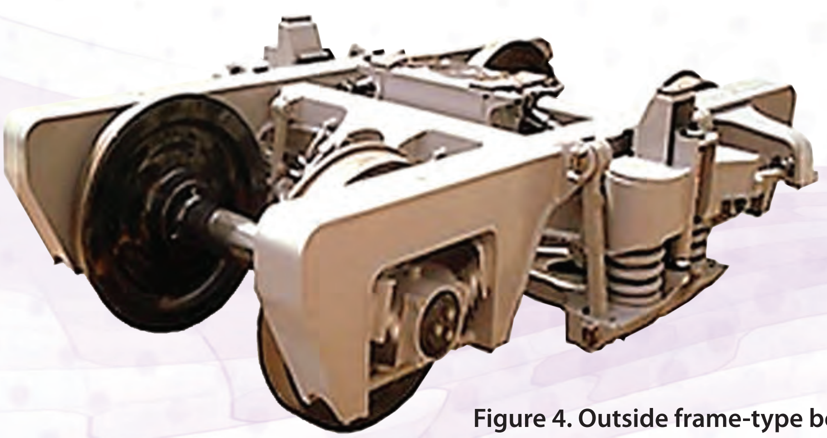

Figure 4. Outside frame-type bogie assembly secondary

Figure 6. Integrated assemblies of the Hybrid Electric Train

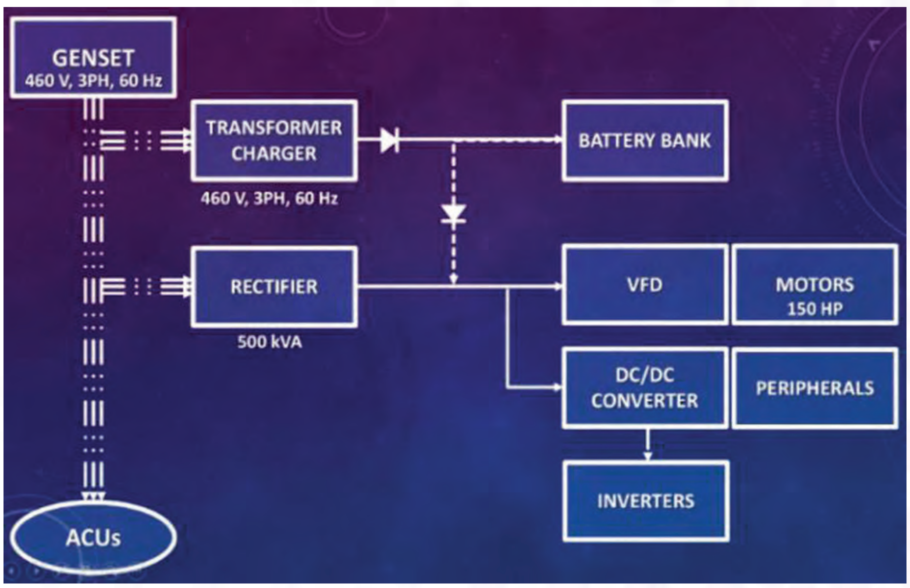

Figure 5. Hybrid energy source for the HET

Table 2. Diesel generator set

Prime Power (kVA)	569
Voltage (V)	440
Phase, Wire (φ)	3-phase, 4
Frequency (Hz)	60
Power Factor	0.8
Speed (rpm)	1800

Table 3. Battery bank assembly

Nominal Voltage (V)	12
Nominal Capacity (ah)	40 (@25°C)
Weight (kg)	13.5
Dimension (LxWxH,mm)	197 x 165 x 169

3.3 Electrical System

The diesel-electric power system using generator set and battery is employed as shown in Figure 5. This is to provide increased system efficiency as well as greater balance in energy supply.

The 500 kVA diesel generator set, installed inside the power coach, serves as the main power source of the trainset. The battery racks are composed of 260 units of lead acid batteries, positioned inside the power coach between the conductor's cabin and generator set room. Table 2 and 3 summarize the electrical specifications of the generator set and the battery bank assembly.

3.4 Control System

The whole train system is controlled by a Mitsubishi PLC and HMI. CC-Link Central System is employed to provide interface among systems. In using CC-Link System, the following can be achieved: (1) all Variable Frequency Drives (VFDs) are networked for remote control and monitor directly to the main PLC; (2) all input/output devices such as switches, relays, and push buttons are directly connected and/or terminated to remote I/O modules to reduce wires and cabling issues; and (3) PLC and HMI are connected to a common hub and can be accessed remotely through a SCADA system. Base content of the control panel board is arranged as presented in Figure 7.

Figure 7. Control panel board

3.5 Assembly Integration

The prototype trainset is composed of five (5) coaches. Each coach has two (2) motors underneath and is carried by two (2) bogie assemblies. Figure 6 shows the fully developed prototype trainset.

The fabricated coupler in Figure 8 has a pivot anchor EFG-2 with rubber spring elements for transmission of compressive and tractive forces to the train body. Horizontal and vertical movements are also ensured by the pivot anchor. It also has stiff tube between the two pivot anchors which is connected by socket joint kits. Automatic couplers are also installed at both ends of the vehicle with an anti-climbing mechanism for additional safety purpose.

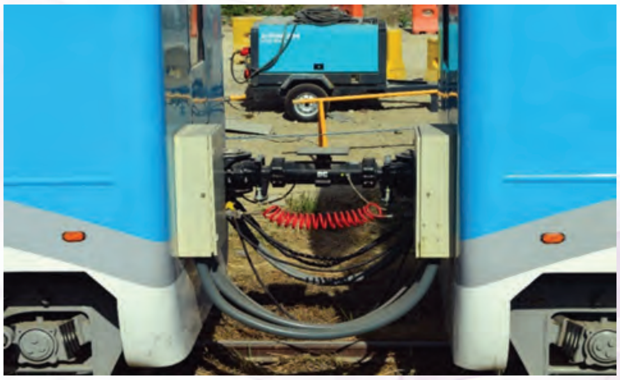

Figure 8. HET semi-permanent coupler

Table 4. General technical specifications of the HET

Maximum speed (kph)	80 (computed)
Capacity per coach (passenger)	175 (design load) 220 (crush load)
Supply voltage (Vdc)	650
Track gauge (narrow, m)	1.067
Gross weight per coach (tons)	25.5
Coach dimension (LxWxH) (m)	12 x 2.85 x 4.432
No. of coaches	5 (1 pilot, 1 power, 3 passenger) (power coach is not rideable)
No. of bogies per coach	2
No. of powered bogie per coach	2
Maximum track grade (%)	1.2
Minimum turning radius (m)	50
Motor rating (hp)	125
Gear ratio	1:4

Table 4 summarizes the technical specification of the designed and developed HET.

3.6 Functional Testing

Preliminary functional testing of the generator set is summarized in Table 5. The target parameters – 500kVA, 460VAC, 3 phase, 60Hz, 1800RPM –were achieved. The temperature was within desired limit and the engine cooling system prevented overheating.

The activation of the battery bank assembly was also assessed to determine if it aids the generator set during high power operation. The power sharing between the generator set (genset) and the battery is illustrated in Figure 9. As seen from the graph, once the genset reaches the 250-kW mark, the battery starts to provide power. This configuration protects the genset components from overproducing power and saves diesel in operation. The total power of sharing is shown in Figures 9 and 10.

4. Summary and Conclusion

The DOST-MIRDC project team has successfully designed and developed the HET that aims to augment the current fleet of the PNR. The train consists of five (5) coaches: four (4) of which are passenger coaches, while one (1) coach serves as the power coach. The train set has a hybrid transport system that runs on either diesel or electricity, and of-

Table 5 Generator set testing results

Run No.	Time	Current (A)	Voltage (V)	Power (kW)	Frequency (Hz)	SP	Temp (°C)	Remarks
1	16:43	107	465	74	60	1800	56	FWD MOVE
	16:43	174	467	128	60	1800	56	FWD STOP
	16:44	183	467	136	60	1800	56	BWD MOVE
	16:44	74	464	61	60	1800	58	BWD MOVE
	16:45	85	464	50	60	1800	57	BWD STOP
2	16:45	136	464	86	60	1800	56	FWD MOVE
	16:46	75	463	55	60	1800	56	FWD STOP
	16:47	91	463	60	60	1800	56	BWD MOVE
	16:48	194	467	141	60	1800	56	BRAKING
	16:50	175	467	128	60	1800	57	BWD STOP
3	16:55	196	467	82	60	1800	58	FWD MOVE
	16:56	72	463	55	60	1800	57	FWD STOP
	16:57	84	463	64	60	1800	56	BWD MOVE
	16:57	74	464	53	60	1800	56	BWD STOP
GEN SET TRIPPED UNDERFREQUENCY								

fers a wide range of benefits including significantly lower emissions, increased efficiency, and reduced maintenance costs.

The development centered mainly on two primary assemblies – the bogie and the coach. The bogie assembly was manufactured abroad with its specifications determined from the results of the X-Ray Fluorescence Analysis, Chemical Analysis, and Hardness Test on existing PNR rolling stocks. The coach assembly, on the other hand, was locally made with design verification via computer-aided Stress Analysis. The coach dimension (LxWxH) in meters is 12 x 2.85 x 4.432 capable of embarking a crush load capacity of 220 passengers per coach. PLC and HMI were installed to establish an interface among the systems.

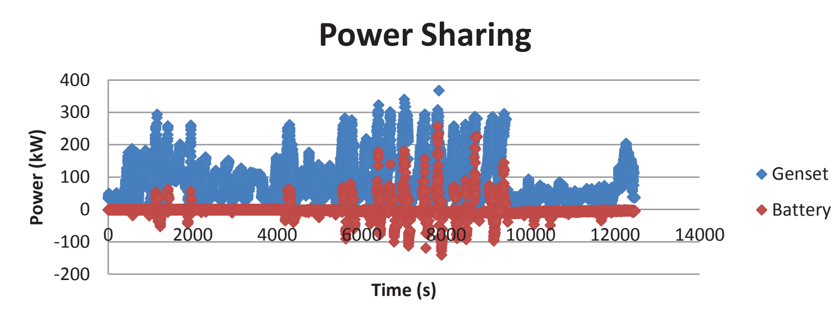

Figure 9. Power sharing of generator set and battery

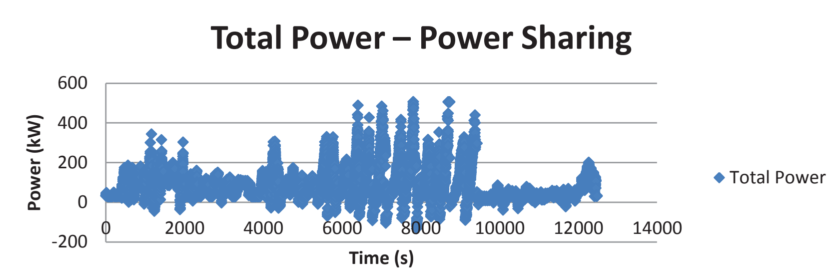

Figure 10. Total power after combining power from generator set and battery

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Jewelry Investment Casting Process Review: A Contract Research Project with T.R. Santi Enterprises

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Abstract

This contract research investigates and describes the process of jewelry making by investment casting. The study reviewed the various processes involved and made several recommendations to reduce the various defects encountered. The basic investment casting operations should be standardized to current best practices, while critical process equipment for investment mold burnout and melting and casting are recommended for upgrading to mainstream technologies.

Keywords: investment casting, creative industry, jewelry, emblems

I. Introduction

The Philippine creative industry embraces a wide range of sub-clusters, such as music, fashion and design in general, multimedia, architectural heritage and its preservation, literature, arts, and crafts, among others. This industry, which showcases individual creativity, excellent workmanship, and product innovation, is one major contributor to economic growth. Filipinos have a good global reputation in the creative industry. What adds value to this industry is that it allows a specific region to uphold its unique culture and traditions. Although technology steadily evolves through the years, the industry continues to provide local job opportunities as processes involved still require human skills, talent, and passion.

The country continues to boost its sense of nationalism by pursuing arts and crafts that reflect ancestral inheritance, and one dependable field in the creative industry is jewelry making which makes use of the metalcasting technology.

One of the major domestic players in jewelry making is T.R. Santi Enterprises which has its roots way back in the 1890s when the first SANTI metal emblem jewelers were making buttons and uniform regalia for the army of General Emilio Aguinaldo. The company was founded by Teofilo Santi only in the late forties. T.R. Santi has grown to be among the most experienced makers of class rings, emblems, pins, and medals in the country, catering to the requirements of elite military institutes like the Philippine Military Academy (PMA), the Philippine National Police Academy (PNPA), and the Philippine Merchant Marine Academy (PMMA). The company eventually expanded their product line to include wedding rings that are customized and designed uniquely for each customer. Shown in Figure 1 are some of T.R. Santi's creations.

Figure 1. Samples of TR Santi's products

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Process improvement and optimization are key considerations to ensure that resources yield excellent turnover in terms of product quality and quantity. Small intricately designed products are the outputs in jewelry making. The processes involved in jewelry making, from design to quality control, have become complex and multifaceted with the utilization of a combination of machine and handworks.

Investment Casting Process

The investment casting process is the prevalent process used in the production of jewelry. Investment casting is a highly versatile process: simple and intricate shapes can be produced in small or large quantities. Metallic items such as engineering components and jewelry are often most economically produced through the metalcasting process. However, investment casting is not a simple process. There are many metallurgical principles that must be considered and complied with in the entire process. The processes are made complicated by the small size of jewelry casting that makes process control more difficult.

The most visible step in investment casting is the melting and pouring stages. However, these are already the final steps in the multi-stage process. Every step can potentially contribute to casting defects, which may or may not interact with each other to compound a problem.

Investment Casting Process Review

The typical steps in the investment casting process are as follows:

1 - Designing
2 - Making the master model
3 - Making the rubber mold
4 - Producing the wax patterns
5 - Assembling the tree
6 - Investing the mold
7 - Dewaxing the flask
8 - Burnout
9 - Melting
10 - Casting
11 - Cooling
12 - Cutting the cast piece off the tree
13 - Assembling and finishing of the jewelry

Figure 2. Common casting defects on cast emblem rings

Except for the last two steps, all other steps directly or indirectly involve understanding of metallurgical concepts to attain good quality products.

Optimal productivity is usually hindered by a number of major factors like unavailability of standard procedures, mishandling of materials, poor condition of equipment, inefficient energy management, lack of skills to operate machine/equipment, and high defect rate, to name a few. T.R. Santi inked a contract research agreement with the DOST-Metals Industry Research and Development Center (DOST-MIRDC) to establish a standard procedure that is more economical, practical, and simple.

2. Methodology

The research project was implemented based on a series of activities focusing on process review and improvement aimed to reduce defects, increase quality of the products, and achieve technology upgrading.

In the case of the T.R. Santi, most of the defects noted are cracks, pitting, brow/pinholes, casting discontinuities, defective surface, and detailing, among others (Figure 2). Such defects are casting process-related and may significantly be reduced through process improvement and standardization.

An inventory of the replaced rings in 2015 was conducted and the reasons given for their return and subsequent replacement were ranked. The results are summarized in Table 1.

As shown in Table 1, majority of the rejects were caused by casting defects followed by defects brought about by other processes, such as design, finishing, and stone setting.

The DOST-MIRDC team reviewed the processes and identified those that require the most intervention. A survey of the defects encountered was conducted and the respective process steps where they originated were identified.

Most of the defects were metallurgical in nature. The project team then focused on the following steps: producing the wax patterns, investing the mold, dewaxing the flask, burnout, and melting and casting.

Cause of Defects	Number of Samples
Casting Process	316
Wrong Specifications	5
Design and Other Processes	184
Total	505

Table 1. Summary of the number of defective rings and cause of defects

Figure 3. Wax Assembly

2.1. Production of the Wax Patterns

Wax patterns are produced by wax injection. The handling of wax materials during the melting, conditioning, and injection stages have a direct effect on the quality of wax patterns produced. The correct handling procedures can eliminate various casting defects attributable to wax pattern preparation. It is important to note that all materials used in investment casting are part of a system that must work together to make a quality casting. Pattern wax is the starting point in the production of an investment casting. Therefore, the final casting can only be as good as the wax patterns produced.

Pattern waxes are blends consisting of the following components:

- Petroleum waxes
- Natural waxes
- Natural and synthetic resins
- Organic fillers

The first stage in wax pattern production is melting. Overheating can oxidize some of its component materials and can cause the wax to become too brittle or rubbery depending on the preparation. Some components in the wax are sensitive to temperature when overheated. The fillers can separate from the base wax and result to dimensional variation, poor flow and surface defects in the wax pattern. It is important to follow and maintain the wax manufacturer's recommendation on the meltdown temperature. For most pattern waxes, the meltdown temperature is between 185-1950F and must not exceed 2100F. Constant agitation during meltdown is also required.

For the required meltdown temperature to be achieved and maintained, the wax melter temperature controller must be in good working order and regularly calibrated. The project recommended for the aforementioned measures.

2.2. Investing the Mold

There are two basic types of investment powder used for jewelry production. The difference is mainly in the bonding material used, while the refractory material is the same – a mixture of quartz and α-cristobalite. The bonding material used is calcium sulphate, also known as gypsum, and phosphate. Gypsum-bonded investment are typically used for casting gold and silver alloys, while phosphate-bonded investment are used for casting at higher temperatures such as for palladium, white gold, and platinum alloys. Different investment powder manufacturers also include some proprietary components to control processing properties such as rate of setting and the properties of the set investment.

There are also special grades of investment containing additives that allow casting with gemstones already in place. Stone-in-place casting offers the advantage of lower labor cost, resulting to savings in the range of 50-80%.

These investment powders are set only with the addition of water. However, the process is not as simple as it seems. In fact, making the investment mold is one of the

Figure 4. Investing wax pattern

critical steps in the investment casting process. This stage consists of a sequence of simple operations that must be strictly adhered to. Defects ranging from surface imperfections to cracked molds can result. The sequence of steps for investing the flask is as follows:

1. Weigh of the investment powder and water. Both water and powder must be weighed accurately – graduated cylinder for water and measuring scales for the powder.
2. Mix the powder in the water. The powder must always be added to the water to facilitate good mixing and to prevent the formation of lumps.
3. Vacuum the mixture. The mixing process inevitably introduce some air into the slurry that must be removed.
4. Filling the flask, to fill the flask around the wax tree.
5. Vibrate the flask under vacuum. To eliminate any remaining air bubbles that may have stuck to the wax patterns. Air trapped in the wax patterns will prevent good replication of the details.
6. Let the flask stand for the investment to set. The investment needs time to set and strengthen. Moving of the flask during this stage subject it to the risk of cracking.

Figure 5. Experimentation on investment powder at the DOST-MIRDC laboratory

In investing the mold, setting time is of utmost importance and is the basis in performing all the operations involved in creating the invested flask or mold. Setting of the investment slurry is a chemical reaction causing the hydration of calcium sulphate hemihydrate. The process is strongly influenced by both the investment powder and water, particularly its composition (mineral content) and temperature. Most investment are designed to be used with deionized water at 200C / 680F temperature. Cold water will result to slow setting time, while hot water will speed up the set time.

Since most jewelry casting houses do not use deionized water, a simple test is required prior to each batch to establish the setting time of the investment given the condition of the available water. The test, called "gloss-off" test, establishes the setting time and the available working time for the investment. The working time should be 1 minute less than the "gloss-off" time. The sequence outlined above must be finished with the working time of the investment. A typical gloss-off time of most commercial powders is 9-10 minutes. The working time should then be 8-9 minutes. A sample procedure for a powder with a gloss-off time of 9 minutes can be as follows:

1. Powder to water ratio: 100:38
2. Mixing time: approximately 3 minutes
3. Vacuuming time: approximately 1.5 minutes
4. Pouring the slurry in the flask: approximately 1.5 minutes
5. Vacuuming and vibrating the flask: approximately 2 minutes

Total working time: 8 minutes

The working time must be followed, not too fast or too slow. Too fast working time will allow the slurry to sit for a longer time before setting. The water could separate at the interface between the wax and investment and to form watermark defects.

Figure 6. Testing of electric burnout oven

The DOST-MIRDC team tested a sample of the T.R. Santi's investment powder at the Center's laboratory to establish its gloss-off time. For T.R. Santi, a written guideline was also prepared for conducting the gloss-off test and for the proper procedure in investing the mold.

2.3. Dewaxing and Burnout

Dewaxing is the process of removing the wax pattern from the mold. While burnout is the process of removing the last traces of wax in a burnout oven and preparing the investment mold for casting. The final characteristics of the mold, such as its strength, depend on the burnout cycle selected. A typical burnout cycle is as follows:

- Dewaxing at 150ºC for 1 hour
- Slowly ramp to 250ºC in 1 hour
- Hold at 250ºC for 2 hours
- Ramp to 450ºC in 1 hour
- Hold at 450ºC for 2 hours
- Ramp to 730ºC in 1.5 hours
- Hold at 730ºC for 3 hours
- Cool down to casting temperature
- Hold at casting temperature for at least 1.5 hours before casting. The casting temperature chosen depends on various parameters, such as the type of alloy, section thickness of pieces to be cast and other factors.

Bigger flasks typically need a longer burnout cycle, while smaller ones involve a shorter cycle time.

The reason for the elaborate burnout cycle is to ensure that the investment powder does not develop stresses that could lead to cracking during the heating process. As the investment is heated, several chemical transformations take place accompanied by volume expansion or contraction. Heating too fast or cooling too slow can result to build up of stresses that may result to cracking of the investment.

For this project, the DOST-MIRDC team recommended the upgrading of T.R. Santi's burnout furnace – one that facilitates accurate and repeatable temperature control.

The DOST-MIRDC also inspected an existing electric burnout oven of T.R. Santi that has been unutilized for at least three (3) years, for testing and evaluation. The existing burnout furnace is found to be in perfect working condition and have accurate temperature control. Its capacity, however, is too small for T.R. Santi's requirements.

2.4. Melting and Casting

There are three basic methods in melting metal alloys for jewelry: gas torch, resistance heating and induction heating. Torch uses propane, natural gas or oxy-acetylene, often in combination with oxygen to produce a flame hot enough for melting metals. In the Philippines, many jewelry-casting houses still use this method. In modern jewellery factories, however, this method is no longer used because of the difficulty in control and repeatability of process parameters such as temperature.

Electrical resistance heating is another popular melting method until the recent introduction of induction heating. Induction heating was already mainstream in industrial casting houses and only recently introduced to jewelry application. Induction melting is very fast, induces stirring of the molten metal and allows easy atmosphere control. Most modern casting machines use induction technology due to its ease of control.

Melting is considered to have the highest "metallurgical" content among the steps in investment casting. Various defects and problems can arise if the basic principles are not followed. Some of the guidelines for melting are the following:

1. As with regular casting of industrial parts, the required amount of precious metal should be calculated prior to melting.
2. The amount of recycled scrap should be as low as possible. Due to cost consideration, the use of all virgin charge is not economical. However, scrap metal should not exceed 50% of the charge.
3. Any scrap to be remelted should be clean and free from oxides and investment powder remnants.

Figure 7. Casting and burnout

4. As mush as possible, the charge should be in grain form.
5. Prior to casting, the molten metal should be stirred first.
6. Upon reaching the casting temperature, the metal should be poured as soon as possible to prevent oxidation losses of alloying elements.
7. The required casting temperatures must be followed – both the metal temperature and the flask temperature.

For this project, the DOST-MIRDC team recommended the upgrading of T.R. Santi's torch melting to induction melting.

3. Results and Discussion

The various recommendations were consolidated into a set of investment casting process guidelines for T.R. Santi to follow. Likewise, the team assisted T.R. Santi in applying for facility upgrading through the DOST SETUP program, particularly for the casting machine and the burnout furnace. It is recommended that T.R. Santi upgrade to an induction centrifugal casting machine and digital burnout furnace.

4. Conclusion

The seemingly simple and traditional jewelry manufacturing industry requires the application of modern metallurgical engineering practices for their processes to be effective and efficient – and for the industry to be competitive.

The sound casting practices applied to industrial and engineering ferrous and non-ferrous metal parts similarly applies to casting of precious metal alloys. In fact, the small size of jewelry pieces and their high requirements on surface finish magnifies the negative effects of miscalculations and careless practices. Careful review of the processes is needed before adjustments may be recommended and applied.

In summary, the project first recommended the standardization of basic process and acquisition of critical equipment to mainstream technologies.

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Upgrading of the DOST-MIRDC Heat Treatment Facility

Nelson L. TUMIBAY*1

Abstract

The 'Upgrading of Heat Treatment Facility' of the DOST-MIRDC is a project that aims to build the Center's competence in heat treatment technology in support of the metals and engineering industries. The first activity involved the assessment of the vacuum furnace, followed by the refurbishment proper. Test runs and training of heat treatment personnel were conducted. Various metal grades were heat treated to evaluate their response to the recipes as carried out using the furnace. Results showed that tool steels D2 and H13 readily hardened in the refurbished furnace while 1045, 4140, and O1 did not. The addition of refurbished vacuum furnace in the Heat Treatment Facility of Surface Engineering Building will contribute to the capability of the DOST-MIRDC in terms of heat treatment services. The refurbished Chugai Ro Vacuum Heat Treatment Furnace is a welcome addition to the Center's existing ULVAC Vacuum Heat Treatment Furnace. With the availability of two vacuum furnaces, the DOST-MIRDC can readily address concerns about heat treatment, R&D activities, processing of jobs, and industry assistance requiring vacuum conditions. However, the existing specification can still be improved if satisfying the requirements of standards is desired (e.g., installation of real time leak detector, acquisition of helium leak detector, and retrieval of operations data for monitoring).

Keywords: heat treatment, vacuum heat treatment, furnace refurbishment, functional testing, performance testing

1. Introduction

Heat treatment is the controlled heating and cooling of metals in order to alter their microstructure which affects mechanical properties. By following particular heating and cooling procedures, the desired properties are achieved and performance in specific application is enhanced. Heat treatment is carried out more commonly through the use of atmosphere or conventional furnaces. However, due to the nature and design of such furnaces, heat treated samples are susceptible to surface quality degradation - oxidation, decarburization, and other adverse chemical reactions. In order to prevent such phenomena from occurring, the environment inside the furnace chamber must be practically devoid of reactive matter. To ensure such condition is achieved, vacuum condition must be established. Vacuum heat treatment technology addresses maintaining of surface quality of metals during the heat treatment process.

The Department of Science and Technology-Metals Industry Research and Development Center (DOST-MIRDC) acquired a vacuum heat treatment furnace with utilities in 2012 to cater to enterprises in the metals and engineering industries with vacuum heat treatment process requirements. A year earlier, the Center received an old, non-operational Chugai Ro Vacuum Heat Treatment furnace as a deed of donation from a heat treatment company with the agreement that it will be refurbished and utilized by the Center.

The upgrading of the heat treatment facility of the DOST-MIRDC aims to build the Center's competence in heat treatment technology in support of the M&E industries. Specifically, it intends to achieve the following: (1) strengthen the vacuum heat treatment services of the Center through the refurbishment of a vacuum furnace unit, and (2) upgrade the existing electrical system to meet the operations requirement of the Heat Treatment Facility and Surface Engineering Facilities.

2. Methodology

2.1. Furnace refurbishment

2.1.1. Preliminary inspection

A preliminary inspection was conducted to come up with an inventory of components and their corresponding conditions as well as recommendations and suggestions. A set of compiled manuals for the Chugai Ro furnace was also furnished by the donor.

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2.1.2. Vacuum heat treatment furnace assessment

The assessment was performed with assistance from an entity with vacuum system expertise. Assessment was completed with the following activities: vacuum pumps overhauling and offline testing; chamber disassembly; cleaning and parts replacement; CDA and N2 lines and instrument replacement; heater system disassembly; cleaning and parts replacement; vacuum system disassembly; cleaning and parts replacement; cooling system disassembly, cleaning and parts replacement; electrical integration and assembly; energizing and I/O check; functionality check; leak test; vacuum condition checking; pressure control test (P/Q); heating test; thermoprofiling; and alarm and safety interlock checking.

Afterwards, the furnace was transferred from its temporary storage in MWTD-2 to the Surface Engineering Building, as shown in Figures 1 and 2.

Figure 1. Transfer of donated vacuum heat treatment from its storage to Surface Engineering Building.

Figure 2. Civil works of the flooring which will serve as permanent location of furnace at Heat Treatment Facility.

2.1.3. Gas (Nitrogen) Pipeline Installation

As shown in Fig. 3, nitrogen gas was introduced to the chamber to allow the furnace to achieve sudden cooling. In a hardening process for steels, quenching is the most critical step since it will determine whether enough re-

Figure 3. Installation of nitrogen line to the furnace for quenching of heat treated metals.

Figure 4. Installation of pumps (one as spare) for the cooling water system.

quired microstructure is formed to meet or go beyond the required hardness.

2.1.4. Cooling water line system installation

Pumps were installed so that water is available to cool down all the equipment during the heat treatment process. This is shown in Fig. 4.

Figures 5 and 6. Assessment and overhauling of rotary pump and booster pump.

2.1.5. Booster pump and rotary pump installation

The first activity was functional testing of the rotary pump and booster pump. Testing included vacuum capability and leak testing. Subsequently, intensive check-up of internal parts was conducted (Figure 5 and 6).

2.1.6. Testing

The system was powered on to start the functionality testing after parts completion and system assembly. This step determined the status of each sub-system such as temperature control system, cooling system, vacuum control system, safety system, and utilities control.

After functionality testing, performance testing followed. Important machine capabilities were determined at this stage, such as maximum temperature, heating up time, temperature uniformity, ultimate pressure, pumping down speed, cooling speed, leak test, pressure build up check, and actual vacuum heat treatment of DOST-MIRDC provided workpieces.

Figures 7 and 8. Orientation and training of Heat Treatment personnel on the operations of Chugai Ro vacuum heat treatment furnace.

2.1.7. Test Run and Personnel Training

Once the whole system had been energized, the vacuum systems specialist trained the Heat Treatment personnel on the furnace operations and end user maintenance. The procedure was documented to serve as official training material for the furnace (Fig. 7 to Fig 11).

Figures 9 and 10. Touch screen control panel showing the status of the systems of vacuum furnace. Peeking through the sight glass shows glowing inside the chamber at elevated temperature.

Figure 11. Heat Treatment personnel conducting hardness testing on heat treated samples to confirm transformation of microstructure and achieving desired hardness.

Figures 12 and 13. Erecting of MERALCO posts by accredited service provider. Putting up of electrical Installation inside the building.

2.2. Electrical upgrading

In order to meet the specific objectives, the project sought to upgrade the electrical design and installation at the Surface Engineering Building in order to carry load requirements of transferred and newly installed equipment including the vacuum heat treatment furnace after its planned refurbishment (Fig. 12 and Fig. 13).

3. Results And Discussion

3.1. Heat Treatment Trials Using the Chugai Ro Furnace

Three material grades are commonly encountered at heat treatment facilities, namely: AISI 1045 (medium carbon steel), AISI 4140 (chromium-molybdenum low alloy steel), and AISI O1 (oil hardening cold work tool steel). These materials have been subjected to hardening heat treatment using a specified heat treatment recipe (Fig. 9) utilizing the Chugai Ro Furnace. The activity has a two-fold purpose: to evaluate the three metal grades after vacuum hardening and to determine if the refurbished furnace can still operate and soak at high temperature of 860ºC.

Another set of commonly encountered steel grades, AISI D2 and AISI H13, were heat treated using a different recipe (Fig. 14). AISI D2 Tool Steel is a high carbon - high chromium air hardening tool steel. On the other hand, H13 Tool Steel is a chromium-molybdenum hot work steel.

Table 2 summarizes the response of the metal grades to conventional, vacuum, or both.

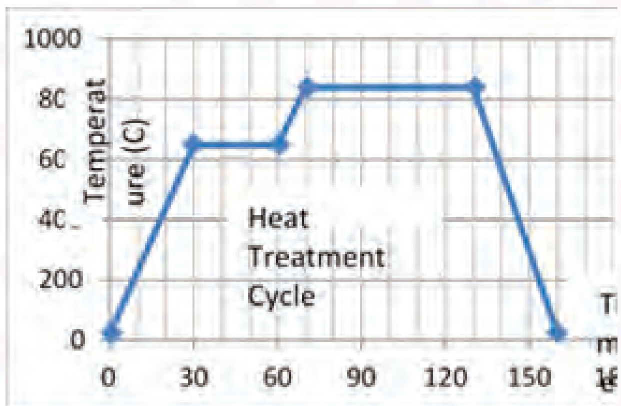

Figure 14. Heat treatment recipe used on AISI 1045, AISI 4140, and AISI O1 steel grades.

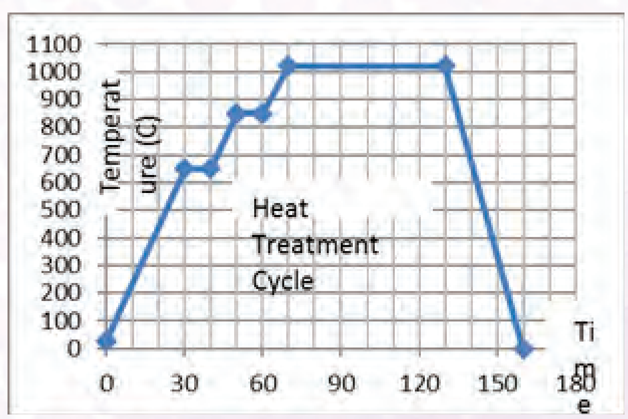

Figure 15. Heat treatment recipe used on AISI D2 and AISI H13 steel grades.

Table 2. Results of hardening heat treatment of some commonly received steel grades.

MATERIAL	SIZE (inches)	HARDNESS RANGE (HRC) AFTER QUENCHING	REMARKS
AISI 1045 (carbon steel)	3x3x3	60-65	Hardened by conventional heat treatment (oil quenching)
	4x4x4	60-65	
	5X5X5	60-63	
AISI 4140 (low alloy steel)	3x3x3	50-55	Hardened by conventional heat treatment (oil quenching)
	4x4x4	47-50	
	5X5X5	55-60	
AISI D2 (tool steel)	3x3x3	62-63	Hardened by conventional heat treatment (oil quenching) and vacuum heat treatment (nitrogen gas quenching)
	4x4x4	60-63	
	5X5X5	61-63	
AISI O1 (tool steel)	3x3x3	58-60	Hardened by conventional heat treatment (oil quenching)
	4x4x4	62-64	
	5X5X5	58-60	
AISI H13 (tool steel)	3X3X3	52-55	Hardened by conventional heat treatment (oil quenching) and vacuum heat treatment (nitrogen gas quenching)
	5X5X5	50-51	

Figures 16 and 17. NSTW advertisement featuring Surface Engineering which includes vacuum heat treatment furnace. Guests listening attentively during Open House.

4. Conclusion

Activities for the upgrading of the heat treatment facility involved assessment of the vacuum furnace. This is followed by the refurbishment proper, along with the installation of utilities including the cooling water system, the nitrogen pipeline for quenching media and pneumatics, and electrical tapping. After refurbishment, test runs were conducted parallel with the training of heat treatment personnel on furnaces operations and end user maintenance. Various metal grades were also heat treated to evaluate their response to the recipes as carried out using the furnace. Results showed that tool steels D2 and H13 readily hardened in the refurbished furnace while 1045, 4140, and O1 did not. For the electrical system, a new electrical plan which considered acquired new equipment and future expansion became the basis for the electrical upgrading.

The refurbished Chugai Ro Vacuum Heat Treatment Furnace is a welcome addition to the Center's existing ULVAC Vacuum Heat Treatment Furnace. The DOST-MIRDC promoted the facility to the industry via the National Science and Technology Week (NSTW) exhibitions (see Fig. 16 and 17). With the availability of two vacuum furnaces, heat treatment R&D activities, processing of jobs, and industry assistance requiring vacuum conditions can be addressed. However, the existing specification can still be improved if meeting the requirements of standards is desired (e.g., installation of real time leak detector, acquisition of helium leak detector, and retrieval of operations data for monitoring).

The dynamic and ever-changing demands for improved properties and qualities of engineering components relatively require specific and specialized processing. The Center has an ongoing project on establishing a gear making facility aimed to be the central research and development facility in the designing and manufacturing of gears as required by industries. Part of gear manufacturing is carburizing as surface finishing. The establishment of a vacuum carburizing furnace at the Surface Engineering Bldg. will cater to such requirement.

Some components especially intended for aerospace applications require cryogenic treatment. It is a supplemental treatment to steels to boost the microstructural transformation from austenite to martensite and formation of very fine carbides which could improve or impart specific properties. Establishment of cryogenic treatment facility will be beneficial in studying and achieving desired microstructures in steel which are not normally possible in available quenching media.

On the other hand, there are parts or components where only specific locations require heat treatment or are very large that they will not fit in heat treatment chambers. These concerns can be addressed by induction heat treatment. Setting up an induction heat treatment facility will provide an avenue where designing and manufacturing of inductor coils for particular components can be performed.

5. Acknowledgment

The project was implemented with the collaboration of the T.R. Santi, and consistent support from the DOST-MIRDC, especially the Executive Director, Engr. Robert O. Dizon, and the Deputy Executive Director for R&D, Engr. Jonathan Q. Puerto. Likewise, the project team acknowledges the support provided by the DOST-Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD) and the ULVAC Philippines.

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ENGR. RUPERTO C. MAGNO:

Lessons, Realizations, and Aspirations in the Metal Finishing Industry

Zalda R. GAYAHAN[*1]

'Nag open up ang opportunity vision ko. Basta nandyan ang metal industry, may electroplating. Staying in one industry will never let you go bankrupt.'

The DOST-MIRDC's more than one hour of interview with Mr. Magno turned out to be a candid conversation that drew us into so many happy, sad, exciting, desperate, and hope-filled experiences all at the same time. It was an opportunity to get up close and personal with a very prominent personality in the metals and engineering industries, particularly in the field of electroplating. His story took us back to when he was still a young boy reprimanded for taking money from his mother's store, a college student with honors, a young entrepreneur who had the guts to take risks, a family man realizing that success in business had some inevitable tradeoffs, and finally, to the part where he looks back and says that, at 81, there are still so many things he wants to do.

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Mr. Ruperto 'Penn' C. Magno, Chief Executive Officer and President of Chrome Dazzler and other companies under the RCMagno Group of Companies, was born on August 5, 1937. An entrepreneur, a risk-taker, a family man, an industry leader - he is all of these, beautifully packaged into one man whose stamina and positive outlook in life has kept him going even through the toughest of times.

Being business-minded is surely a trait that he got from his parents. Penn was an independent child. He is just one of two siblings in the family. He remembers his father buying a sack of *pandesal* to sell every day. At age seven, his daily routine consists mainly of waking up at three in the morning to join his mother to her trips to Divisoria and attending school at 7:00 am. But doing business is not the only thing that he learned at a young age. He also learned he has a soft heart for the less fortunate.

RCM: *Nung may tindahan ang nanay ko sa San Miguel, parang Tondo yan e. Oras-oras may saksakan. Sobra dun e. E mahirap yung lugar. Nangungupit ako. Nahuli ako ng lola ko. Sabi isusumbong daw ako. Tinanong ako bakit ako nangungupit? Kasi, sabi ko, yung mga kalaro ko walang pambili ng pagkain.'*

DOST-MIRDC: Did you come from a family of entrepreneurs?
RCM: My mother, *hindi nakatapos yun, pero* entrepreneur. *Kung ano-ano negosyon nun. May* jeep, *lahat. May* groceries. *Tatay ko hindi din nakatapos.* High school *lang.* Janitor. But he grew. *Nagtayo ng isang malaking kumpanya. Ambisyoso sya, kaya natuto din ako sa kanya.* Risk taker *din. Nanay ko hindi pahuhuli ng buhay yun e.*

DOST-MIRDC: Did you really go into the metal finishing industry?
RCM: Chem Eng (chemical engineer) *ako e.*

DOST-MIRDC: Why Chemical Engineering?
RCM: *Gusto ko talaga ng* business course. *Sabi nung isang tito ko, wag yan. Mag* chem eng *ka na lang. Marami tayong negosyong magagawa. Alam mo, ang kumpanya sa* America *pag nasa* sales *ka, tapos* chem eng *ka, magiging presidente ka ng kumpanya. E ambisyoso ako. O sige!*

And so, taking his uncle's advice, Penn graduated from the Mapua Institute of Technology with a BS degree in Chemical Engineering in 1960. He worked for one year for a private company in Taguig, then transferred to a chemical supplier. There, he became acquainted with PHILACOR. *'Sabi nya magtayo ka na lang ng* plating,' tells RCM, to which he replied, *'Malay ko dyan, wala akong alam dyan. Sabi nya, alam mo yan.* Chem Eng *ka e.'* Mr. Magno says he worked for three companies for three years before he accepted the challenge of putting up his own company. RCM chuckles as he tells the story of how he got into the metal finishing industry. 'Accidental, *hindi plinano. Ang plano ko magtrabaho sa* America *para magamit ko ang* chem eng *ko.* One opportunity led to another. I contributed to industry improvement in my own way,' reflects RCM.

RCM with his Japanese business partner.

His company started in 1962. RCM continues to tell his story, 'I happened to meet a Japanese friend. Taught me the nitty gritty. If not for this friend, *matututunan ko din, pero matagal. Yung lote ng nanay ko hiniram ko.* We offered copper-nickel chrome. *Nung panahon na yun,* backyard *ang* plating.'

The company was set up through his partnership with his Japanese friend. *'Nagtayo ng* electroplating shop *na malaki.* First customer *ko* PHILACOR *e.* They produce Westinghouse refrigerator, and they need plating support. *Medyo malaki ang* order,' shares RCM.

RCM further shares, 'I wanted mass production techniques. I traveled to America to learn the trade. I traveled to Europe to learn more. *In*adopt *ko dito. Pag pumunta ako sa* America, I visit plating companies.' RCM also became heavily involved with other local plating companies. As a matter of fact, he was a former President of the Philippine Electroplaters Association (PEA). 'With the association, we also visited companies, and observed [modern techniques]. With the PEA, RCM also went to Japan to observe plating improvements.

At this point, RCM pauses for a while, and gives us some personal inputs. *'Ang pangarap ko, kung hindi* plating, any business that I can start and grow from scratch. And also spread the news by motivating other small entrepreneurs to advance, to flourish. *Parang ang ambisyon ko,*

The Boss, CEO/President, with the staff of Chrome Dazzler.

*bago ako mawala o mag*retire, I have motivated 100 young entrepreneurs to go into business, not necessarily plating. *Iniisip ko maka*develop *ako ng* 100 entreprenuers. 100 x 10, *e di* 1000 *empleyado na yun. Malaking bagay na sa Pilipinas yun.* That's a lot of employment. *Medyo* nationalistic *ng konti.* I love my country,' he says while giggling.

'I was offered a better job in America *pero hindi ko sinunggaban e. Kailangan ng Pilipinas ng* employment, *e baka maka*-generate *ako,'* he adds.

DOST-MIRDC: Did you always know na entrepreneur *kayo?*
RCM: I know. *Kasi nung* college *ako hindi ako nagsa*summer. *Hindi ako nagbabakasyon.* I took up management subjects, business subjects, economics, in preparation for my entry to business. I wanted to go into business *kasi ang gusto ko talaga makatulong sa* employment generation.

When his company began in 1962, he already employed 10 staff. Just like all businessmen, he has encountered ups and downs. RCM reveals that in the process of delivering and improving his services, he met Mr. Eduardo R. Lacbay, then Deputy Executive Director for Industry Development of the Department of Science and Technology-Metals Industry Research and Development Center (DOST-MIRDC). He says he learned stamping from Mr. Lacbay. 'Fabrication, metal finishing, *kasi di ba* they go together e. *Pumuprodukto ka ng metal,* they need finishing. *Parang* vertical integration.'

Chrome Dazzler engages in copper-nickel chrome, decorative plating.

DOST-MIRDC: Who are your competitors?
RCM: *'Maraming maliliit lang, pang bahay-bahay lang. Ako ang nag*introduce *ng* industrial plating. *Inaral sa ibang bansa.* I am a risk taker. As an entrepreneur, you have to take risks.'

DOST-MIRDC: How much capital did you have to set up the company?
RCM: 'P14,000 starting capital. *Inutang ko pa sa* DBP *yun,'* says RCM while laughing. *'Ang* technique *talaga, iba e. Kung ano-ano ginawa ko.* Localized *lahat para makatipid ako. Tyaga lang.'*

RCM then talks about the property he acquired through the company's earnings.

RCM: *Dalawang lote yun, yung una nabili ng nanay ko, yung pangalawa ako na nakabili.* 2,500 m^2. *Kaya lang pinapaalis ako dun kasi naging* condo-residential area *na e.* I am planning to move out, God permits, *sa* Laguna Technopark *o sa* Carmona. *Meron kasi akong kaibigang Intsik na merong* industrial park *e. Sabi ko, "Pare, bigyan mo ako ng lote dyan." Sabi nya, "Sige, punta ka dito. Dito ka na* mag-expand. *Yang lugar mo* residential *na, baka palayasin ka na ng* LLDA *dyan o* DENR."'

DOST-MIRDC: From the time that you opened the business, *nasustain na yung* company?
RCM: *Dumami na yung* clients. There was a time I was operating 24 hours. *Nag*boom *yung* industry. *Nung nag mura ang* labor *ng* China, *bagsakan kami e. Kasi mas mura na mag* import. *Ngayon, nagbabalik na naman kasi tumaas ang* labor *ng* China, *mga* x2. *Nagbabalikan na naman. Gusto ko mailipat sa* Laguna Techno Park before I go. *Pero* this time *pag punta ko dun, yung benta ko na* 30-70%, *ititira ko sa pamilya ko.'*

DOST-MIRDC: Are you into export?
RCM: *'Nag e*export *ako ng* metal products before. *Ang* finishing *wala pa kasi.* I'll be competing with my partner, *kaya ayaw kong mag* export,' he says seriously.

DOST-MIRDC: Compared to other countries, *kanino po nakakaka angat ang* electroplating industry *natin?*
RCM: Bangladesh. *Dati mas magaling tayo sa* Vietnam. *Ang bilis. Nasa tao din e. Yung* culture *natin* as a people, *mababaw ang kaligayahan natin. Konting angat, masaya na tayo.* In the process, you stop with the innovative ideas to put up a business.

DOST-MIRDC: *Sino po ang pwede nating habulin?*
RCM: *Dati kapareho natin ang* Thailand. *Iniwan na tayo ng* Thailand *e.* Indonesia, *kaya pa natin habulin.* The bigger the population, the bigger the market, *kung* ok *ang gobyerno.*

DOST-MIRDC: What were the biggest challenges you encountered?
RCM: 'July 1987. Financial fiasco. Interest rate grew to 40%. *Nagbagsakan kaming lahat. Nagbawas ng tao* to survive. *Nag* unload. Economic slumber. *Nung una gumanda, ngayon bumababa na naman e.* Because of Mr. Duterte's style, *lahat inaaway e,'* he replied with a hint of a smile.

DOST-MIRDC: But you have an impressive story, considering that the company only started with a capital of P14,000.
RCM: *'Takot na takot ako, baka pag nalugi ako papatayin ako ng nanay ko dahil kanyang lote yun e,'* he again said jokingly.

On a more personal note, RCM shares, 'When I put up the company *single pa ako. Akala ng asawa ko mayaman na ako.* Demanding *ang asawa ko e. Sabi ko hindi pa ako kumikita, pero naintindihan nya naman,'* says a very candid Mr. Magno. 'She got busy teaching *sa* MAPUA, *sa* UP, *sa* Japan, *sa* Australia, *sa* America. *Pa*-six months, six months *lang.* She is an invited professor.'

DOST-MIRDC: *Kailan nyo naramdaman na* made *na kayo?*
RCM: *Nung naka* 10 years *na ako, ok na ako.* But I got into trouble sa fire protection. *Mayabang e.* I have another company, water heater. *Medyo sumabog. Kasi, dapat ang* lesson, *kung saan ka magaling, magfocus ka dun. Dapat* related *sa* main industry as much as possible. *E ako* I got into the food industry, *mayabang e,'* he shares his realizations with chuckles in between.

Mr. Magno elaborated on his realizations with more stories. *'Ang* business *pag nagsimula tataas yan e. Mabilis. Tapos magpa*-plateau. *Pag napabayaan, bababa na yan. Kailangan ma*-address. *Dito pa lang* [at the point where the business takes a plateau] *ma*-address *mo na e. Hindi maiiwasan mag*plateau *kasi* you will keep expanding *e. Pag dumadami ang tao mo, lumiliit ang kita mo.'*

'Ang kapal kapal ng bulsa ko, tuwang tuwa ang misis ko e. Nung nag expand *ako, naramdaman ko nawawala yung pera ko,'* reveals Mr. Magno, while laughing and shaking his head in disbelief at the same time.

'From electroplating, *ang ginawa ko* I expanded into fire protection. *Ang tao ko umabot sa* 700. *Mahirap mag*manage. *Kuha ka ng* engineer, *walang alam, galing sa skwelahan,'* says RCM.

DOST-MIRDC: Was that your first mistake?
RCM: Yes, first mistake.

DOST-MIRDC: What was your second mistake?
RCM: Second mistake, when I put up Jett water heater. Anybody can import *e. Nauna ako, nung bandang huli marami nang nag* import, *bagsakan ang presyo.* Right now, I cut down my employees from 60 to 20. Part of a group of companies. *May* food – bakeshop. *May* outdoor ads.

DOST-MIRDC: With a variety of companies, *yung* market *nyo hindi na nawawala? Laging may* market?
RCM: *Sa* water heater, *mas malaki ang* demand *ngayon kasi* necessity *na sya e. Sa* hotel. *Dati kami ang gumagawa pero yung* taxation *natin tinamaan ako. Mas mura pa mag* import *kesa gumawa. Dami dami nang nag iimport, nagbagsakan ang presyo. Nag*focus *ako sa* technical side. Inventor *ako e.* Innovative.

DOST-MIRDC: What is your contribution to the electroplating industry?
RCM: *Dati kasi mano-mano lang.* I introduced the semi-automatic process. *Malaki ang* opportunity *sa* metal finishing industry. Don't ever ever lose hope *sa* industry *na pinasok mo. Nung una kasi akala ko wala nang pag asa yung* industry. Nung umalis ako, lalo akong sumemplang.

Ang plating *mahirap e, kasi* multi-talent. Chrome Dazzler serves the metals industry, appliances, transportation, agriculture, construction. *Lahat ng* metals industry need a good finishing job *e. Dun ako nasira e. Akala ko babagsak na to. Alis ako.* Diversify. Not related. *Semplang.*

DOST-MIRDC: What trends do you see when it comes to ups and downs of business?
RCM: Economic factors. At the time of Mr. Ramos, I was into stamping. *Tapos wala namang nangyari. Nung*



bumagsak, nag stay ako with local manufacturing of parts. *Ngayon* I am busy with a powder coating line, copper nickel chrome, industrial chrome.

RCM generously added, *'Nag open up ang* opportunity vision *ko. Basta nandyan ang* metal industry, *may* electroplating. Staying in one industry will never let you go bankrupt. *Dyan ka na natuto, dyan ka na magaling, aalis ka pa? E yung* ups and downs *ng* business, *nandyan yan. Parang gulong yan e.* Stay on. *Wag mawawalan ng pag-asa.*

DOST-MIRDC: How much is the company worth now?
RCM: P100M net worth, with 60 employees. *Dati* 120 *yun. Nagbawas ako ng* line in preparation for my retirement.

DOST-MIRDC: How do you know that you offer a competitive package to your employees?
RCM: Profit sharing *ako* with employees *e. Kaya* they stay. *Pero kung minsan hindi rin e. Kahit anong ganda ng* offer *mo, ang kalaban mo* abroad *e.*

He adds, 'Management is a big issue *din. Pag masyado kang malapit sa tauhan mo, inaabuso ka. Pag malayo ka naman, nagagalit sa 'yo. Sabihin lang sa 'yo itong* boss *ko mukhang pera lang. Pag hindi* personal *ang pagma*manage *mo, hindi* delegated with less control, so risky. *Kasi ang utak mo, hindi utak ng* manager *mo e. Isa pa yung* auditing. Last time, I lost P10M. *Mahirap kumuha ng* manager. *Pag nagkamali ka ng pagkuha ng* manager, *naku…'* and his sentence trailed off, with RCM leaving us with our own options to fill in the needed ending.

DOST-MIRDC: *Dumating ba yung* time *na wala kayo masyado* to supervise?
RCM: I was about to retire *sana. Umatras ako. Dun ako sumemplang na.* So, *balik na naman.* Super hands-on. *Noong nag*delegate *ako,* I have 5 chemists, 5 engineers, manager.

DOST-MIRDC: *Ilang araw po sa isang* week *ang* personal time?
RCM: *Sa ngayon wala e.* 24/7 *ako e.* 81 yrs old *ako sa* August, *dapat pa*golf-golf *na lang ako e.*

DOST-MIRDC: *Nag-e*enjoy *ka* in what you do?
RCM: As an entrepreneur, *dapat you* enjoy what you do, otherwise *baka mag suicide.*

At this point, Mr. Magno remembered to share a story about a particular point in his past. 'One year ago, *nagtayo ako ng isang* Pusong Entrepreneur. *Dun ko kukunin yung* 100 entrepreneurs. *Meron akong isang* supervisor *sa* plating *noon. Sabi sa akin,* "Sir, *magnenegosyo ako." Sabi ko, anong gusto mo?'* "Plating." *Sabi ko turuan kita. Nung kumita, bumili ng kotse, ng bahay. Nung sumemplang, nagpakamatay. Nagbaril.'*

He went on to add, 'After that, I learned my lesson *na hindi mo lang imo*motivate. *Iga-*guide *mo. Ang negosyo hindi laging pataas. May pababa din yan.* It's not all roses *e.'*

RCM added another personal note to the conversation. He shared that his children, all four, did not show interest in the company. *'May mga* tradeoffs *e,* when you're so busy with the business. *Yung panganay kong anak na babae, bihira na kami magkita. Uuwi ako, tulog. Aalis ako, tulog.* Family is the motivation why you do business, *pero* in the process, the family will suffer. *Palagay ko pwede ma*balance *ang oras* between family and business, *pero pag masyadong mabilis ang* expansion *mo, ang oras mo hindi na sa 'yo e. Kaya alalay lang, kasi hindi mo na makikita ang pamilya mo e. Magkita kayo* once a week *lang.* I can provide them with all the material things that they need. Material *lang yan e. Ang importante* relationship *mo sa pamilya mo,'* RCM said quietly, like a father who sits down and talks about life's lessons with his child.

He admits that there came a point where he was 'emotionally battered,' but he still managed to be there for the company.

In hindsight, Mr. Magno reviews all that he has been through and positively says that, although there were difficult times with the family, he has helped the industry grow by promoting goodwill among his peers. *'Nasunugan ako ng* shop. *Ang tumulong sa akin,* competitor *ko. Yun ang importante e,* relationships. It's not money. Relationships *kasi* can go a long way. Money? *Pag harap mo kay* St. Peter, *hindi naman itatanong sa 'yo kung magkano ang kinita mo. Itatanong sayo, "nung nasa lupa ka ba natulungan mo ang* less fortunate? *Kung natulungan mo, lika na; kung hindi, balik ka." Yun ang* value *ng pamumuhay – yung* relationship *mo sa tao,'* he says with so much wisdom.

DOST-MIRDC: What can you say about MIRDC and its relationship with the industry?
RCM: 'Improve the library. Technical books are very expensive. Technology won't let you down.' He again laughs at his comment, as he remembers the tagline of a famous commercial in the past.

DOST-MIRDC: *Ano po yung navi*visualize *nyo na kaya pang i*achieve *ng* metals industry?
RCM: *'Kulang na kulang tayo sa* technician. *Walang marunong gumawa ng* rectifier. *Dun sana mag-*focus *ang* MIRDC. Training for maintenance *ng mga* equipment. *Pag nasira, itatapon na lang.*

He adds: 'Nickel alloy *dati meron sa* Vigan. *Nagsara. Ngayon nag i*import *tayo ng* nickel ore. *Yung* nickel iron. *Isa lang ganun* P1200 per kilo, *dati* P200 *lang.* That [high cost] can make the plating industry suffer.

Here, Mr. Magno reveals that he has another contribution to the industry. 'I am writing a book, "The Rise and Fall of an Entrepreneur." Two months *pa, matatapos ko na yun. Sa gabi ako nagsusulat. Gusto ko lahat ng nagyari sa buhay ko* as a businessman, *wag na ulitin ng mga* young entrepreneurs. *Kasi pag sumabit, ang hirap bumangon e.* There was a time I lost P200M. *Ang laki, kasi* I had to unload my properties e.'

DOST-MIRDC: Aside from the book, *may inisip ka pa po na gusto mo ma-*achieve?
RCM: *Gusto ko mag-iwan* at least P2M *sa pamilya ko. Para*

RCM with the whole family

stable *na ang pamilya ko.* They're already making good *sa* America. *May arkitekto, may* engineer.

'*Ang nakita ko kasi, mayaman ka nga.* Ang net worth *mo* P1 B, *wala ka namang cash. Pag nagkasakit ka, magbebenta ka ng* property. *Dapat* liquid. *Ang kailangan mo pambili ng gamot e. Nung nagkasakit ang misis ko,* I spent P6M. RCM's wife passed away last year. He says she was diagnosed with stage 4 cancer of the blood.

'Isa ko pang gusto, mag Initial Public Offering (IPO) *ako.* Stock market. I don't *mind kung wala akong* share *dun. Basta yung pamilya ko stable,'* he continues.

The father in him again surfaced as he once again thought about his children. '*Ang gusto ko sana sa mga anak ko,* if they venture into agribusiness, *yung makatulong tayo sa mga* farmers. *Kasi ang mga* farmers *natin mababaw din ang kaligayahan e. Yung* farm to road structure, *kulang na kulang e. Sa* mountain province, *nagtanim ng gulay sa bundok. Hindi maibaba. Sa* Japan *ang* farm to road, *grabe.* Agribusiness is good business *kasi pagkain yan e. Ang* thrust *ng gobyerno hindi nasa agri e, nasa* import *ng* rice.

DOST-MIRDC: *May kulang pa po ba sa nagawa nyo* for the industry?
RCM: The banks. Sa America *nag*stay *ako ng* six months, *nagtayo ako ng* business. They give free seminars. They teach young people to put up a business. I was thinking, if I can put up a professional group *na magrerekomenda sa bangko, ito pautangin nyo, ito hindi. Hindi naman masyadong mataas na ambisyon 'yon e. Walang nang magpapautang na bumbay.* 4% interest per month. *Ang kikita lang yung bumbay. Minsan ayaw ng* banks *magpautang sa* agri entreps *kasi walang ibabayad. Pero ang* agri entreps *iga*guide mo, they can pay *e. Kaya kung minsan ang mga Pilipino,* they have money, *gastos kaagad yan. Wala na pambayad sa utang.'*

DOST-MIRDC: What advice can you give to starting entrepreneurs?
RCM: 'Know the business. I know my cost *e. Sa* plating *alam ko ang* cost. *Ako ang* leader *dito.* Others base their cost on my cost. *Wala silang sariling diskarte sa* cost *nila. Pag hindi mo alam,* either *makuha mo ang negosyo o hindi mo makuha.'*

DOST-MIRDC: What are your strengths?
RCM: My stamina. *Sa akin lahat* possible *e.* Positive mental attitude. *Kung wala akong ganun, matagal na akong sarado.*

DOST-MIRDC: Based on your standards, can you say that you are a success story already?
RCM: 'Yes, I think I made a mark in the industry. You can ask my competitors,' and the room was suddenly filled with his hearty laughter.

One part of our conversation can summarize the kind of man that Mr. Magno is. The DOST-MIRDC asked him how he was like back in college. He said, 'Sa UE, *nasa* top 10 *ako. Sa* MAPUA, I placed second *e.'* And he adds with a handsome grin, *'Pag na* challenge *ako, grabe talaga ang pagka* fighter *ko.* I will prove my worth.'

And he did, and still continues to do so. The metal finishing industry can't be more fortunate.

SERVICES

CHROME PLATING

Renowned as the country's most preferred metal finishing company because of its unmatched superior quality plating services. The only one in the country providing the unique bluish silver chrome finish - the distinct mark of Chrome Dazzler's finest quality.

POWDER COATING

As the company vows to give superior quality finishing services, its powder coating facility is always available to provide a durable, economical and environment friendly method of metal finishing. It is equipped with a complete pre-treatment process that ensures superior quality always.

METAL FABRICATION

The company's competence extends to customization of different metal fixtures and accessories. With skilled and experienced craftsmen, the ability to fabricate items based on client's specification becomes limitless.

METAL STAMPING

Proud of its full capability as a manufacturing company, Chrome Dazzler's facility is all set to produce and supply various OEM parts in bulk quantity. The support of an in-house Tool and Die team is vital in exceptional tooling that guarantees utmost customer satisfaction.

PRODUCTS

DURAWALL

MOUNTING BRACKET

LED TV Bracket

Aircon Bracket

It is a steady support for mounting LED TVs and window-type aircon units. The brackets are designed to keep home and office appliances safe and secured while mounted on the wall.

DURABASE

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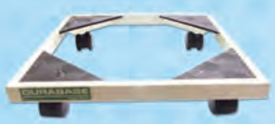
It provides easy movement to make cleaning easier while protecting your appliances from corrosion due to accumulation of dirt, moisture and rat and cockroach infestation.



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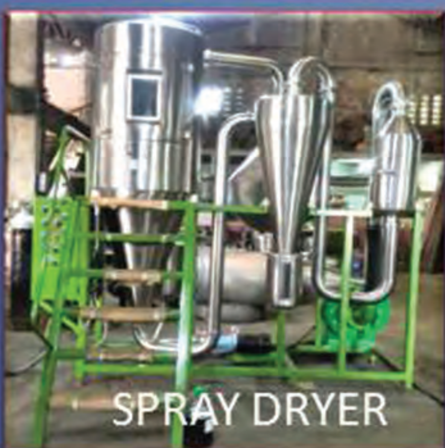

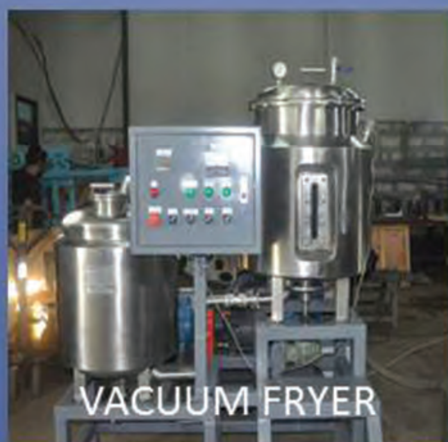

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Feature Article

THE METALWORKING INDUSTRIES ASSOCIATION OF THE PHILIPPINES, INC. (MIAP):

Creating a clear direction and giving a unified voice to the Philippine metalworking industry

WHAT IS MIAP

The Metalworking Industries Association of the Philippines, Inc. (MIAP) is a trade association of firms engaged in metalworking and related activities that was organized in 1978 to answer the need for a body that can represent the metalworking industry sector. The MIAP is a national organization composed of 15 chapters nationwide.

ITS VISION

A metalworking association that can provide services/assistance to its members in order to effectively compete both in the local and global industry arenas.

ITS MISSION

Work for the development of a truly progressive and dynamic metalworking association that can firmly support the needs of its members and stand as the backbone of the various industries.

The incorporation of the Metalworking Industries Association of the Philippines, Inc. (MIAP) as a national organization was approved by the Securities and Exchange Commission (SEC) on 04 October 1988 with the following as incorporators (and also the first board of trustees):

• Leon Ang	Metro Manila
• Eduardo C. Chan	Northern Mindanao
• Raul M. Consunji	Metro Manila
• Pacificador C. Directo	Metro Manila
• Alberto P. Fenix, Jr.	Metro Manila
• Jose Y. Mateo	Metro Cebu
• Hernando P. Morante	Metro Cebu
• Peter U. Ong	Metro Cebu
• Pablo M. Paras	Northern Mindanao
• Heinz Thomann	Northern Luzon
• Magdalena S. Villaruz	Iloilo

MIAP actually had its beginning on 11 December 1978 when it was originally incorporated. Although intended to be national in scope, the membership was drawn mostly from Metro Manila. On 06 June 1986, the original Articles of Incorporation and By-Laws of the association was amended to give way to the formation and incorporation of a truly national organization. Along with the establishment of regional and provincial chapters was the change in its business style and the association's name to Metalworking Industries Association of the Philippines, Inc. – Metro Manila.

In 22-23 April 1988, the first national metalworking convention was held in Cebu City which was attended by five chapters, namely: Metro Manila; Northern Luzon; Metro Cebu; Northern Mindanao; and Iloilo. At this convention, the formation of the national organization was formally launched with the adoption of the Articles of Incorporation and By-Laws and the corporate name of METALWORKING INDUSTRIES ASSOCIATION OF THE PHILIPPINES, INC. (MIAP).

MIAP CHAPTERS

The national organization of MIAP is composed of provincial/city/regional chapters which are associations of metalworking firms or enterprises that are engaged in metals and engineering. Each chapter is autonomous and can pursue their own activities provided such activities do not contravene the Articles of Incorporation and By-Laws of the association. The chapters of MIAP and their dates of establishment are listed below:

Chapter Name	Date Organized
• Metro Manila	11 December 1978
• Metro Cebu	23 August 1986
• Pangasinan/Dagupan Reg. 1	October 1986
• Cagayan de Oro	10 February 1988
• Zamboanga City	29 October 1988
• Iligan (Industrial City)	28 October 1989
• Davao	19 October 1991
• Negros Occidental	November 1992
• General Santos	October 1996
• Butuan City	23 November 1996
• Bohol	
• Kidapawan	
• Iloilo	October 1988
• Surigao Del Sur	
• Cagayan Valley	April 19, 2013

The following served as President of the MIAP National:

• Raul M. Consunji	1988-1989
• Pacificador C. Directo	1989, 1990 and 1991
• Alberto P. Fenix, Jr.	1992
• Pacificador C. Directo	1993 and 1994
• Raul M. Consunji	1995 and 1996
• Jimmy T. Chan	1997
• Ramon R. Cura	1988 and 1999
• Eduardo N. Chua Co Kiong	1999 and 2001
• Eduardo C. Chan	2001 and 2003
• Philip N. Tan	2003-2004
• Marcelo C. Zafra, Jr.	2004-2007
• Almarco C. Brito	2007-2009
• Jose Y. Mateo	2009-2010
• Hector D. Malonzo	2010-2011
• Virgilio F. Lanzuela	2011-2014
• Inesitas L. Palermo	2014-2018
• Virgilio F. Lanzuela	2018-present

MIAP Chapter Presidents represent their organization.

The newly-elected MIAP officers led by Mr. Virgilio F. Lanzuela, take their oath during the 29th MIAP Convention.

One of the significant activities that is undertaken annually by the MIAP National is the National Metalworking Convention which is traditionally hosted by a MIAP Chapter determined during the convention preceding the year to be hosted. So far, the association has held 29 national conventions, with the 2018 convention as the 30th.

Most of the chapters are currently undertaking capability building through manpower development and skills upgrading of employees. Some have obtained foreign assistance to be able to offer more effective training programs besides tying up with the regional offices of the Department of Science and Technology (DOST), the DOST-Metals Industry Research and Development Center (DOST-MIRDC), the Department of Trade and Industry (DTI), the Technical Education and Skills Development Authority (TESDA), and the Philippine Chamber of Commerce and Industry (PCCI).

Participation in foreign study tours has proven to be an effective way of getting exposed to technological advancements in the field of metalworking. Attendance to both local and foreign trade fairs and exhibits has also proven beneficial in terms of acquiring modern machines to enhance Philippine metalworking firms' capabilities, and gaining new product insights, thus opening additional market opportunities.

Over the years, the MIAP has endeavored to work closely with government agencies and instrumentalities within the limits of its mandates as a trade association in the promulgation of national and local government policies that impact on the industry in general. When called upon to do so, the association participates in studies conducted by the government and private institutions in the furtherance of sectoral growth and support of government programs. The association partners with the DOST, the DOST-MIRDC, the TESDA, and the Technological University of the Philippines (TUP) in reviewing existing Training Regulations and Competency Standards in machining in order to be more attuned to the needs of the industry and in crafting the new Training Regulations and Competency Standards in CNC Programming and operations of the different qualifications in the Philippine qualification framework.

(L) DOST Secretary Fortunato T. dela Peňa (1st row, third from right) and DOST-MIRDC Executive Director Robert O. Dizon (2nd row, second from left) join the MIAP officials on the occasion of MIAP's 30th National Convention and 40th Founding Anniversary; (R) DOST Sec. dela Peňa, MIAP President Virgilio F. Lanzuela, and DOST-MIRDC Exec. Director Dizon answer the industry's concerns and inquiries.


KAPIHAN/PRESS CONFERENCE & SIGNING
OF MEMORANDUM OF UNDERSTANDING
"Clustering of Regional Enterprises of CAR
Texas Instruments


S&T Human Resource Development
Technical & Consultancy Services
Department of Science and Technology


PROTOTYPING DIVISION

The MIAP, as a private industry member of the AFMEC (Agricultural and Fisheries Mechanization) committee and the National Agricultural and Fishery Machinery Assemblers, Manufacturers, Importers, Suppliers, Distributors and Dealers Accreditation Board (NAMDAC), helps the government in the policy review of the implementing guidelines of the Department of Agriculture's mechanization program and in the procurement of quality standard agricultural and fisheries equipment and in the accreditation and classification of suppliers.

Still relatively lagging behind its counterpart in industrial countries abroad in terms of capabilities and productivity, the MIAP nevertheless feels that it can rise to meet the challenges of national industrial growth and development for as long as every stakeholder in both government and private sector aligns each effort to attain this goal.

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Metals Industry Research and Development Center

VISION

Center of excellence in science, technology and innovation for a globally-competitive metals, engineering and allied industries by 2025.

MISSION

We are committed to provide both government and private sectors in the metals, engineering and allied industries with professional management and technical expertise on the training of engineers and technicians; information exchange; quality control and testing; research and development; technology transfer; and business economics and advisory services.

CORE VALUES

PROFESSIONALISM	We adhere to the highest ethical standards of performance. We value our work and are committed to perform to the best of our ability.
RESPONSIVENESS	We spearhead implementation of projects that address the needs of the metals and engineering industries. We find solutions to real-life problems through science, technology and innovation.
INTEGRITY	We act responsibly, work honestly, and encourage transparency.
DYNAMISM	We perform our jobs with vigor and enthusiasm. We welcome change as an opportunity for growth and continual improvement.
EXCELLENCE	We adhere to world-class performance and continuous improvement in all we do. We always do our best in every task/endeavor.

QUALITY POLICY

We are committed to provide products and services to both the government and the private sectors in the metals and engineering and allied industries with the highest standards of quality and reliability within our capabilities and resources and aligned to our strategic direction, to comply with applicable statutory and regulatory requirements to plan and implement actions to address risks and opportunities and to continually improve the effectiveness of our Quality and Information Security Management Systems in order to enhance customer satisfaction at all times.

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