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Appraisal of SME Casting Industry in Thailand

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***Abstract*—Cast products form component parts in many manufacturing industries, especially in the automotive sector. To keep pace with the rapid growth of automotive and other manufacturing industries in Thailand the country's foundry industry has had to develop its production capacity and technical capability at a relatively rapid rate. The Thai-owned SME companies have had to build up their production capabilities without strong back-up experiences and technology. Limited investment, lack of applied R&D, inadequate testing and metrology services, plus a general shortage in engineering skills and overall training have significantly restricted their technical development. Against this background and with particular respect to the automotive SME sector, this short review examines some of the strengths and weaknesses of the Thai Foundry industry and the improvements that need to be made for companies in this sector to survive and prosper in an increasingly competitive quality-driven marketplace.**

***Index Terms*—automotive SME sector, casting industry, current state, improvements needed, future development.**

I. Introduction

Over recent years quality management and process controls in foundries around the world have been significantly improved raising casting quality levels and increasing customer confidence in cast products. However, there is still room for improvement since the production of scrap castings continues to result in unacceptable levels of waste of raw materials, energy, and effort. Foundries are still wasting money because they do not pay sufficient attention to the metallurgical and other technical aspects of their operations. This generalization is particularly relevant to many foundries in Thailand where large scale manufacturing, notably in the automotive industry, has developed at a rapid pace. Following the continual expansion of motor cycle and vehicle assembly plants in Thailand there is a large market for the supply of automotive castings, but if Thai foundries, especially those in the SME sector, cannot become and remain technically competent and competitive enough, then business could be lost to overseas competitors due to the recent trend in global procurement of automotive assemblers. Many overseas foundries, especially in Europe and USA, satisfy the Quality System requirements of the major automotive assemblers. These foundries benefit from many years of experience in meeting these standards and in the implementation of Total Quality Management (TQM) and Continual Improvement including techniques such as Statistical Process Control (SPC), Failure Modes & Effects Analysis (FMEA), and Design of Experiments (DOE). Together with foundries in other countries, notably India and China where the automotive sector is also rapidly expanding, they provide intense competition for Thai foundries. Non-automotive casting producers also face the same challenges since the manufacturers of electronic equipment, electrical appliances and home fittings, etc. have now become just as demanding as the automotive industry in terms of quality, price and on-time delivery.

Around the world small foundries are finding that it is increasingly more difficult to survive. Over the last few years in Europe and the USA it has been hard for even competent small foundries to compete such that increasing numbers have gone out of business. Small foundries in Thailand face a different and more demanding set of problems when compared to their more mature competitors in Europe, Japan and USA. For example, in Thailand many shop floor workers are from an agricultural background and lack experience in industry and there is still only limited foundry craft and technician education and skills training. Small foundries cannot find funding to support training or invest in new equipment or technology, let alone attract and keep technical graduates or skilled staff.

Against this background this paper provides an outline review of the development and current status of the casting industry in Thailand with a focus on the small & medium sized enterprises (SME) that produce parts for the automotive industry. Towards the survival and future prosperity of these foundries

some of the many difficulties that they continue to face are discussed and potential solutions or areas for improvement identified.

II. Development of The Casting Industry In Thailand

Cast metal has a long history in Thailand in that discoveries of Bronze objects, including cast spear heads, excavated at Ban Chiang near Udon Thani in the Northeast are believed to date from 3600BC [1]. Metal casting as a foundry industry in Thailand began to develop from the mid-19th century with the production of canons, weapons and hand tools. Gradually industrialization gave rise to many small and medium sized foundry shops scattered around Bangkok, and in the southern and eastern parts of the country. Industrial growth has accelerated in the last 30 or so years and Cast Irons (mainly Grey and Ductile grades), Cast Steels, Aluminium alloys, and Copper based alloys are all now produced as castings to supply the automotive and general engineering sectors. There are some well-established jobbing ferrous foundries producing a range of steel castings including High Manganese and Stainless grades and alloy cast irons such as Ni-Hard, Ni-Resists and High Chromium irons. Cu base alloys are mainly for marine, water, architectural and lighting applications.

During the booming decade (1987~1997), several large plants were established to produce high quality casting parts for the automobile and cement industries. Since then, in spite of the S.E. Asian recession, the automotive industry has grown steadily such that current annual capacity is around 2.7 million vehicles. This could reach 3 million during 2017 since several auto-producers in Thailand have increased the capacity of existing facilities or are building new plants. Currently Thailand is the 5th largest commercial vehicle builder in the world after China, Japan, Canada and Mexico, and is the 2nd largest producer of pick-up trucks behind the USA. In addition, around 2 million motorcycles are produced each year. Outside the auto sector most of the castings produced in Thailand are for electronic & electrical appliance, machinery, construction and agricultural applications.

There are no detailed production data just for the Thai castings industry since separate data on foundries does not appear to be recorded but are hidden in the statistics on the Iron & Steel and the Automotive Industries. Current capacity is estimated at 1 to 1.2 million tonnes of ferrous castings and around 120,000 tonnes of non-ferrous, most of which are aluminium base die-castings. High pressure diecasting for vehicle and electronic parts is well established together with low pressure die-casting of auto wheels. There are about 450 companies which produce cast products with about 80-90 % of these being classified as small to medium sized enterprises. The Thai Foundry Association currently has 83 ferrous foundries and 102 non-ferrous foundries listed as members. The large manufacturers are mostly subsidiaries of multi-national automotive companies from Japan. The levels of plant, equipment and technology and continual updating in these relatively new, larger plants have enabled them to compete on the world stage for the last 20 or so years [2].

All foundries in Thailand currently face the worldwide problem of skill shortages at all levels from foundry operatives to technical management. Even in the large automotive foundries technical staff consist mainly of graduates in science or engineering, who may have limited understanding of foundry metallurgy and processes. Other than overcoming the “dirty, dusty and noisy smokestack image” the foundry industry is not a special case since across all sectors of industry in Thailand there is a shortage of science & technology based professionals with the problem being more widespread at the vocational level. Among the hurdles of globalization and competing on the world stage, coping with more stringent requirements from customers, introducing new technology and improving environmental performance the shortage of technical skills is perhaps the greatest threat to the continued development of the casting industry in Thailand.

III. A General View of The SME Foundry Industry In Thailand

The SME casting producers are generally family run with one owner or partnership among relatives. Workers are generally unskilled to semi-skilled with low to medium levels of education. There are relatively few trained graduate-level engineers or foreman/supervisor level personnel with vocational diplomas. In some cases, management responsible for technical and quality matters may not hold any form of technological qualification. The low skill levels combined with the use of second-hand or rebuilt equipment, due to limited investment, result in a number of production and quality problems. Green sand and CO_2 processes are widely used for their ease and to minimize the cost of moulding but without appropriate control, even these basic processes can suffer from high levels of defects such as pin-holing, blowholes and burn on. Process control is limited and only final sampling inspection tends to be used, many problems only coming to light during subsequent machining by customers. Some foundries do monitor composition by spectrographic analysis but mechanical properties are usually assessed by hardness.

SME foundries can be innovative in re-engineering of second hand equipment and in reverse engineering but most production problem solving and methods engineering still follow trial and error routes. Costs management needs improvement. Small foundries tend to have only basic accounting systems that lack

of detailed analysis of the total costs of fulfilling orders. This means that in general, managers do not often recognize the financial need to solve quality problems. They do not realize how much the inability to reduce defect and rework levels is costing. Likewise, some foundries are still giving insufficient attention to energy efficiency and environmental issues. Hence for this sector tackling quality problems, improving process control, and cleaning up their production processes are major steps that must be taken. There are however encouraging signs that second and third generation owners, who are technically trained, do see these problems and are improving the technology of their operations.

IV. Towards Improving Technical Performance And Quality.

Making castings is not as easy as it looks. Production is subject to many interacting variables that affect the behaviour of the various materials and processes used and hence the casting quality. A basic understanding of "why, how and when" materials & processes need to be monitored and controlled is essential even when relatively simple castings are being made – if they are to be produced without defects.

In consulting with foundries, not just in Thailand, one is often met with the response:

"We want the process to work! We do not want to know why it works and we do not want to spend money to find out why - or indeed make it work better! Anyway, we have not got the time or staff, and we can't afford to do any training, let alone get involved in any research or development!"

Managers are under pressure to maintain production so this may not be a fair view of foundries and management attitude. However, it does show that foundries, especially in the SME sector, need more encouragement, guidance and support in seeking to make technical improvements in their operations. In Thailand, there is still a need for better co-operation and interaction between industry and the university/ government R&D centres.

In the past industry in Thailand has increased and improved production capabilities by importing mature technology from overseas. Hence industry, including metal casting, has yet to develop a "R&D culture". However, this should not discourage SME foundries from approaching the universities with their technical or other problems as potential topics for under-graduate or even post-graduate projects. Several universities have well established metallurgical & production engineering departments with metal melting & foundry facilities and advanced materials characterization equipment. There is now considerable research experience in cast metals in areas such as structure-properties relationships in casting alloys, heat treatment, simulation and modeling, semi-solid processing, etc. [3]. Likewise, MTEC - the National Metals & Materials Technology Centre has long term experience in R&D, consulting and training for the foundry sector with recent emphasis on high pressure die-casting, casting simulation, computer aided engineering and robotics. To stop firefighting and make real improvements SME foundries should make use of this proven research capability and seek assistance in examining and benchmarking their performance and in identifying, investigating and solving their most pressing problems.

Many small foundries face many very similar technical problems, e.g. cost effective use of charge materials, coping with high return greensand temperatures, storage deterioration of cores in high humidity, control of inoculation, etc. If there was a reliable database on casting production, via a foresight or revised master plan approach, in Thailand then such common problems could be more easily identified. Research capabilities and funding could then be more efficiently prioritized and used to make improvements for the overall well-being of the industry. Clearly this requires co-operation between competitor foundries – this has been normal for many years in Europe and the US, so there is no reason why it cannot happen in Thailand.

All parties, especially those that control the provision of research funding, should recognize that to be innovative, the research projects do not only involve design and development of new products but also the further development of existing processes by improving quality, efficiency and environmental aspects and by reducing costs. It is believed that optimization of existing processes offers real opportunities for improvements in the Thai SME metal castings sector.

Towards process optimization all foundries, both large and small, could make better use of tools and techniques such as FMEA and SPC to reduce variation in processes and improve quality and reliability. Even foundries showing compliance with certified quality management systems could make more use of the process and inspection data that is already being collected. Up to the present time, in the SME foundries little use has or is being made of SPC or indeed of any basic "cause & effect" analysis towards defect reduction. At very little cost the use of simple "fishbone" or "why-why" cause & effect exercises via informal brainstorming (not blamestorming) sessions can quickly point the way towards where improvements could be made and highlight variables where SPC could be used. Pareto analysis can be used to decide which problems are to be tackled first. It is worth noting that most resistance to SPC is from management with the shop floor being much more receptive once it is explained that the aim of SPC is to prevent defects. The shop floor has a first-hand view of scrap produced every day and know that any steps taken towards its reduction will increase their job security.

SPC can perhaps be most easily introduced into small foundries via attribute charts from inspection data and basic variable charts e.g. for critical dimensions (mean & range) or metal pouring temperature (reading-moving range) [4]. As a foundry gains more experience and confidence the cause & effects approach can become more detailed as design and process FMEA studies. Small foundries should also consider taking on university work experience students or provide some support for in-company post-graduate study to tackle process optimization projects through a Design of Experiments (DOE) Taguchi approach.

V. Involvemnet In The Complete Production Route

Where possible all foundries need to become involved in the design of a cast product and then after the casting has been produced they must understand and apply correct heat treatment, machining and any other required finishing operations such as surface treatments. If a foundry is not involved in the design process then they may be asked to produce a component having a shape and size for which it is very difficult or costly to produce a satisfactory casting. For example, consideration must be given to: shapes which are difficult to mould or require complex core-boxes or dies; designs with sharp changes in section thickness; designs which are difficult to fill correctly during pouring; designs with regions that are difficult to feed, etc. All these features must be considered with due regard to the nature of the alloy to be cast and the need for any subsequent heat treatment, dimensional control and machining operations. By making use of computer based process modeling and simulation all foundries can confidently solve the methods engineering problems in designing the gating and feeding system for a given casting. The casting can effectively be made on the computer to ensure correct design of any pattern equipment or tooling so that when the casting is made then it is "right first time". The design, since made, could then be accumulated in a data base for subsequent use to minimize design lead time in the future.

The use of simulation offers considerable savings in time and production costs since yield (in the foundry sense) is optimized by avoiding oversized gating and feeding systems, whilst overall yield is improved by reduction in scrap caused by defects such as shrinkage, misruns, dross and inclusions in castings. SME foundries do not have to invest in simulation software but can make use of "bureau" services available in Thailand, for example at some universities, at MTEC and at companies such as M5 Engineering. All foundries should keep up to date with on-going simulation developments aimed at modeling and predicting events such as the occurrence of certain casting defects, residual stress patterns, microstructure and properties variations in different parts of a casting, effects of thermal treatments, flow of sand in core production, etc.

Pre-production work times can also be shortened by making use of rapid prototyping via additive manufacture. Additive Manufacturing (AM) via 3D Printing will also increasingly complement existing casting production technology since it offers faster routes into production, greater degrees of accuracy, reduced costs and less environmental impact [5]. For example, Fused Deposition Modelling (FDM) can build up polymers produce patterns for sand moulded castings with the advantages of time-saving and reduced costs when compared to conventional CNC machined Aluminium patterns. Where only one or two castings are required a pattern is not necessary. Sand moulds and cores and sand models of castings for prototyping can be produced directly from CAD data enabling pattern-less casting, reverse engineering, and customizing of cast parts. In particular, broken or worn out parts can be quickly replaced minimizing any downtime in the use of plant or equipment. One small company, Speed 3D Mold situated near Bangkok has already led the way in Thailand by investing in 3d scanning and binder jet 3d printing technology [5].

It is very important for the future of SME foundries that "bureau' and training services in simulation, modeling, prototyping and additive manufacture be expanded to enable wider improvement in product and tooling/die design. High pressure diecasting is one area where modern production capacity has rapidly expanded in Thailand but where there is still very limited design capability.

energy and environmental issues.

Since the 1970s there have been ongoing initiatives in various industrialized nations to save energy and reduce waste in manufacturing industry especially in the castings production sector which is energy intensive. In the UK for example the Best Practice Programme run by the Energy Efficiency Office encouraged and provided information to foundries to make energy savings especially in metal melting and liquid metal handling which accounts for 60-70% of energy use in foundries. [6]. There are no current energy conservation and waste prevention schemes aimed at the foundry industry in Thailand. The large joint venture automotive foundries are up to world class standards with their environmental performance and energy usage but many of the SME foundries need to make significant improvements in both energy usage and environmental performance.

As in the case of energy conservation there has been no reported overall survey of environmental issues in Thai metal casting but initial attempts have been made to develop an indicator model to evaluate environmental impact from the "machinery" sectors [7].

A study in Europe has shown that foundries tended to underestimate their energy saving potential at 7.5% (on average) which is less than one third of the 25% saving estimated for the European industry in general. This study also concluded that the main drivers for improving energy efficiency were financial including the threat of rising energy prices and the availability of beneficial loans for investments to improve efficiency. There are several areas where savings can be made by Thai foundries particularly via quality improvements to reduce scrap and increasing casting yield. Experience shows that a typical aluminium foundry could save at least 20% of its energy costs without any major capital investment just by tightening up quality control and by good housekeeping [8].

Under the Industry 4.0 banner innovation is currently being promoted in Thailand. In SME Thai foundries and the metals industry in general, Industry 3.0 needs to be made much better by co-encouraging greater take up of best available technology (BAT) for energy efficiency. This together with practical process development projects via improved contact with universities and research centres will certainly improve overall technical capability and quality levels.

Thailand is not alone - in a United Nations Industrial Development Organization (UNIDO) project on sustainability across the Philippines, Indonesia, Vietnam and Thailand, the metals industry has been called a "growth with care" industry [9]. This study noted that many metal companies across the ASEAN region have inadequate understanding and practices in process control thus producing more scrap, more re-work, using more energy & other resources than they should and creating more waste. The study also observed that in the region there are many world-class companies using BAT in "green" production practice, and that the knowledge and experience in such companies could be used by government organizations to help support training & education for the technical development of local industry. This is especially relevant in Thailand where SME foundries could improve their performance by learning from the approaches to production & process control in the modern casting plants of the automotive sector. In SMEs obtaining suitable investment is always the major obstacle but that should not be an excuse for not making energy savings by not using basic process controls and not having good housekeeping on the shop floor. For example, correct storage of charge materials in iron and steel foundries to avoid contamination and mix-up of ferroalloys and especially avoiding the charging of wet and oily steel scrap into induction furnaces just requires common sense.

SME foundries not only need help in setting up effective process controls, reducing defects and improving energy efficiency but also in improving environmental performance – notably noise, dust and emissions control and the disposal of wastes. SME foundries have very limited knowledge of pollution control or Environmental Management Systems (EMS) and many seem to be unaware of the dangers posed by the raw materials that they use, e.g. resins and binders, and by the emissions and waste from their processes. It is of concern that most small foundries do not have product data sheets for consumables such as fluxes, treatment alloys, binders, coatings, etc. available. Insufficient knowledge about the materials that are being used has serious safety implications. Foundries must demand complete safety information about their raw materials from their suppliers. They must also ensure that shop floor personnel receive correct training in the safe handling, storage and use of materials such as melt additives, exothermics, resins, coatings, etc. In many small foundries safety equipment such as eye and ear protection is often not being used. Also, many workers do not have adequate footwear protection. Safety wear is said to be available but its use is clearly not being enforced. Many of the smaller foundries have poor storage arrangements, poor lighting, and bad-housekeeping in general. These problems can be tackled at relatively low cost and by improving shop floor discipline.

In metal casting across the world processes such as melting, pouring, mould & core production, knock-out and cleaning will continue to be affected by on-going Environmental Legislation, especially in Europe and the US. Worldwide it is accepted that future developments should be "sustainable". In moving towards clean and economic use of resources, all foundries must develop Energy and Environmental Management schemes and minimize waste.

All foundries face similar "waste" disposal problems, for example:

- Spent greensand or chemically bonded sands such as CO_2-Silicate, Shell, Hot-box, etc.
- Sludge or dry residue from wet scrubber or dry bag filter systems
- Drosses from melting and metal treatment.

It is almost impossible for small foundries to tackle such problems alone. The problems can only be addressed on an industry wide basis such as that used both in the US and UK. There is a need for the Thai casting industry as a whole to examine sand reclamation, applications for spent foundry sand, and the recovery of metal from dross. At present, much of this valuable "by-product" goes to uncontrolled landfill to pose future environmental threats from leaching into soils and watercourses.

The foundry industry as a whole across ASEAN could address these problems and seek to provide clear information and practical advice to SME foundries on how to save energy, how to make better use of waste such spent sand and slag, and especially how to be cleaner and safer.

VI. Equipment, materials and processes.

Existing plant and equipment needs to be updated and improved e.g. by the use of sensor technology in burner control in particular, and in automatic control in general. Modernization of melting equipment, moulding lines, knockout and fettling areas with improved fume & dust extraction requires considerable investment. At lower costs, the performance of older plant & equipment can be improved by making use of condition monitoring and by ensuring that timely & correct maintenance is carried out. This will give better reliability and reduced variation in performance. There is considerable scope for the use of robots in foundries, for example pick and place in mould production, handling and pouring molten metal, and automated high pressure die-casting [10]

Much more attention must be given to mould and core-making practices. Most mould related problems are due to the poor state of maintenance of mixing and moulding plant and limitations in sand control. Many foundries continue to use damaged poorly fitting moulding boxes such that flash, mismatch, sand inclusions, and other defects due to mould damage are very frequently found in castings. The provision of correctly matching boxes and box pins is vital if castings are to be made with greater dimensional accuracy, less machining allowance and to more complex designs.

A large volume of FC and FCD Iron automotive castings are produced in Thailand, as elsewhere greensand moulding, i.e. the use of clay bonded sands, is employed., Ambient temperatures are relatively high in Thailand so all foundries, both large and small, experience mould related defects caused by the excessive high temperature (above 50^{o}C) of sand returning to the mill in greensand plants. As production levels have increased in some foundries they have tended to outpace sand plant capacity such that system sand in storage hoppers does not have sufficient time to cool. Hence there is need for better production planning & scheduling to reduce the demands on the existing sand plant, for the use of improved sand cooling mechanisms and for regular hopper maintenance. There is also the R&D challenge to develop bentonite clays whose bonding properties are less sensitive to higher temperatures.

There are still some basic problems to be tackled when using chemically bonded sands. Simple process controls such as control of gassing time and rate in the CO2-silicate process, and control of temperatures and times in Shell moulding are not being used. Such lack of control gives under or over-cured moulds or cores and guarantees casting defects. The solution is quite simple – correct work instructions and training of operators. Most foundries are also unaware that stored cores can deteriorate very quickly in the high humidity conditions, especially in the wet season. Foundries are encouraged to do their own practical testing to determine the maximum safe storage time of each type of core, and then control core production accordingly.

Another area of common problems in most iron foundries is that of consistent melt treatment and inoculation in producing FC and FCD irons. Many SME foundries do not make effective use of melt conditioning and also tend to not only use too much of the wrong type of inoculant but also use it incorrectly. There is a need for correct application of ladle and in-stream inoculation procedures. There are particular problems still to be overcome in the inoculation of the very low Sulphur content FC iron produced as a result of steel scrap based charges. To assist iron foundries, there is considerable opportunity for practical research into the combined influences of charge materials, notably the presence of Ti containing and Zn coated steel scrap which is now in common supply, inoculation and other variables on microstructures and machinability, especially with regard to the quality of machined surface finish.

Many small foundries have tried to cut their costs of imported supplies by making use of raw materials and spare parts from less expensive overseas or home-based sources. This can and has given rise to quality problems due to the lack of suitability and consistency of some of these materials or parts. The application of “cheaper” raw materials needs to be more carefully considered and monitored, since the use of any sub-standard material can lead to higher reject costs which will far outweigh the raw material savings. Clearly there is a need for research into local materials such as alloying/treatment additions, sands, binders and refractories, etc. so that they can all be used in a cost-effective way without compromising quality.

Looking to the future, cast iron parts have long been subject to replacement by light alloys. At present pressure diecasting of Al alloys for motor cycle and computer parts is well established here but there is limited capability for sand and gravity Al castings, and no experience with Mg based alloys. In Al castings for cylinder blocks non-turbulent controlled mould filling technology as in the Cosworth (cold set zircon core assembly) and the later Gemini (box-less greensand) processes has set new standards for clean, consistent, accurate sand castings. Both systems use electromagnetic pumping to ensure non-turbulent filling to avoid oxide film and bubble damage in castings. Such processes or similar are not yet being used in Thai foundries. Correct mould filling, its simulation, system design and control are key areas for developments in Al alloy casting production by both sand and die casting processes and are also important in producing other alloys, e.g. alloy ductile iron exhaust manifolds. Foundries also need to look at the market for castings for application in electric powered vehicles including light alloy body parts.

Thai research in Al diecasting includes the relatively new techniques of Semi-Solid- Metal forming (SSM) – thixocasting, rheocasting and squeeze casting and the production of metal matrix composites as castings. SSM and single shot melting offer Thai foundries the potential for considerable energy savings coupled with easily automated, high-rate production of high integrity, near net shape components having fine, uniform microstructures with enhanced mechanical properties.

In meeting competition from light alloys, iron founders will have to develop the ability to produce thinner walled castings to save weight – this will require improvements in both dimensional control of moulds and cores and in melt conditioning & inoculation treatments to obtain correct microstructures at relatively high cooling rates. Worldwide in the automotive sector, for improved mechanical properties compacted graphite irons (CGI) are replacing conventional grey iron FC grades, e.g. for engine blocks, and austempering is being more widely used to heat treat ductile irons, e.g. for truck wheel hubs.

Hence scope for widening the range of cast alloys in general include:

The introduction of compacted graphite irons and austempered ductile iron into the automotive and general engineering sectors

Magnesium based castings for auto-parts and electronics

Improved production of corrosion and heat resisting steels

Special alloys for use in power generation such as Ni-base

VII. Summary.

If the 2021 vision in the Thailand Automotive Industry Master Plan (2012-2016) which specified that, "Thailand is a global green automotive production base with strong domestic supply chains which create high value added for the country", is to be achieved then the Thai SME foundries and die-casters in the automotive sector need to continue to improve all aspects of their operations. The continued success of Thai foundries in all sectors depends on maintaining and improving delivery of cast components which, against all forms of competitive sources and processes, satisfy the increasingly more demanding requirements from customers. These demands are for higher quality and reliability, for increased dimensional control, for improved casting alloy performance, for thinner walled castings and weight savings, and for shorter lead times, etc. As well as achieving these improvements foundries must also respond to the "costs down" approach of customers, especially those in the automotive industry, and to clean up their processes to comply with ever increasingly environmental legislation.

SME foundry companies in Thailand have a "Can do" mentality – this is encouraging. However, for survival in a tough marketplace this attitude must become "Can do correctly, efficiently, consistently, cleanly and safely"

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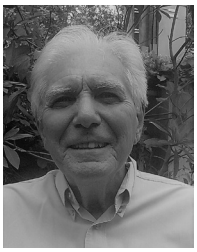

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A Prototype of Job Distribution System for Community: A case study of a Corporate Social Responsibility using NFC

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***Abstract*—Corporate Social Responsibility (CSR) is one of the activities that help make society better. One of CSR's activities is to create jobs to support communities. To operate such activity, can be time and resource consuming for the organization. Also it might be hard for people to join due to different personal restrictions. A prototype of this Job Distribution System for Community was implemented to help increase income for people in community. The application has been tested in one organization with three communities. The result showed that the prototype application can help manage CSR project and help people in the community to be able to find jobs that suit their preferences.**

***Index Term*—Job Distribution System, Community Social Responsibility, Near Field Communication, Location Service**

I. Introduction

Thailand economy has moved to Thailand 4.0 which is to change economy structure to become value-based economy that is driven by innovation. The concept of Thailand 4.0 is to do less but gain more through innovation and technology. In order to accomplish the innovation driven economy, creativity of process and product is needed. Some examples of this would be traditional agriculture that used mostly manpower reformed to become innovative agriculture that uses innovation and technology such as internet of things to support agriculture. Another example would be service industry that has changed from low value service to high value service. The fields that Thailand 4.0 covers are, Healthcare & Medical Technology Industry, Food/ Agriculture and Biological Technology Industry, Digital Technology and Internet Industry, Creative and High-Value Service Industry, and Smart Robot and E-Control System Industry [1]. These five fields are aimed to take Thailand out of middle-income trap and become higher income country.

Currently in the society, many people are working to earn income to support individual or family. Full time job alone might not make enough income to suit individual needs or family needs. Many people have started to look for part time jobs to earn some extra income. However, due to various restrictions of individuals such as age, time, resource, education, location, and so forth, which has made it hard for them to be able to find part time jobs that suit their availability. For example some people might be over the age limit the job description demands, even if they are still capable of doing the work. Elderly people (age 60 and above) make up 14.9 percent of the population and that number is growing in Thailand according to data [2]. Due to the restrictions from job descriptions, they might not be able to find suitable job that suit their current life style. Another group that we need to pay attention to is the teenagers with no education which has made it hard for them to be able to find a job. Due to some restrictions, part time jobs might be another option that can help these people earn additional income.

However some of job offers or part time job offers might consume large resources; that one individual might not be able to accomplish. For example a hotel would like to hire people to make a thousand souvenir gifts. Many people might be interest in this job but due to the limitation of time and resources, they might not be able to complete the job. Reach of information for job offer is also crucial, the information might appear only on the company site so many people might not realize that there are part time jobs available until very late.

To solve these problems while focusing on Thailand 4.0 model, technology; such as application on smart phone can be considered useful due to its flexibility, range of reach and access. This research is done to implement a system for job distribution in the form of mobile application. Its aim is to help increase the reach of information, while dividing a large portion of job into smaller portions that meet the need and capability of an individual. This can help people to get the part time jobs that they are able to complete and earn income to suit their needed.

II. Literature review

Implementing mobile application alone to process the task might not be enough to support the whole operation. Other technologies need to be considered to improve application to be even better and suitable for the job. Near Field Communication (NFC) is one of the technologies that can be used in multiple ways to increase the performance of smart phone through application. NFC is a contactless short range communication between two devices for information exchange. These two devices do not need to be connected; this allows data exchange to be easier and faster [3]. There are three modes of NFC operations:

Card Emulation Mode: In this mode, the NFC device operates as a smart card that stores certain information to processing. When user brings the device to the NFC reader then the information from user device will be send to the reader for further processing. It can be used in various ways such as; identification card to identify the user, used as security card to grant access to security or personal area, used as credit card/ e-wallet for business transaction.

Reader / Writer Mode: In this mode the NFC device will read/write data from the NFC tag. When user brings the device to the NFC tag, the device will process the data and present the output to the users. This operation can be used in various ways; such as read data from the NFC tag at the bus stop and then the device shows the detail of bus service to the user, used to open a application or certain website; used to receive a electronic coupon.

Peer to Peer Mode: In this mode the NFC devices will exchange information between two devices. This operation can be used in various ways such as e-money transfer from one user to another by doing so the cost of credit card reader or point of sale machine can be reduced. Another use is transfer of contact information between others such as e-business card.

With these three types of operation modes, the NFC can be modified and applied in various ways to meet the need of users. Due to the simplicity feature, the devices can be processed without contract or connection between devices. This makes the data exchange and transfer become fast and easy. As a result, NFC is one of the technologies that can be useful in various ways.

Location service is the function in the smart phone that can identify the position of the smart phone for user or device to process information as needed. There are two different methods to get the location of users though the smart phone. One method is to use global positioning system (GPS) which used satellites to identify the location. The other method is quite similar but instead of using the satellites, the cell towers are used to identify the location [4]. The location service system can be applied and used in many ways including navigation on the map, information alert when user is close to certain area, identifying location for reservation, etc.

In the developing world, mobile applications have been applied to help society in many ways to enhance service and performance. One of the usages is applied to mobile phone to improve health in developing world [5]. This uses mobile phone as a means of communicating the health issue. A study showed that with communication through mobile phone helps people to get necessary information regarding health information, widely across the location. Another example of mobile application usage is Mobile Applications for Agriculture and Rural Development which focus on improving agriculture supply chain and provide necessary information [6]. The users are including farmers, buyers, suppliers, content providers, etc. The benefits of using mobile application in agricultural and rural development are better access to information, better access to extension services, better market links and distribution networks, and better access to finance. These show that mobile use and application can be applied widely to enhance the process, service, performance, and many more.

III. Methodology

The system is implemented in the form of mobile application which can operate on smart phone. Technology such as Near Field Communication (NFC) and Location Service are also considered in the development system. NFC can grant quicker access to jobs and also confirm identity for payments when submitting jobs. Location Service can increase the reach of information for users when they are near by the organizations offering the job. There are two users to focus on in the development process; one is organization or anyone that has a job to offer and the other is the people that are looking for jobs.

NFC Technology can be applied to the system with two purposes. The first one is for the quick access to the job information. When users bring the smart phone close to NFC Tag, the system will launch the application and open the job offer page for user to accept the job offering. In this task, NFC is use as reader mode which read the data from NFC tag and process. Then the result will be presented to the user the information of the job. The second one is to identify the users that submit the job task when they completed. They can bring the smart phone close to NFC reader of the organization or the smart phone of the one that offer the job. The system will show the detail of user, quantity of the job to be submitted and amount of money or points that they have earned from the organization. In this task, NFC is used as peer to peer mode which exchanges the information between users. NFC can help enhance speed of the information access and exchange while ensuring accuracy and collection of data for the task. The flow of the NFC functions is presented in figure 1.

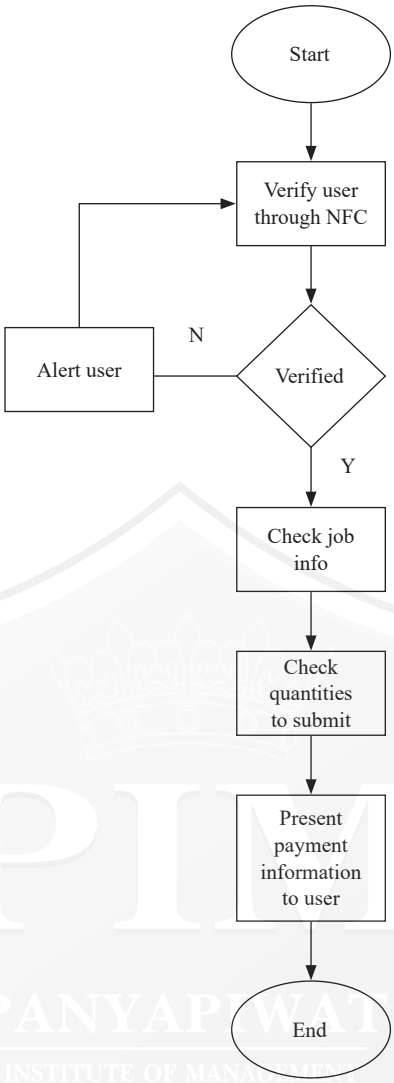

Fig. I. Identity verification and job submission through NFC

Location Service System is used to present the information of the job when the users are in the range of the pinpoint location. With Location Service System, users will be able to gain information of the job that is nearby their location. This can help alert the users of the job offer which increases the reach of information for users.

The alert system is for alerting users when the deadline of the job offer that they participated is getting close. This function is to ensure users who are able to complete the job on time and for organization or individuals that offer the job, will receive the products or merchandises on time. The alert function can be set up multiple times; 15 days prior to deadline, 10 days prior to deadline, 5 days prior to deadline. In case those users are unable to complete the job, they can inform the system and job owner so the system will alert other users that are interested in the job and redirect the job to them.

As for organizations or people that have jobs to offer, they can post the job information and necessary information such as quantity and deadline of the job. Once they are open the application and login to the system they can post job offer including job description, quantity, price, deadline, contact information, etc. As for individual that looking for part time job, once they open the application and login to the system they can browse for the job that suit their best interest. Once they accepted the job they can choose the quantity that they are able to complete, after that the system will reduce the total quantity for others that are interested to join the job. The process of the system is shown in figure II.

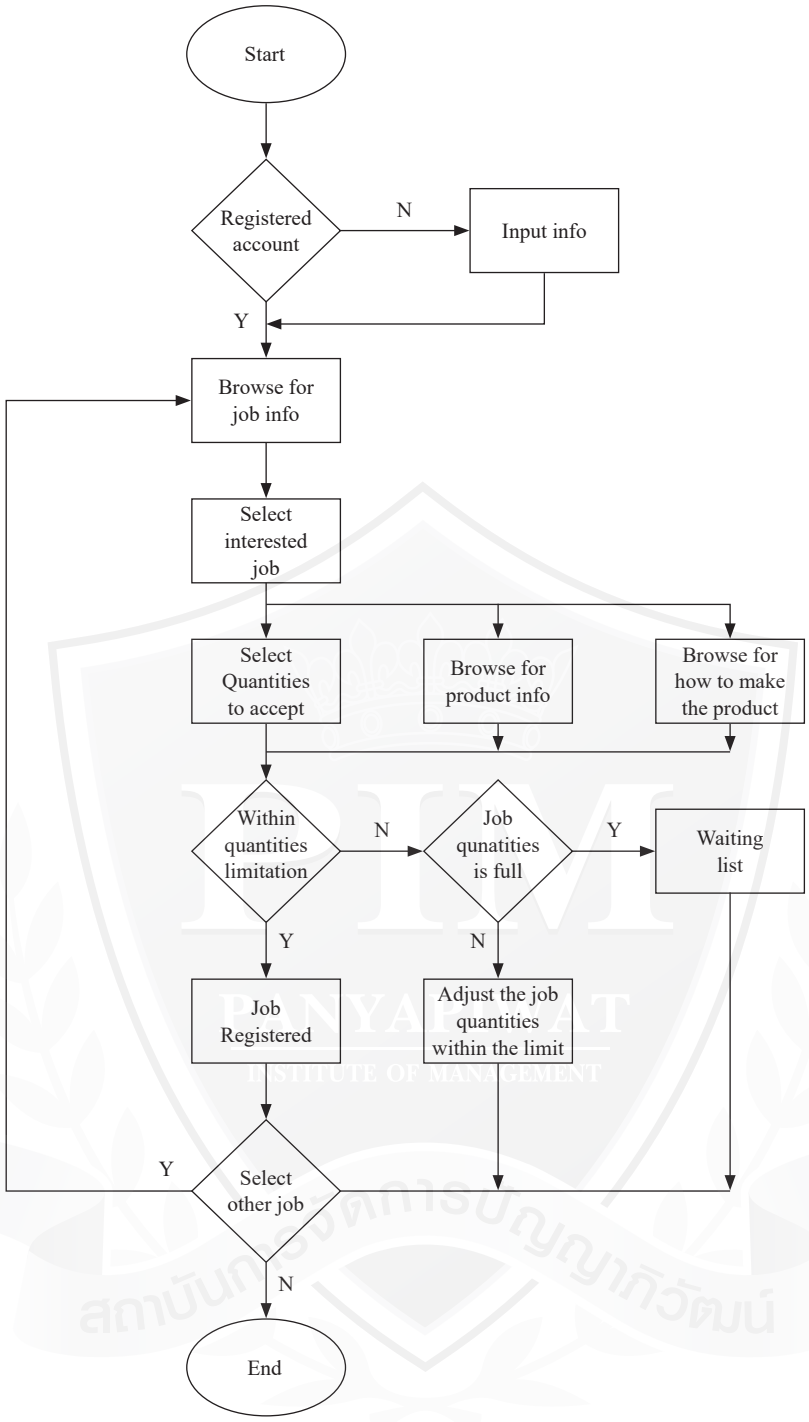

Fig. II. Flow of the prototype system

IV. Experiment: A Case Study of Corporate Social Responsibility

Corporate Social Responsibility (CSR) is the activities that benefit the society. It is a concept that companies or organizations to voluntarily contribute to a society and environment [7]. In society there are various groups of people that need to be concerned such as elder people or people with no education. Due to age range in job description, elder people who are still able to work might not be able to get the job they want. Some elder people are staying home to take care of home or their grand children. They are still have spare time where they would like to work to earn some income to support family as well. The second group that needs to be addressed is teenagers with no education. It is harder for these people to get a decent job and will likely end up as a taxi driver, motorcycle taxi driver, or daily wage worker.

Company A foresees such issue in the community in rural area of Nakornnayok, Thailand. Instead of

hiring a sub-company to produce handmade merchandise such as water lily, soap, shampoo, incense, etc to distribute to hotel or other company to be use as gift for guest and other purposes. Company A together with the community discussed the purposes of CSR project to help create jobs to support society by hiring elders and teenagers with no education for part time jobs.

At first the company used public relations to provide information to the community through the headman or person that in charge of the community. However the information was not spread to all people that were interested due to distance and time. Still people that were interested could get a part time job from making the merchandise but the manpower needed to make the merchandise was still not enough to meet the quantity of order. Another problem was that the quantities that people were able to accept was not guarantee due to some personal problems that occurred later which make them unable to complete the job or meet the quantity. Without centralized information and access of information, CSR Project of creating job to support society might be hard to accomplish because it is difficult to manage people in different location.

The prototype of Job Distribution System for Community was implemented for Company A to run CSR Project effectively and efficiency. The system was developed in the form of mobile application that operates on the smart phone. This is because the information can reach to the people in community equally with less cost. After implementing, the application was tested in 3 communities nearby Company A. There were 53 participants from 3 communities consisting of 32 elderly people and 21 teenagers with no education. The job offers were to produce 1000 small bottles of water lily and 300 sets of incense for company gifts. Both of job offers were given the time one month to complete.

When the company released the information of job offer, people in the community were able to receive information immediately as it is published as shown in figure 3. Also people in remote area or rural area are able to receive the information without having to travel into the organization or headman/ person that in charge of the community. The location service function also helps people in the area to see available job that offered in the closed by area. As a result people in the community will be able to get the job notice without traveling which will save cost for people in the community. After information was released, both job offers was accepted in less than two hours by 17 people to produce 1000 small bottles of water lily and 10 other people were waiting for job cancelation. Also 13 people accepted offer to produce 300 sets of incense and 5 other people waiting for job cancelation.

Fig. III. Job offering screen

People in the community could access the information of the job. The information of how to make the merchandise was also available in the system to be used as a guideline for people to follow as shown in figure 4. People that registered to the system could accepted the job with the quantity that they were able to accomplish. The detail of quantities of merchandise that individual accepted is present in table 1.

Fig. IV. Job Information Screen

TABLE I
QUANTITIES OF JOB THAT DISTRIBUTED TO INDIVIDUAL

TABLE I QUANTITIES OF JOB THAT DISTRIBUTED TO INDIVIDUAL		Incense	
TABLE I QUANTITIES OF JOB THAT DISTRIBUTED TO INDIVIDUAL	Quantity	People	Quantity
Number. 01	100	Number. 01	30
Number. 02	200	Number. 02	30
Number. 03	50	Number. 03	20
Number. 04	50	Number. 04	30
Number. 05	50	Number. 05	20
Number. 06	50	Number. 06	30
Number. 07	100	Number. 07	20
Number. 08	50	Number. 08	20
Number. 09	50	Number. 09	20
Number. 10	50	Number. 10	30
Number. 11	50	Number. 11	20
Number. 12	50	Number. 12	20
Number. 13	30	Number. 13	10
Number. 14	30	Spare Number. 01	15
Number. 15	30		
Number. 16	30		
Number. 17	30		

When they had completed producing the merchandise they notified Company A for date and time to bring the product to Company A for submission. Alert function also is of key important to keep users informed about the deadline of job submission. Both jobs offer were completed at least 10 days before deadline. In the Incense merchandise case, people number. 04 was unable to complete the job due to the limitation of resource so the user informs the system by request readjustment of quantity. Then the system informed other people who were waiting for cancellation, that there is job available to produce 15 sets of incense.

After completion of merchandise, they brought the merchandise to Company A. When they arrived to the Company A, people could identify themselves through NFC feature which showed personal information, the merchandise to submit, and total income that they were to receive if all products pass Quality control as shown in figure 5 and 6.

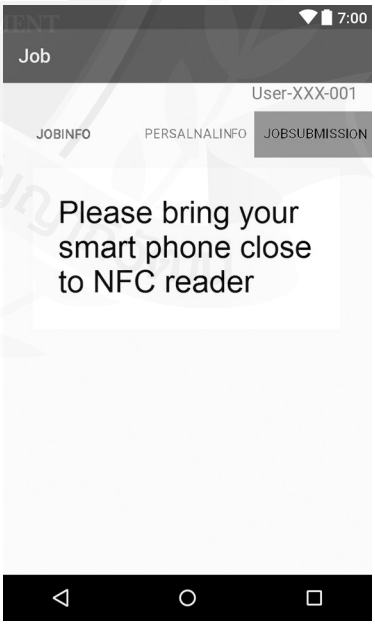

Fig. V. Job submission through NFC

Fig. VI. Details of job submission

V. Evaluation

The evaluation of the prototype system covered three parts: information access, system performance and benefit of the application to society. In the information access part, Information Quality Framework is considered to evaluate the system. The evaluation covers how application enhances the reach of information for people that are far away were able to receive information equally. Information access focused on how application is able to help people to access to information that they looking for. Information is up to date focused on information that people received is the most updated information. Information relevancy focused on information from the application that is related to the tasked that they need to complete. The second part covers how the system performs including: ease of use which means the application is easy to use, speed of the system that is focused on the speed of system to perform the task, correctness of the system that is focused the correction of data that is submitted into the system such as quantities number that users would like to accept for the job.

The third part covers how the application impacts the users and society. In this part participants were asked how application could benefit them including whether the application was helping them to get the job that suited their preferences. This part also concerned whether the application help promoted CSR project in the community and helped improve it to be a better society. The result of evaluation is presented in table 2.

TABLE II
Evalution of phototype system

Information Access		
Question	Average	Range
User is able to receive information from anywhere	4.11	Agree
User is able to access information as preferred	4.04	Agree
Information that provided in the application is up to date	3.92	Agree
Information that provided in the application is relevant to the task	4.25	Very Agree
Information that provided in the application is sufficient for user to complete the task	4.23	Agree
System Performance		
Question	Average	Range
The application is easy to use	3.98	Agree
The application is fast and allows user to complete his task quickly	4.15	Agree
The process of the system is flexible	3.92	Agree
The data that user input into application is correct as it should be	3.96	Agree
Impact of System		
Question	Average	Range
The application is benefit to the society to help people in community to get a job that suit them	4.06	Agree
The application is essential for CSR Project to help create job to support society	3.85	Agree

The ranges are:

Very Agree : 4.25 - 5.00
Agree : 3.75 - 4.24
Neutral : 3.00 - 3.74
Disagree : 2.00 - 2.99
Very Disagree : 1.00 - 1.99

From the result of evaluation, most of participants are agree that the application helped with information access of CSR project to help create job to support society. They were able to receive and access the information of job offering from anywhere at any time to get the most up to date information. The participants were very much in agreement that the application provided relevant information to the job offering such as time, place, location, and detail of product. Lastly the participants agreed that the application provided was able to help user to be able to complete the merchandise/ product to complete their task. The participants also agreed with all aspects in System Performance. The application was somewhat easy to use due to less number of processes to receive information and accept job offer which helped the user to complete the process quicker. Nonetheless the application was also flexible with quantities adjustment function that users were to readjust the quantities of product to produce then the system would distribute the job to other users. The application also ensured correctness of data in the application. Even after job quantities readjustment the system would keep monitoring and controlling data to prevent error from occurring. Finally the participants all agreed that the application was helping promote and support CSR activities such as creating job to support community. They also agreed that the application helped provide necessary information for users that have limitation to be able to get the job that suit their preference.

VI. Conclusion

The prototype of Job Distribution System was developed to be able to divide a large quantity of jobs that could be difficult to accomplish by a single person to a smaller part in which they could choose the quantities that they are able to accomplish. This helps reduce the limitation of manpower, time, cost, and other resources to the level that they could afford to complete the job. Through application that operates on the smart phone this helps enhance the reach and access of information to those people in different locations. People were able to received and access to information at any place and any time. So they can start working at home immediately without having to travel to the company or information center to get the information of the job which will help reduced the cost and time of traveling. Once the users got used to the application, they found that the application had ease of use and flexibility. Furthermore from the experiment, the result showed that the application was able to help distribute the work load to those that needed the jobs. It was also shown that the application is giving the benefit to the society which creates the job for those that have certain restriction. From the organization perspective, it is helped the organization to manage such activities and reduce the time and people to operate the CSR project. The application could distribute information, manage job load and alert the deadline of the job offer which help reduce manpower to run the CSR project. This showed that technology such as mobile application can be beneficial to the organization to help save cost of operating activity such as CSR activity and should be considered to apply to other CSR activities.

VII. Future Work

Currently the application only supports android operating system. The next step is to adjust the application to support other operating systems on the smart phone to be able to distribute information more widely and equaled. The prototype application can be enhance and modified to other CSR project types to help support both organization and community. This will help make a better community where they can support themselves without relying on the organization to support. If many organizations join and use application to promote CSR project then the location service can be used to be the best benefit. The application will alert users when they are closed to the pinpoint location to get the job notification. Other CSR project that the application can be modified to support including Garbage Bank, Community Service, Blood Donation, and so forth.

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Phannachet Na Lamphun, Ph.D. in Information and communication Technology, Asian Institute of Technology, Panyapiwat Institute of Management, e-Government collaboration, semantic web, ontology, and linked open data.

A Case Report on Root Cause Analysis of No-Go Parts in Refrigerator Factory

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***Abstract*—This paper studies the causes of customer complaint to a refrigerator manufacturer. No-Go (NG) product in manufacturing process not only affects the manufacturing cost but also increase problem about waste management. Main potential cause was identified with Quality Control (QC) tools and Failure Mode and Effects Analysis (FMEA), and it was weakness of legs of cooling blower shroud after injection process and unintended dropping of the blower in assembly station. To proof the hypothesis, the first stage of investigation with Finite Element Analysis (FEA) was performed with the drop test at the height of 0.8 m with impact angle of 45 degrees from the level of an assembly table. According to convergence testing of the FE analysis, the results were well consistent with the found defection. The FEA exhibited the stress of the model of dropping height was 135.6 MPa which almost reached the ultimate stress of the blower material. Therefore, an improvement was done by setting the assembly level at 10 cm lower to diminish the kinetic energy of unintended dropping while transferring. After the improvement was made, no any of NG products was found.**

***Index Terms*—Seven QC Tools, FMEA, Finite Element Analysis, Blower, Refrigerator.**

I. Introduction

A general issue which always accompany with the all types of manufactured products is a customer complaint due to products quality that does not meet the necessary standards. This issue affects directly on the manufactures in terms of reputation and investment cost. In general, there are three main factors which must take into account: quality, cost, and delivery, as shown in Fig. 1. Among all three factors, the most important factor to be considered first is quality. Therefore, to obtain product quality which satisfies customer requirements, the manufacturers must apply suitable systems to control their manufacturing process.

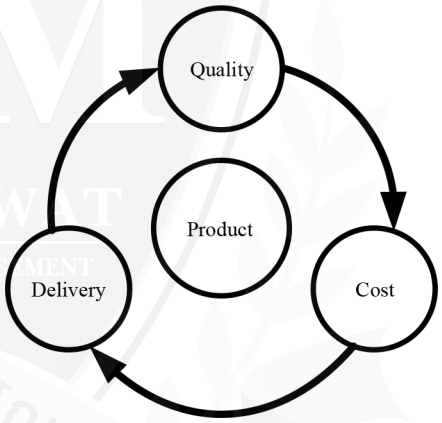

Fig. I. Three main factors for production.

The case described in this paper is of a refrigerator manufacturer. One indicator determining success of the factory is to reduce the customer complaint relating to inefficient operation of the blower in the refrigerator which may directly impact on satisfaction of the customers.

As a result, it is desirable to keep product quality in standard to maintain company reputation by solving the quality problem. However, general solutions for an industrial problem are often made by using experience of technicians to evaluate the causes of the problems which is usually ineffective. Therefore, this paper adopts QC Tools, FMEA, and FEA altogether to analyze the problem in both technical and management oriented facets [1-6].

Form the described problems above; analysis has been made to improve both the manufacturing process and therefore the finished product.

II. Data Collection and Analysis

This research began to collect symptoms of fault products found from complaints of customers for a nine-month backdate, from December 2013 to November 2014. This information was categorized into percentage and then analyzed with QC tools and FMEA. Next, the factory was examined to prove the hypothesis of FMEA.

A. NG PART DATA COLLECTION AND ANALYSIS

Most of the problems detected are ice adhesion, plastic debris clogging, broken wires, and broken leg of cooling blower shroud. The percentage of these problems were 1.6, 4.6, 5.2 and 13.7 respectively, as shown in Fig. . The problem which can be clearly specified and has second priority is broken leg of cooling blower shroud; physical damage is shown in Fig III. Hence, this problem is considered to be solved first.

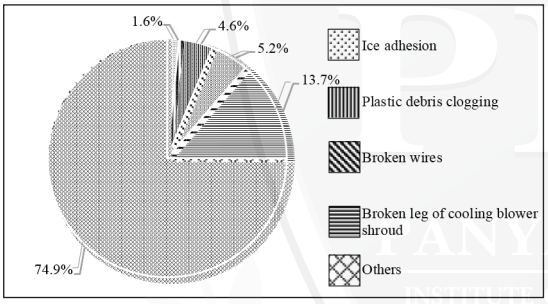

Fig. II. Percentage of problems found in fault products collected for nine months.

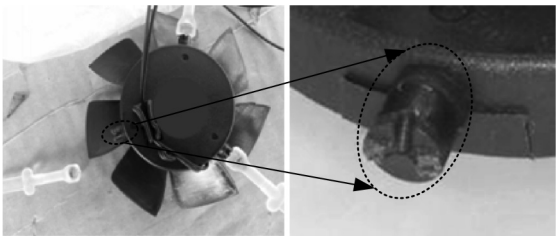

Fig III. Position where leg of cooling blower shroud is broken.

Analyzing the Probability of the Problem with QC Tools and FMEA

In the first step of Six Sigma DMAIC, brainstorming is adopted to examine root causes of the broken leg using cause-and-effect diagram as displayed in Fig.VI, one of seven QC tools. After team investigation is operated, four main root causes are found: 1) the blower leg is too small, 2) improper setting up conditions for injection, 3) improper package, and 4) unintended impact during assembly.

FMEA in the second step is tabulated in Table I. The RPN column shows that unintended impact during assembly has the highest priority which its value is 180. This is because during inspection of the assembly process, it was found that the operators used conveyor table to transfer finished part in the assembly station with height of 0.8 m above ground, as seen in Fig. There is high chance that finished part will fall to the ground which results in mechanical failure. The authors decided to use Finite Element Analysis (FEA) to verify the hypothesis of unintended impact during assembly.

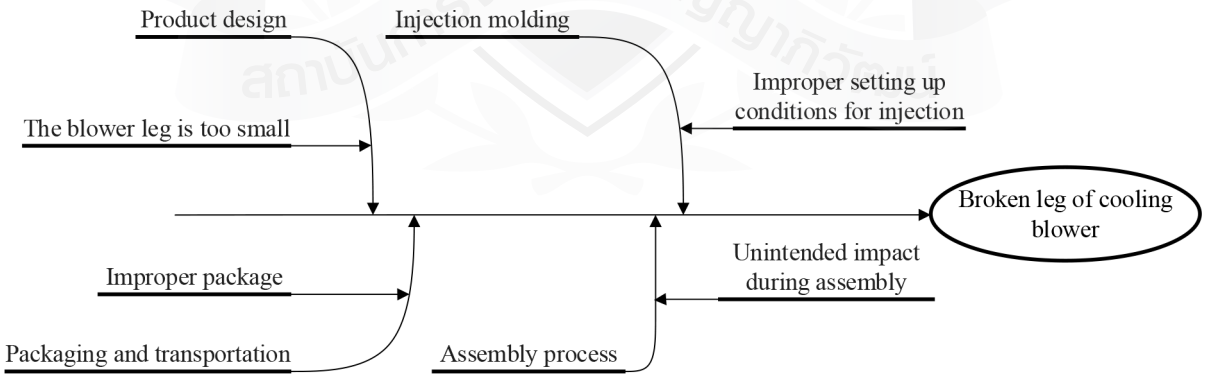

Fig. IV. The cause-and-effect diagram used to investigate root causes of the broken leg of cooling blower.

TABLE I
FMEA USED TO DETERMINE THE HIGHEST PRIORITY AMONG FOUR MAIN ROOT CAUSES

Process	Potential Failure Mode	Potential Failure Effect	Severity Rating	Potential Cause of Failures	Current Process Control	Occurrence Rating	Detection Rating	Critical Characteristics	RPN
Product design	The blower leg is too small	Broken leg	6	- Improper product design	None	2	3	N	36
Injection molding	Improper setting up conditions for injection	Broken leg	6	- Improper mold design - Improper conditions for injection	Inspected at QC unit	2	4	N	48
Assembly process	Unintended impact during assembly	Broken leg	6	- Improper operating proximity	None	5	6	Y	180
Packaging and transportation	Improper package	Broken leg	6	- Improper package is used during transportation	Inspected at QC unit	6	3	N	36

Fig. V. The improper installed position of a blower packaging box and the level of assembly table.

III. PROVE OF THE HYPOTHESIS

A. 3D CAD Creation

Before performing FEA analysis, it is necessary to create 3D model of a workpiece in detail as closely as possible to the real object to obtain the best approximated results. The 3D model of cooling blower shroud with three legs is shown in Fig. 1.

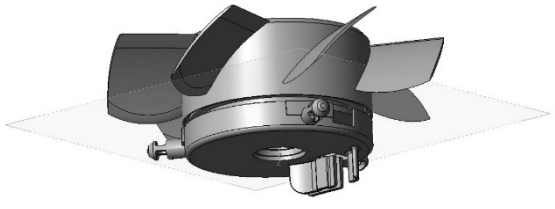

Fig. I. The 3D model of cooling blower shroud with three legs.

B. Material Properties for FEA Analysis

To analysis with a Computer-Aided Engineering (CAE) not only, the exact size of the workpiece has to be known, but also its material properties. In this experiment, 30% glass fiber reinforced Polybutylene Terephthalate (PBT-30GF) is a raw material used to make the blower shroud where some essential mechanical properties of PBT-30GF are shown in Table II.

TABLE II
MECHANICAL PROPERTIES OF PBT-30GF IN SI UNIT [7]

Mechanical Properties	Range	Average value
Tensile Strength, Ultimate	20.0 - 186 MPa	121 MPa
Tensile Strength, Yield	82.7 - 155 MPa	119 MPa
Elongation at Break	1.00 - 130 %	3.51 %
Elongation at Yield	2.00 - 5.00 %	2.97 %
Modulus of Elasticity	0.824 - 15.0 GPa	9.49 GPa

The stress-strain curve tested at temperature of 23 °C is shown in Fig. II. There is no obvious yield point. Therefore, the 0.2% offset method is employed to determine the yield strength. Then, the stress-strain relation in the plastic deformation region can be found in Table III.

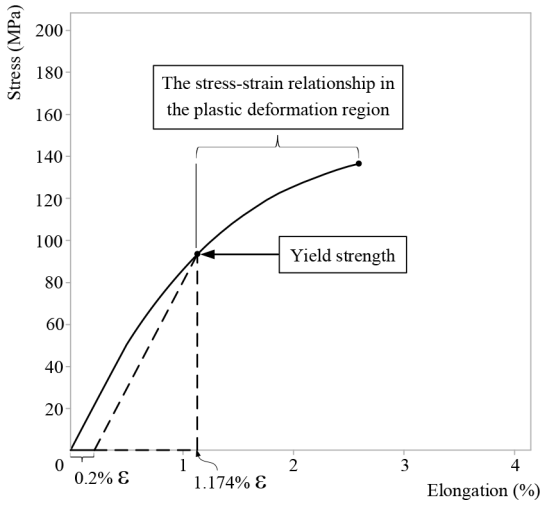

Fig. II. The stress-strain relation in the plastic deformation region of PBT-30GF at temperature of 23 °C [8].

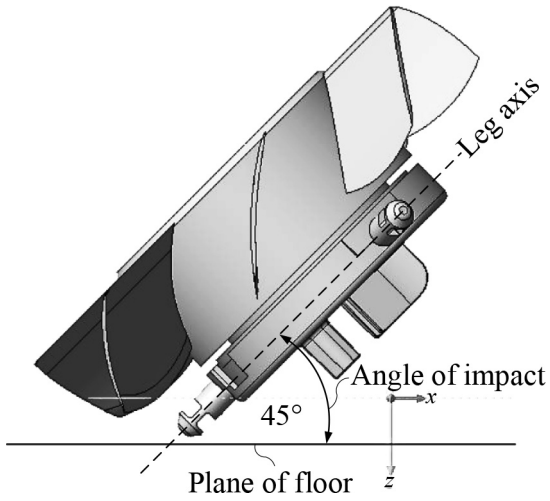

Fig. III. Leg of cooling blower shroud with impact angles at 45 degrees.

TABLE III
THE STRESS-STRAIN RELATION IN THE PLASTIC DEFORMATION REGION OF PBT-30GF AT TEMPERATURE OF 23 °C

% $\varepsilon_{plastic}$	σ, MPa
0.0%	94.0
0.1%	99.0
0.2%	103.9
0.3%	108.1
0.4%	111.7
0.5%	115.5
0.6%	118.4
0.7%	121.2
0.8%	124.0
0.9%	126.1
1.0%	128.2
1.1%	130.3
1.2%	132.1
1.3%	134.2
1.4%	135.6

Since FEA test is a time-consuming process, it is necessary to find the appropriate element size that is commonly known as convergence testing. For preliminary investigation of this case, the authors used the height of 0.8 m and the impact angles 45 degrees model as shown in Fig. III. The four-noded tetrahedron elements with size of 1.1, 1.6, 1.7, 1.9, and 2.0 mm are experimented to achieve optimal element size [9-10]. Table IV shows the convergence testing which is obviously seen that no significant change in stress level for element sizes smaller than 2.0 mm. So, the element size of 2.0 mm is chosen as a controlled element size.

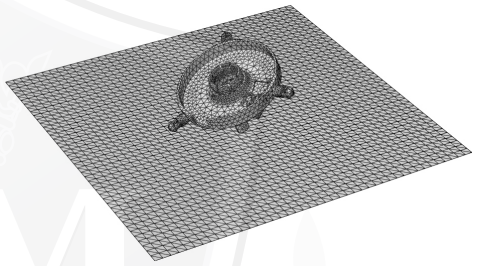

Fig. XI. The FE Model for impact tests.

TABLE IV
EXPERIMENT RESULTS AT VARIOUS SIZE ELEMENTS WITH DROP HEIGHT OF 0.8 M AND IMPACT ANGLES AT 45 DEGREES

Element Size, mm	Number of Elements	Maximum Stress, MPa
1.1	34,302	135.6
1.6	19,362	135.6
1.7	17,235	135.6
1.9	15,275	135.6
2.0	14,110	135.6

Since an impact angle smaller than 25 degrees will cause a shroud fin break before the leg and if an impact angle smaller than 45 degrees, a blower blade will break before the leg as well. Therefore, in order to save time for more investigations, the researchers selected 2.0 mm elements for impact tests with the impact angles of 25 degrees and at the height of 0.5, 0.6, 0.7, and 0.8 m as shown in Fig.. One of the results is shown in Fig. X.

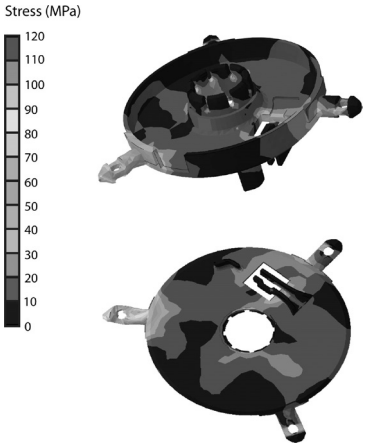

Fig. X. FEA result of stress distribution on the cooling blower shroud where element size is 2.0 mm, drop height is 0.8 m, and impact angle is 25 degrees.

The whole experimental results in combination of the drop heights and impact angle of 25 degrees are tabulated in Table V.

TABLE V
THE WHOLE EXPERIMENTAL RESULTS IN COMBINATION OF DROP HEIGHTS AND IMPACT ANGLE OF 25 DEGREES

Drop Heights, m	Maximum Stress, MPa
	Impact Angle, degrees
0.5	99.0
0.6	111.0
0.7	111.0
0.8	135.6

All experimental results in Table V have the same maximum stress beyond the yield strength of PBT-30GF that is 94.0 MPa as shown in Table III.

C. Results after Improvement

To solve the highest priority of causes that cause NG products, due to the FEA result, the assembly line is improved by reducing kinetic energy that the leg of blower shroud will absorb. Hence, the level of the assembly table was reduced by 10 cm and the direction of placing the workpiece box is changed to ease ergonomically working.

After improvement, the amount of NG products had been monitoring for three months, and there was no report about broken leg of cooling blower shroud taken into account and the FEMA after improvement is shown in Table VI.

IV. Discussions

All the maximum stresses from FEA in Table IV are beyond the yield stress and reach the maximum stress of PBT-30GF. This indicates that falling of blower at height of 0.8 meters will lead to breakage of blower leg. In addition, the position of the maximum stress observed in FEA in Table IV was the same as position of the broken leg as shown in Fig. 3. Therefore, unintended impact during assembly is a major root cause of broken leg of the cooling blower shroud.

In the following experiment as the results shown in Table V, this indicates that the lower levels from installed position of the assembly table will not make broken leg of the cooling blower shroud from unintended impact from falling during assembly process. However, the leg will still be deformed because all maximum stresses are beyond the yield strength of PBT-30GF.

The improvement was done by minimizing kinetic energy that the leg of blower shroud will withstand; as a result, the level was reduced by 10 cm. Then, tracking of the amount of NG products had been monitoring for three months, the number of RPN in Table VI is reduced significantly from 180 to 90. This implies that the solution is correct. Therefore, the process analysis tools are effective to determine the root causes of the problems rather than a group of unsystematic humans experience; and for continuous improvement, all the remaining three main problems should be fixed to minimize NG products in the further study.

Even though, the reactive improvement by reducing the height of the assembly level provides no breakage, but if the cooling blower shroud falls, it still be deformed. Moreover, it is non-ergonomic operation if the level of an assembly table height is reduced less than 0.5 m. So, the alternate preventive adjustment is to further rearrange the assembly station for well ergonomic operation to keep the workpiece from unintended falling.

Conclusions and Recommendation

This paper utilizes seven QC Tools and FMEA to determine major root causes of NG products of refrigerated cooling system. According to 13.7% of collected complaints, the broken leg of cooling blower has the second priority after others unidentifiable causes. So, this research selects it to be solved first. With the RPN of 180 from FMEA, the unintended impact from falling during assembly process was suspected as the main cause of broken leg, and it was set as the hypothesis of this study. After validating with FEA that simulated blower shroud fell from height of 0.8 m above the floor, the maximum stress value of 135.6 MPa occurred consistently around the position of real broken leg.

Finally, the improvement in this paper is the reduced height of 10 cm from the previous assembly level, to guarantee when the product falls into the ground it will not be broken. However, since deformed leg also dissatisfies customers, this issue should take into the cause of NG product as well in the further study.

TABLE VI
FMEA USED TO DETERMINE THE HIGHEST PRIORITY AMONG FOUR MAIN ROOT CAUSES AFTER IMPROVEMENT

Process	Potential Failure Mode	Potential Failure Effect	Severity Rating	Potential Cause of Failures	Improving Method	Occurrence Rating	Detection Rating	Critical Characteristics	RPN
Product design	The blower leg is too small	Broken leg	6	- Improper product design	–	–	–	–	–
Injection molding	Improper setting up conditions for injection	Broken leg	6	- Improper mold design -Improper conditions for injection	–	–	–	–	–
Assembly process	Unintended impact during assembly	Broken leg	6	- Improper operating proximity	Reducing the level of assembly table down for 10 cm	3	5	Y	90
Packaging and transportation	Improper package	Broken leg	6	- Improper package is used during transportation	–	–	–	–	–

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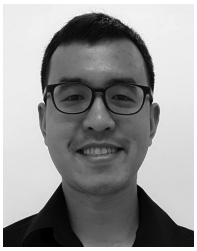

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Combine Particle Swarm Optimization with Artificial Neural Networks for Short-Term Load Forecasting

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***Abstract*—Electricity consumption curves are highly non-linear as many external factors affect the electricity consumption. Artificial Neural Networks (ANNs) are popular in electricity load forecasting since its pattern recognizing and learning abilities of data. Training ANNs are important as it directly affects the forecasts. However, backpropagation training algorithm likely to stops at local minima. Therefore, this research uses Particle Swarm Optimization to train an ANN for forecasting short-term load demand in Thailand. One-year training data is used to forecast the days in 2013. Forecast are evaluated in terms of the Mean Absolute Percentage Error (MAPE). Monthly, yearly, weekdays', Mondays', weekends', holidays', and bridging holidays' average MAPEs from PSO are compared with MAPEs from backpropagation training algorithm. Average MSPEs show that PSO outperforms backpropagation for training ANNs in short-term load forecasting.**

***Index Terms*—Short-Term Load Forecasting, Artificial Neural Networks, Backpropagation, Particle Swarm Optimization.**

I. Introduction

Short-Term Load Forecasting (STLF) helps on making decisions related to the utility activities such as fuel purchasing, maintenance scheduling, and generator scheduling [1]. STLF is one of the three categories of electricity forecasting where it targets on forecasting one hour to one-day electricity consumption [2]. However, time series patterns appearing in each of these categories are different [3]. Forecasting techniques are divided into sub-groups considering the usage of data [4]. Time series forecasting techniques use only the historical data to forecast the future electricity consumption. External factors such as temperature variations can be included to forecast the future electricity consumption with causal forecasting techniques. Therefore, causal forecasting techniques are popular among the researchers due to their promising forecasting outcomes. Some of the well-known causal forecasting techniques are Multiple Regression models, Bayesian techniques, Artificial Neural Networks (ANNs), and Support Vector Machine.

ANNs are widely used in the forecasting field due to the easiness of understanding the concept. ANNs can recognize and learn the non-linear patterns in data series. Weights and bias of ANNs are adjusted based on the patterns in the training data sets before it works with the unseen data. The ANN architecture has been evolved over the years where the Feed forward neural network is the based and the most common ANN architecture to use with many applications [5]. Advantages and disadvantages of these ANN based techniques are discussed in [6].

One of the ways to show the forecasting performance of ANN is comparing the forecasting outcomes of ANN with other techniques. ANNs' forecasts are compared with the forecasts from Support Vector Machine (SVM) in [3] to show that ANN performs better in their research. The same conclusion is made in [7] when ANN compared with the Box-Jenkins method. Considering the case of Ireland electricity demand forecasting, [2] identifies that ANN is better to forecast all three time horizons: Short-Term Load Forecasting (STLF), Medium-Term Load Forecasting (MTLF), and Long-Term Load Forecasting (MTLF).

Since, ANN requires a large number of data and time during the training phase, it is considered as a disadvantage. As forecasts depend on the ANN's parameters and initial values of weights and bias, continuous monitoring is required to get accurate forecasting outcomes. Backpropagation is the most common training algorithm for adjusting the weights and bias of ANNs [8-11]. Since it is a gradient search algorithm, Backpropagation has its inherent training drawback that it can trap in local minima during the training process [8, 12,13].

Drawback of using Backpropagation to train ANNs for forecasting short-term load demand is addressed in this research by integrating ANN with Particle Swarm Optimization (PSO). Considering the ability of solving complex non-linear objective functions with PSO [14], several attempts, where it is used to train ANNs for STLF, can be found in [15-17]. The

concept of using PSO to train the ANN for SLTF is practically applied for the case of Thailand using the data from Electricity Generating Authority of Thailand (EGAT).

The rest of the paper is arranged as follows: in the next three sections, basics of ANN, Backpropagation, and PSO are explained, respectively. Design of experiment including data cleaning, data arrangement, ANN arrangement, and training ANN using Backpropagation and PSO is explained before discuss the results and make the conclusion.

II. Artificial Neural Networks

Basic components of ANNs are input and output nodes, hidden layers, hidden neurons, weights that connect each node of the adjust layers, and bias in hidden neurons and output nodes. All these components are illustrated in Fig. I.

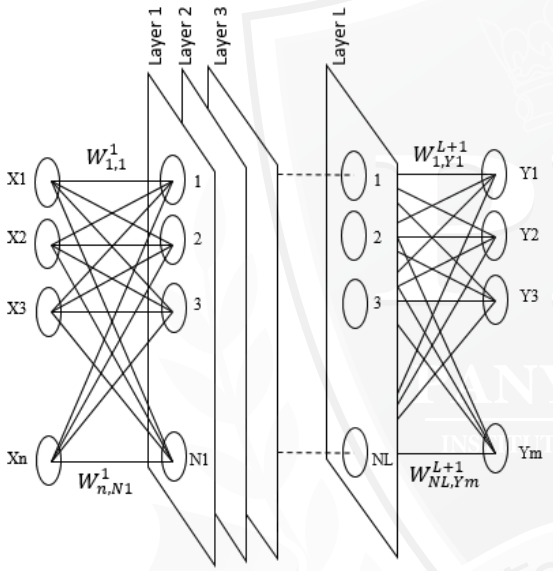

Fig. I. Basic ANN structure

The given basic ANN structure has *X1, X2, X3,....Xn* input nodes, *Y1, Y2, Y3,....Ym* output nodes, *L* hidden layers, and *N1, N2, N3,....NL* hidden neurons in each hidden layer, respectively. Weights that connect the *Layer* (*L-1*) and *Layer* (*L*) indicate as W^L. As given in the fig. W^1, represents the weights that connect inputs and the hidden nodes in the 1st hidden layer and W^{L+1} represents the weights that connect nodes in *Layer* (*L*) and output nodes. Therefore, $W^1_{1,1}$ is the weight that connects first input node and the first hidden neuron of *Layer 1* and $W^1_{n,N1}$ is the weight that connects n^{th} input nodes and the $N1^{th}$ hidden neuron of the *Layer 1*. All these weights are adjusted to get the minimum training error between the target outputs and the network's output for the training inputs. There are different training algorithms to minimize the training error and they take each weight to an optimum value at end of the training iterations called epochs.

III. Backpropagation

Backpropagation is a supervise training algorithm where it uses a target series to adjust the weights and bias. It can be easily found in many ANN related research as it is easier to use than other training algorithms [8-11].

Training inputs move through the randomly initiated weights to get the ANN output. These outputs are compared with the target series to calculate the training error. Training error is propagated back to the input layer for adjusting the weights and complete the first training cycle. This process runs until the training error reaches to the predetermined minimum error or the number of training cycles.

IV. Particle Swarm Optimization

Each particle in PSO is a set of weights that gives different outputs for the training inputs. The fitness of each particle is the Mean Squared Error between the training output for that specific weights and the target series. Weights in each particle are updated to minimize the training error.

After evaluating the fitness of all the particle, PSO updates the personal best (pbest), where the best fitness of each individual particle that has obtained thus far and the global best (gbest), where the best fitness that obtained by any particle for the whole particle set.

Based on the pbest and gbest of the current population, the velocity and potion of each particle are updated for the next generation as given in Eq. (1) and (2), respectively.

$$V^i(t+1) = w \times V^i(t) + c1 \times rand1 \times (p - X^i(t)) + c2 \times rand2 \times (g - X^i(t)) \quad (1)$$

$$X^i(t+1) = X^i(t) + V^i(t+1) \quad (2)$$

$V^i(t)$ and $X^i(t)$ are the velocity and position of i^{th} particle at generation *t*, respectively. *p* and *g* represent the position of the pbest and gbest, respectively. *w* is the inertia weight which defines the effect of current velocity for the next generation. rand1, *rand2* are random values between 1 and 0 and c1, c2 are learning factors which have to be predetermined.

V. Design Of Enxperiment

A. Data Cleaning

The data population includes data from March 2009 to December 2013. A sample data set is selected to forecast all the days in 2013 using one year training

data. Holidays, bridging holidays, and other outliers due to missing values or measurement errors change the regular patterns appearing in the historical data. Including the abnormal data in the training data set weakens the forecasting accuracy. Therefore, these abnormal data of the data gathered by Electricity Generating Authority of Thailand is removed.

Data cleaning process is started removing the calendar holidays within the sample data period. These holidays' data are replaced with the weighted moving average as given in the following equation.

$$L'_t\,(d) = w_1\,L_t\,(d-7) + w_2\,L_t(d-14) \qquad (3)$$

Where $L_t(d)$ and $L'_t(d)$ are actual and the estimated load data on day d at time period t. w_1 and w_2 are the weight parameters and set to be 0.7 and 0.3, respectively. Then the B' holidays which is a day between two holidays or between a holiday and a weekend are estimated using the same equation that used to estimate the holidays demand.

With the purpose of recognizing other outliers easily and accurately, data are separated into different time-windows considering the similar consumption behavior of similar time periods on similar days. Since there are 7 days per week and 48 time periods for each day, data are divided into 7 48 time-windows as below.

$$V_t(d) = [L_t(d'), L_t(d'-7), L_t(d'-14), .. L_t(d'-7\times m)] \qquad (4)$$

Where $d \in \{d', d'\text{-}7, \ldots, d'\text{-}7\text{m}\}$, d' is the last 7 days in the data set and m is the number of weeks for each day, d (m = 105 when d = Sunday, Monday, and Tuesday. m = 104 when d = Wednesday, Thursday, Friday, and Saturday). Then the standard deviation of each time-window, and the four-period moving average are used to create the time-window based filtering band, as given in Eq. (5).

$$B_t(d) = \left[\frac{\sum_{i=1}^{4} L_t(d-7\times i)}{4}\right] \pm N \times SD(V_t(d)); t = 1, \ldots 48 \qquad (5)$$

All the data lying outside the time-window based filtering band are identified as the outliers and replaced by the weighted mowing average as given in Eq. (3).

B. Data Arrangement

One year data is prepared to forecast all the days in 2013. Each time period t of each day d is forecasted separately using four inputs to the ANN: previous week's, same time period's load $L'_t(D-7)$, previous day's, same time period's load $L'_t(D-1)$, previous day's, same time period's temperature $T'_t(d)$, and the same day's, same time period's temperature . Since, the target series consists with similar days, only 52 training sets are used to forecast the time periods of Sundays and Mondays. Time periods of all the other days are forecasted using 51 training sets.

C. ANN arrangement

The ANN structure consists with four input nodes and one output node according to the data arrangement. One hidden layer with four hidden neurons is included in the ANN so the total number of weights and bias equal to 25: 16 weights to connect the inputs nodes and the hidden neurons, 4 bias in hidden neurons, 4 weights to connect hidden neurons and the output node, and the bias of the output node. The suggested ANN structure according to the above parameters is illustrated in Fig. II.

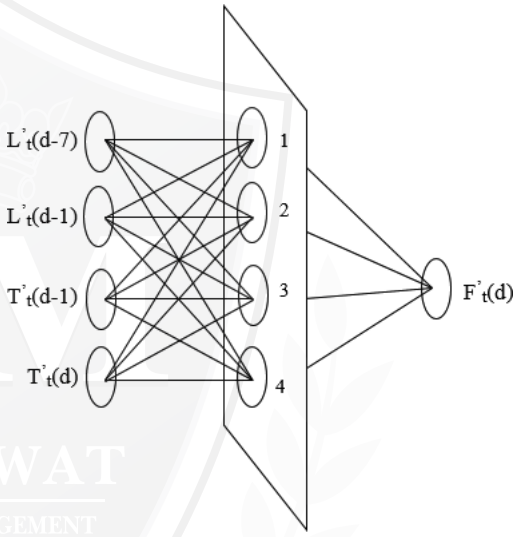

Fig. II. The suggested ANN structure

D. Training ANN with Backpropagation

Once the data and the network are ready, weights and bias of the network can be adjusted by backpropagation training algorithm. The place, where the training algorithm should stop, has to be defined early. The minimum training error (Mean Squared Error between the network outputs and target series) and the maximum number of training cycles are considered as the stopping conditions. These values are set to 0 and 1000, respectively, expecting the maximum training performances.

E. Training ANN with Particle Swarm Optimization

1) Encoding

Weights and bias of the network should have specific places in each particle. The process of placing these weights and bias in particles are called encoding. Since the total number of weights and bias of the suggested ANN is 25, each particle should have the same number of elements in them. Each of these weights and bias are placed in particles as given in Table I.

TABLE I
ENCODING WEIGHTS AND BIAS INTO PARTICLE

Weights/Bias	Elements
$W^1_{1,1}$	1
$W^1_{1,2}$	2
.	.
.	.
$W^1_{1,4}$	16
$b_{(1,1)}$	17
.	.
.	.
$b_{(1,4)}$	20
$W^2_{1,1}$	21
.	.
.	.
$W^2_{4,1}$	24
$b_{(4,1)}$	25

First 16 elements of each particle belong to the weights that connect the input nodes and hidden neurons. Four bias of hidden neurons are placed from 17th element to 20th element. Weights that connect hidden neurons and the output node are placed from 21st element to 24th element. Finally, the bias of the output node is placed at the end.

F. Fitness Values Calculation

During the fitness calculation, elements of each particle are placed in the network at their specific places to get the network output. This output is compared with the target data series and calculated the Mean Squared Error (MSE). Therefore, MSE is the fitness of each particle or the objective function for the PSO. Since the job of the PSO is to minimize the objective or the fitness value, weights are updated at each generation and reach to an optimum set.

1) Setting the Parameters

For updating the pbest and gbest, the fitness of each particle directly involves. However, parameter values have to be defined for updating the velocity and position of each particle. The inertia weight w and the learning factors c1 and c2 are set to 0.6, 2, and 0.5, respectively so that the current velocity and pbest give a higher impact on particles for the next generation. Two random values between 0 and 1 are assigned to rand1 and rand2 each time for updating the velocity and position. The PSO algorithm stops when it reaches to 200 generations, 0 fitness value, or 20 stall generations where there is no or very less improvements given by the fitness values between successive generations.

G. Evaluating the Accuracy

The error between the forecasts and the actual demand is interpreted with Mean Absolute Percentage Error (MAPE). Since the cleaned data is used to train and test the ANN, the error and the MAPE are calculated as given in the following equations.

$$e'_t(d) = L'_t(d) - F'_t(d) \tag{6}$$

$$MAPE'_d = [(\frac{1}{48}) \sum_{t=0}^{48} \left| \frac{e'_t(d)}{L'_t(d)} \right| \times 100 \tag{7}$$

The error $e'_t(d)$ of day d at time t is calculated using the cleaned load $L'_t(d)$ and the forecast $F'_t(d)$ of day d at time t. This error and the cleaned load are used to calculate the MAPE of day d.

VI. RESULTS AND DISCUSSION

Monthly and yearly average *MAPE′* with backpropagation and PSO training algorithms are given in Table II.

TABLE II
MONTHLY AND YEARLY AVERAGE FOR 2013

Monthly Average *MAPE′*		
Month	BP-ANN	PSO-ANN
January	3.837	3.139
February	3.480	3.215
March	4.253	3.492
April	3.398	2.604
May	3.416	2.938
June	3.591	3.200
July	3.173	2.932
August	2.541	2.574
September	2.653	2.611
October	3.388	3.257
November	2.914	2.554
December	8.470	8.637
Average	3.769	3.439

The yearly average *MAPE′* with the PSO training algorithm (3.439) is less than the yearly average with backpropagation (3.869). August gives the minimum monthly average *MAPE′* (2.541) for backpropagation while November gives it for PSO (2.554). The highest monthly average *MAPE′* for both training algorithm belong to December and these values are equal to 8.470 and 8.637, respectively. Regardless of the training algorithm, the average *MAPE′* in August, September, and November are lesser than 3 while the average *MAPE′* in January, February, March, June and October are higher than 4 with the special case of December.

The reason that December has the highest monthly average *MAPE′* for both backpropagation and PSO

is, the electricity consumption in December is lower than the other months even though the holidays and B' holidays are replaced with the estimated data. When the ANN is trained with the consumption values from other months, ANN assumes that December also has the same level of consumption values. Therefore, most of the time, forecasts from ANN for December are higher than the actual consumptions in December. This special case is best illustrated by Fig. 3 with its forecasted and the actual consumption curves for 23rd Monday of December, 2013.

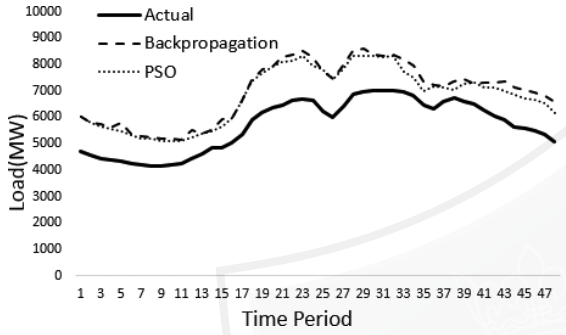

Fig. III. Actual vs Forecasted load for 23rd Monday of December, 2013

Contrast to the above forecasts behavior, Fig. 4 gives accurate forecasting outcomes with both training algorithms.

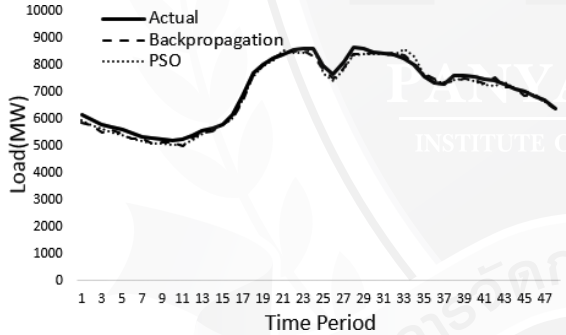

Fig. IV. Actual vs Forecasted load for 25th Wednesday of September, 2013

The day has been selected considering the lower *MAPE′* in August, September, and December. The *MAPE′* on 25th Wednesday of September, 2013 are lower with both training algorithm and it shows by the graph given in Fig. 4.

MAPE′ are divided into different categories based on the consumption patterns: weekdays, Mondays, weekends, holidays, and B' holidays. Average *MAPE′* of each category is summarized in Table III. The lowest average *MAPE′* of each category belongs to PSO. From those categories, weekdays' forecasting has lower average *MAPE′* by each training algorithm while holidays' forecasting has the highest average *MAPE′*.

TABLE III
MONTHLY AND YEARLY AVERAGE FOR 2013

	Yearly average *MAPE′*	
Category	BP	PSO
Weekdays	3.317	3.145
Mondays	3.666	3.322
Weekends	4.047	3.491
Holidays	5.262	4.554
B' Holidays	4.795	4.407

VII. CONCLUSION

The objective of the research is to improve the STLF accuracy by reducing the training error of ANN. Backpropagation training algorithm is replaced by PSO algorithm to optimize the weights and bias of the ANN. The ability of optimizing weights and bias of ANN using PSO have been proved for the case of Thailand electricity consumption data for STLF and results are compared with the results from backpropagation training algorithm. Considering the yearly average *MAPE′* for 2013, PSO outperforms the backpropagation training algorithm to train the ANN for STLF. Furthermore, PSO is better for training ANNs to forecast the different categories of days compared to the backpropagation. However, forecasting outcomes for days in December is poor due to its low electricity consumption.

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Logistics improvement: A case study of automotive part distribution

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Abstract— Spare parts distribution is one of the key processes in after-sales services of the automotive business. Nowadays, many automotive manufacturing companies are focusing on improving their after-sales services to gain higher competitive advantages over their competitors. Therefore, the after-sales business needs to improve continuously to provide better customer services. The case study company targets at improving its after-sales business processes every year to retain a high position in the market. At its service centres, vehicle downtime (i.e. breakdown and wait until the repair is completed by the service centre) is used as a key indicator to measure customer satisfaction rate. Currently, the vehicle downtime of the service centres is reported quite unsatisfactory due to unavailability of the required spare parts. Hence, after analysing the root causes of the problem, the after-sales service department comes up with an innovative idea of using night-time delivery service instead of daytime to improve the parts supply service. The result shows that the spare parts waiting time of the service centres is reduced around 124 hours per day and also resulting in 35% reduction of the transportation cost. In addition, the number of transportation routes is reduced from 11 to 5 routes.

***Index Terms*— Automotive Parts, Logistics Management, After-Sales Services, Parts Distribution, Night-time Delivery**

I. Introduction

The logistics and customer service are closely linked together and they become one of the most important factors in business survival for the firms which have after-sales services as a core business [1]. High attention must be paid in the logistics processes since better logistics processes could bring about better customer services. The case study company is a main Japanese automotive distributor in Thailand which sells commercial vehicles to nationwide dealers. In addition, spare parts and technical service supports are also core business processes of the company. According to the current situation, the after-sales department needs an immediate attention since significant improvements are necessary for better competitive advantages over its market rivals, e.g. other distributors, non-authorised garages and one-stop service garages. In addition, the company has also sought after cost reduction opportunities along with better customer satisfaction. Therefore, the concerned departments of the company have to develop innovative improvement methods on their related processes.

After brainstorming with the working team, including vice president, head of the business unit, relevance engineers and main dealers, vehicle downtime and transportation cost are concluded as the top priority problems that need to solve instantly. The vehicle downtime is the outage duration of the vehicle under services. In order to create better customer satisfaction, the service centre has to provide better services, e.g. repair, maintenance, etc. with a shorter lead time. The causes of vehicle downtime can be categorised into many reasons, but the one which is responsible by the working team is the spare parts waiting time. In fact, delivery problems and parts availability are both root causes of long waiting time of spare parts.

For the transportation cost, currently, the company uses services from transportation service companies. Within Bangkok's areas, the door-to-door delivery method is used for distributing spare parts to service centres. All service centres will receive their ordered goods or spare parts within a specified committed time. However, the current method causes some problems to the company. The main problem is on loading efficiency of each truck which only uses at 40% average of the full capacity in each trip. According to the trip based transportation fee calculation method, the lower percentage volume of each truck is reflected with the higher cost of transportation per cubic metre. To mitigate the problem, in this research, the night-time delivery method is developed.

Although none of Thai automotive companies have implemented the night-time delivery concept in their current business operations, it is widely used in Europe. Yusen Logistics distributes automotive spare parts to BMW and MINI using night distribution scheme to eliminate spare part waiting time in the next morning [2]. TNT Innight offers night time

express services to various types of customers, e.g. agriculture, automotive, healthcare, etc. in European countries [3]. DANX provides logistics services in Scandinavia by starting its delivery operations in the early evening and finishing them all before 7 A.M. of the next day. The company also provides many options including dropbox as receiving points for customers [4]. Another example is NYK Logistics that integrates cross docking centre and milk-run delivery to distribute ordered parts to customers overnight [5]. From all mentioned cases, it is clear that night-time delivery is an effective concept that could be used to improve the delivery process of the case study company, and therefore it will be implemented in this study.

The outline of the paper is as follows. In Section 2, the new operations processes are created for using in the trial implementation period which is operated with the selected service centres. Section 3 demonstrates the simulated results in case of full implementation for comparing with the current implementation in various aspects. Results and conclusions are given in Sections 4 and 5, respectively.

II. Methodology

A. New transportation operations design

The new transportation method is initially developed by using the WHY-WHY and HOW-HOW techniques [6]. From Table 1, it is clear that traffic jam is the main root cause of all major problems. Table 2 illustrates the method for avoiding the traffic jam problem. Firstly, the driver has to avoid rush hour period which normally occurs between 07:00 A.M. – 10:00 A.M. Not only does this situation happens in city centre areas, but also it is occurred around business and industry areas. To avoid rush hour period, the driver has to work on another time period because it is impossible to solve traffic problems by the company.

TABLE 1
WHY-WHY method for finding root causes of three main problems

Problems	WHY	WHY	WHY
Delay delivery	Traffic jam	Operation hour is rush hour	Delivery commitment
Low loading efficiency	Split too many routes	Spend much time between destination	Traffic jam
Different customer waiting time	Route transportation	Spend much time between destination	Traffic jam

TABLE II
HOW-HOW method for finding solution to avoid Traffic jam problem

Problems	HOW	HOW	HOW
Traffic jam	avoid rush hour	Deliver on other time	Night-time delivery

Night-time delivery is a potential solution that the working team believes to solve the problem. According to the idea of night-time delivery, the driver has to start working at night-time after the warehouse operations is completed. The night-time traffic of Bangkok is totally different with daytime, especially during the rush hour. In fact, the available delivery operations time of the driver is longer than daytime; hence, it is possible to increase delivered volume leading to less transportation trips and higher loading efficiency. In addition, all service centres want to receive spare parts before or at latest at the business opening time so that they could begin the repairing process right after the service centres open in the morning. In fact, the part store staff do not necessary for the night-time delivery operations since the company will provide containers to keep delivered parts at the receiving points.

For the operations design, the ECRS (Eliminate, Combine, Reduction and Simplify) concept is applied to re-design and formulate new operations process flow [7] to follow the night-time delivery scheme. As a result, the operations process flows for the driver and concerned parties have to be revised. Currently, when the driver arrives at the service centre, if delivered goods pass the inspection checking in terms of quantity and quality, the store staff will sign in the transportation sheet. However, for the night-time delivery, there are normally no staffs available at night. Therefore, the goods receiving process has to be modified. The night-time delivery needs containers for storing and protecting delivered goods, and locking system which can only open by the driver and store staff. When the driver arrives at the service centre, the driver will open the container and then put goods into the container. After checking is completed, the driver signs in the transportation sheet and then put the copy of the transportation sheet in the container. At the service centre opening time, the store staff open the container and recheck the received goods and associated documents again, and then sign in the transportation sheet for confirmed receiving and moves the goods to the parts store area. The overall process is illustrated in Fig.I

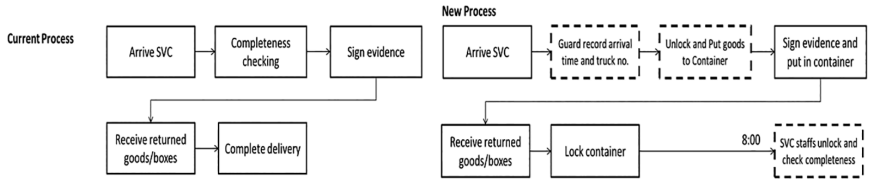

Fig. I. Comparison of the current and new operations work flows

To achieve the delivery deadline, the company needs to create a new work schedule for explaining to all concerned parties. The key change of the new schedule is that the customer orders received in the afternoon after the order cut-off time will be delivered by the night-time delivery. The new delivery schedule. From Figure 2, due to the night-time delivery, ordered parts will be shipped to service centres much earlier, i.e. within the night time of the same day (between 19.00 P.M. - 5.00 A.M.), than they used to be (between 13.00 P.M. - 16.00 P.M. of the next day).

Transportation route	Order (N day)	Current Delivery time	Expected new Delivery time
BKK	08:00 – 11:00	13:00 – 16:00	13:00 – 16:00
BKK	11:00 – 15:00	08:00 – 11:00 (N+1 day)	**19:00 –05:00**

Fig. II. New delivery timetable of night-time delivery

B. Container design

The night-time delivery requires containers for storage received good at the receiving point of each service centre. The container is designed as a goods receiving point which is located in the customer's area, which is called "dropbox". A dropbox is used for two functions, i.e. drop off and pick up goods. The driver drops delivered goods into the dropbox and then closes it. After that, the staff of the service centre unlocks the dropbox and picks up goods inside. On the other hand, the staff at the service centre can also drops defective goods for returning them to the company into the dropbox and the driver picks them up to bring them back to the company's warehouse.

III. Implementation

A. Driver Management

The company decides to implement the night-time delivery at some selected service centres as a pilot experiment. The implementation is executed by trial delivery to the service centres with real ordered goods and transportation routes. The trial delivery is executed to prove whether the delivery operations plan is feasible or not. During the implementation period, the driver strictly follows the delivery plan and the company also checks the readiness of the driver before he starts working. In case of no delivery to some destinations, the driver is forced to drive to those service centres even though there is no good to deliver. The reason is to check the transportation time, arrival time and obstacles during actual transportation. Any abnormal matters are recorded by the driver and inform back to the logistics team to acknowledge the problems.

B. Transportation Supplier Selection

In addition, the appropriate transportation supplier is also selected in order to gain the most efficiency of the new transportation scheme. According to the current situation, the company employs four transportation suppliers to deliver spare parts to nationwide service centres, separated by regions. In order to launch the new transportation scheme, the company has to select a transportation supplier to be responsible for the night-time delivery in the Bangkok area. In fact, a proper supplier selection could increase competitiveness and lead to better purchasing performances, e.g. cost, quality, delivery, flexibility and innovation. The company needs to get good services with reasonable prices since more than 10 million THB is spent on each transportation supplier to deliver spare parts in the Bangkok area.

As a result of bidding, although the transportation supplier C proposes a lower price than the transportation supplier A, the company decides to use both of them for the Bangkok routes. The transportation supplier A is operated for day trips, whereas the transportation supplier C is operated for night trips. By this option, the company will keep benefits of maintaining good relationship with the transportation supplier A (transportation risk management). Meanwhile, the company poses a challenge to both transportation suppliers A and C since they have to compete with each other. The benefit of having more than one the transportation supplier is the quality of work. However, this option is a little bit more expensive and more complicate in the administration process.

C. Execution

After pilot service centres are confirmed, the logistics team and the drivers work together for developing a delivery plan. The delivery plan consists of two important timetables, i.e. estimated arrival time and driver schedule (Figure 3). The driver has to identify the route where he has to drive for the night-time delivery service. Basically, the sequence of the delivery is arranged in the same way as the current route because there is no change in the

transportation destinations. However, the driver has to recheck the actual traffic situation again during the night-time delivery testing on the same route. In addition, a smart phone is used as a supportive device in the night-time delivery service. The driver uses the smart phone to take a video on all events occurred after the truck arriving at the service centre until unloading is completed. The benefit of video recording is for proving that all shipments are handled and delivered with care. If the service centre staff complain the company on damaged parts and poor services, the driver will use the recorded video as a proof for the problematic shipment.

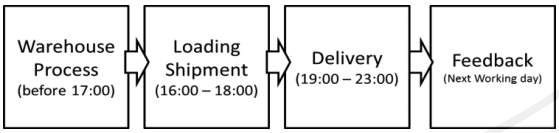

Fig. III. Delivery process flow and time schedule

A. RESULT

Actual trial result

The actual trial result is the result occurred during the delivery services which explains directly on the work result. This information could be used later as raw data for simulation in case of full implementation. Loading efficiency of the actual result is not an important measurement since the trials are done only with pilot service centres selected from the current transportation route. However, the result does not make a clear picture between the trial route and current route. Therefore, the new practice needs to be simulated in case of full implementation to prove if there exist any differences. The result is shown in Figure 3 where the driver has to drive according to the given delivery route (A-H).

The most obvious change is noticeable in the parts waiting time. In fact, the parts waiting time is totally changed from the current operations method because all service centres in the trail routes received goods before their official opening time, i.e. 8:00 A.M. Therefore, all pilot service centres could immediately start their repairing jobs once staff arrive at the service centres in the morning. They do not need to wait for a long time as it uses to be in the current operations method.

TABLE III
COMPARISON BETWEEN CURRENT RECEIVING TIME AND NEW RECEIVING TIME

Service centre Code	Delivery Sequence	Current Receiving Time	New Receiving Time	Diff Time (Minutes)
40100101	A	8:00:00	8:00:00	0
40330311	B	8:20:00	8:00:00	20
40100103	C	8:45:00	8:00:00	45
40470524	D	9:20:00	8:00:00	80
40210201	E	9:40:00	8:00:00	100
40330210	F	10:10:00	8:00:00	130
40330208	G	10:50:00	8:00:00	170
40350207	H	11:10:00	8:00:00	190

B. Simulated result

The simulated result is analysed based on the version of actual trial result to predict the transportation result in case of full implementation for all service centres in Bangkok. The simulated result employs new transportation routes which are totally different from the current routes and trial routes. In this case, the cost-performance index (CPI), loading efficiency and estimated transportation cost are used as performance measurements.

In fact, CPI has been used in the company to indicate how much money that the company has to pay per cubic metre (M^3) of goods. According to the simulated data (Table 4), the calculated CPI is about 487 THB per M^3. It is less than the current CPI of the company which is 647 THB per M^3 or reduced by 25%.

TABLE IV
BENEFITS COMPARISON BETWEEN CURRENT OPERATIONS AND NIGHT-TIME DELIVERY

Index	Current	Result	Diff
Key Indicator			
Spare parts waiting time (Hour)	124 (78 centres receive after 8:00)	0 (0 centres receive after 8:00)	**-124 Hr**
CPI (Baht/m3)	647	487	**- 25%**
Avg. Loading Efficiency	46%	68%	**+12%**
Total Transportation cost			**-35%**
Other Indicator			
% Delay	4.67%	0%	**-100%**
Number of Routes	11	5	**-6 Routes**

For loading efficiency, the new loading efficiency obtained from the simulation is around 68% in average. It is found that the maximum loading efficiency is 93%. This means the night-time delivery could eliminate wastes and results in less number of delivery trips. In addition, even though the cost per trip is higher but the number of routes is reduced from 11 to only 5 routes.

It is found that the new transportation cost is reduced around 35% compared with the current scheme on the same situations (since the transportation cost is confidential information, it could not be disclosed to public). The main reason of the improvement comes from the higher loading efficiency which also results in less number of trucks used in operations. Therefore, the total transportation cost will be reduced significantly if the night-time delivery is fully implemented.

In addition, positive feedbacks from the service centre's staff are received in several aspects. Practically, it is not only better customer satisfaction but it also improve internal processes of the service centre as well. One of the most common feedbacks is faster service operations which result in increasing of service volume and revenue. However, some comments on drawbacks are also mentioned, e.g. theft, thunderstorm in the rainy season and durability of the containers.

V. Conclusion

In this paper, the problem on the vehicle downtime of the service centres causing by unavailable of the required spare parts is tackled. The current practice of the case study company is to use daytime delivery approach. Because of the traffic in Bangkok, this approach limits the number of delivery trips per day and also causes a delay in the starting repair time of the service centres. The night-time delivery scheme is investigate as a mean to mitigate the problem. The new delivery process flow which controls the shipment sequence, checks the quantity of delivery goods, and defines the interaction between the driver and the staff at the service centre is developed. This approach has never been used by any automotive firms in Thailand before. The results from implementing the night-time delivery method show that both operations and marketing aspects could be improved. Positive feedbacks from the service centres and customers are also reported.

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The Exploratory Study of Behavioral Intention to Use the 3D Printing Technology: A Case Study of XYZ Bakery and Coffee

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***Abstract*—The main objective of the study is to explore behavioral intention of using 3D printing technology at XYZ Bakery and Coffee. Based on the theoretical framework of the Technology Acceptance Model (TAM), the four aspects of TAM (intention to use; perceived usefulness; perceived ease of use; and job relevance) were examined. The paper presents a qualitative analysis of 8 participants' comments from semi-structured interviews in XYZ Bakery and Coffee during monthly meeting in October of 2016. The study demonstrated results on factors that have direct impact on the users' perceptions in relation to 'behavioral intentions of use' for 3D printing technology. Namely these are; 1) Perceived Ease of Use (PEU), 2) Perceived Usefulness (PU), 3) Job Relevance (JR). The findings also indicated 'Perceived Usefulness' as the determining component on the factor for 'intentions of use' in users who did not show intentions for use.**

***Index Terms*—Technology Acceptance Model, 3D Printing Technology, Exploratory study**

I. Introduction

Technology will become a key part in driving business across many sectors industry's productivity performance, as mentioned by Hermman et al. (2016). The 3D printing technology has been considered as trigger of the next industry revolution (Barnatt, 2013). It greatly plays apart in advancing technologies, where it contributes to scientific researches in aerospace industries, medical fields, and many studies in business industries. Although, this innovative technology is utilized in many industries such as like consumer products, accessories, automotive, business machineries, as it is just getting the attention from food industry there are much potential for its uses in this growing industry. Therefore, this is an opportunity to explore the potential intention to use 3D printing technology in Bakery industry. The focal study of the research is taken upon the XYZ Bakery and Coffee, which is one of business unit under umbrella of ABC Public Company Limited. It serves clients with bakery and coffee in Thailand. XYZ Bakery and Coffee stands as a business Unit specializing in creating a Café style shopping experience with a mission of provides their best products on bakery and coffee. With over 300 branches, XYZ Bakery and Coffee was selected to be the study site as of its business should be matched with the study.

A. Literature Review Narrative

The most primitive 3D printing technology come to be noticeable firstly in the late of 1980's named Rapid Prototyping (RP) technologies at that time. Its origin was founded in 1986; the first patent was issued for Stereo Lithography Apparatus (SLA) to one Charles (Chuck) Hull, who first conceived it in 1983. Later on, Hull went to be the co-founder of 3D Systems Corporation, which one of the largest and most productive organizations in its operation today (The Free Beginner's Guide – History – 3D Printing Industry, 2016). As the reason of its procedures were initially considered a fast and more cost-effective technique for industry in generating prototypes for product development. Moreover, there have been many researches on the behavioral intention of using new technology. The technology acceptance model (TAM), proposed by Davis et al. (1989), has been broadly used to discuss external and internal motivational factors that drive ones behaviors.

B. The Technology Acceptance Model (TAM)

There have been numerous academic views which addresses the acceptance and uses of (IT) technology. The Technology Acceptance Model (TAM) proposed by Davis et al. (1989) is extensively recognized as it outlines the comprehension of IT users' authorization procedures. The model has shown to be idealistic as it clarifies the abundant of the divergence in users' interactive purpose associated to IT implementations and practices in wide circumstances. Furthermore, the model's superiority implications in numerous amounts of settings where there has been a sizable theoretical and empirical indication evident that it has accumulated the approval of the model's distinctions

as to other supernumerary models like Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB) (Mathieson, 1991).

C. Conceptual Model

Mathieson (1991) mentioned that this is the model that is primary chosen to be dominant in the field. TAM is an intention-based model that stipulates the meaning of advocate knowledge as good predictor of definite practice. The model was shaped to clarify and forestall the upcoming of users' performance based on humble activities engaged in pre-adoption concise of the system or prototype. As suggested by Davis et al. (1989), there are two major perceptual factors that influence the users' intention for technology usage; 1) Perceived Ease of Use, and 2) Perceived Usefulness.

1. Perceived Ease of Use (PEU) is defined as "an individual's perception that using a system with less effort". It views systems as identical and the more time users spend on using, it can help to enhance job performance (Holden & Karsh, 2010).

2. Perceived Usefulness (PU) is defined as "an individual's perception that using a system will enhance job performance". It is the cognitive perception of people's judgments on the usefulness of a system by comparing its' capabilities on the needs to get the job done (Davis et al., 1989).

Job Relevance (JR) is defined as "an individual's perception regarding the degree that the target system is applicable the job" (Liang et al., 2003). Moreover, this is the external factor that has impact on users' Behavioral intentions (BI). According to Holden and Karsh (2010), the behavioral intention to use (BI) defines as "the motivation or willingness to exert effort to perform the target behavior".

D. Theoretical Construct

The basis of the determinants came from three major theoretical framework areas of studies.

Firstly,"Work Motivation Theory" by Vroom (1964) is discussed in supporting of the work motivation theory. Locke and Latham (1990) discussed achievements of goals through task-specific plans, in which performances are designated, united, and sequenced. Secondly, the "Action Theory", in social psychology by Fishbein and Ajzen (1975) is reviewed. Vallacher and Wegner (1987) endorsed a prepared perceptive representation of accomplishment, called the distinctiveness assembly. The distinctiveness construction seems as a straightforward inspiration by which people cognitively correct their performances in the persistence of higher-level goals (Vallacher & Kaufman, 1996). Thirdly, "Task-Contingent Decision Making" from the behavioral decision theory by Beach & Mitchell in 1978 is also reviewed. These are impacts of task-specific goals which guide the behaviors in the course of a conception-matching process connecting contributory performances to goals (Bandura, 1986).

E. Related Research

For over a decade, there was wide-ranging practical evidence accumulated that professed ease of use as significantly linked to intention, both directly and indirectly via its impact on professed usefulness (Davis et al., 1989). Venkatesh and Davis (1996) model also professed ease of use as being dependent on one's general computer self-efficacy and adjusted to account for a system's objective usability via direct behavioral experience using the target system. However, other studies done on perceived usefulness gave other suggestions. Black et al. (1987) and Norman, (1987) did a study in human-computer interaction. Their result suggested similar goal-hierarchy models, but operating at a more micro levels of analysis like higher level goals (e.g., writing a document) and lower-level activities (e.g., level of keystrokes and mouse clicks). Kieras and Polson (1985) said that operators possess discrete acquaintance about their job condition, which they can use as a foundation for influential what jobs can be accomplished with a given system. Overall, there are many different variations of TAM model. The TAM extension often leave one those variable out of the model. As evident in the study by Tung et al. (2008) only studies the effects of independent variable on the intention to use the system. Therefore, in this study, we focus on the effects of three independent variables (Perceived Usefulness, Job Relevance, and Perceived Ease of Use) on the intention to use 3D printing technology.

F. Methodology Objective

The objective of this study is to explore behavioral intention to use 3D printing technology at XYZ Bakery and Coffee Framework of Study.

Based on the theoretical framework of the Technology Acceptance Model (TAM), the effects of three independent variables (Perceived Usefulness, Job Relevance, and Perceived Ease of Use) on the intention to use 3D printing technology were studied as illustrated in Figure 1.

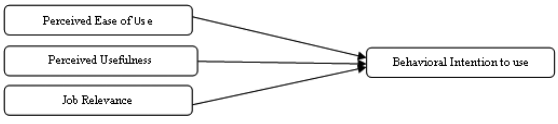

Fig. I. Proposed framework adopted from Davis et al. (1989)

G. Research Design

Qualitative approach was adopted. Semi-structured conducted with eight volunteer participants (n=8); consists of five female and three male, from XYZ Bakery and Coffee in October of 2016 during monthly meeting. The details information of 3D printing technology was presented to all participants. The

interviews were conducted by second research with the assistance of a research assistance who recorded the interviews after the presentation. Participants were asked with the questions related to the factors of TAM framework as shown in Figure 1. The record from the interview was transcribed and sent back to interviewees for confirmation.

H. Findings & Discussions Perceived Ease of Use (PEU)

The 3D printer was designed to replace the manual process in creating new molds for baked bakery. Instead of creating mold for certain shape, 3D printer can shorten the process and makes it effortless. User can be created various shape of products based on their imagination. All participants believed that 3D printer is easy to use.

Positive Perception on Perceived Ease of Use

"My background was not related to IT. At first, I thought it required some IT background to work on this technology but the 3D printer is quite easily to operate." - (Participant B).

"It is very simple to use. It doesn't require intensive training to use it. I think it is great." - (Participant F)

I. Perceived Usefulness (PU)

The purpose of the 3D printing technology aims at bringing valuable benefits to consumers. In businesses it aims to create value added products for customers. In summary, from the study all participants perceived that use 3D printing technology would be beneficial to their business.

Positive Perception on Perceived Usefulness

"This technology can provide an effective way to customize baked bakery for consumers. There were many times that we disappointed our customer who requested for sugar free or gluten free items. With this printer, we can keep up with our customer's need."- (Participant C)

■ "I think it is a good tool for me to be wild on the design and textures. It will change the experience of eating bakery period."- (Participant E)

■ "If I'm able to provide personalized nutrition for my customers, it is a "must have" machine in my shop."- (Participant G)

Mixed Perception on Perceived Usefulness

■ "For me, I think it is a great technology. But my only concern is the processing time for high volume orders during seasonal celebrations. We might not be able to keep up with incoming orders." - (Participant H)

■ "Yes, it provides lots of useful feathers. I'm just wondering how easy to clean all the parts i.e. cartridges and printer heads. We are in food business; sanitization is our priority." - (Participant E)

■ "Well, it can do one layer of ingredient at a time. If my creation supposedly has eight layers, then I have to switch cartridge of those ingredients back and forth. It could be a hassle." – (Participant F)

Negative Perceptions on Perceived Usefulness

■ "Well, I think it is good as it gets for household users. I don't think this technology is appropriated for commercial use in term of production times. It's just my idea." - (Participant C)

■ "What if the printer jams? Can it be easily to get fixed? We cannot wait for days to get it up and run." - (Participant G)

Job Relevance (JR)

Job relevance was investigated as an external factor, in the study all participants has perceived importance of 3D printing technology for enhancing their job or improving performances. The following denotes the comments of the findings in the research.

Positive Perception on Job Relevance

■ "I think it is a great innovation. I can notice lots of benefits from using this technology. It might be time for adopting new invention to enhance our bakery business." - (Participant A)

"Is it important to use this technology? For me, it is absolutely yes! With new technology like this, it can cut down prep time and improve the efficiency."- (Participant D)

■ "I can definitely offer much more for my customers. I can create variety of designs for our bakery. Moreover, I can custom nutrition for different groups of consumer. It is a big plus for us." - (Participant F)

TABLE I
PARTCO AMTS' RESPONSES
THE IMPACT OF PEU, PU AND JR ON
BEHAVIORAL INTERNATIONAL TO USE (BI)

Participant	JR	PEU	PU	BI
A	Y	Y	Y	Y
B	Y	Y	Y	Y
C	Y	Y	N	N
D	Y	Y	Y	Y
E	Y	Y	Y/N	Y/N
F	Y	Y	Y/N	Y
G	Y	Y	N	N
H	Y	Y	Y/N	N

Table I represents the impact of PEU, PU and JR on Behavioral Intention to Use the 3D printer. The finding demonstrated that job relevance (JR) and perceived ease of use (PEU) had direct relationship

with behavioral intention to use (BI); participants who had a positive JR and PEOU shown intention to use the 3D printer.

Furthermore, participant who had positive perceived usefulness (PU) demonstrated intention to use 3D printer, and vice versa. For the three participants who had mixed PU: one intended to use 3D printer; one did not intended to use 3D printer; and one had mixed feelings. It appeared that PU was the determining factor that led to BIU; as two participants, who had positive JR and PEU but had negative on PU, did not intend to use 3D printer; three participants who had positive JR, PEU, and PU intended to use 3D printer.

Positive Perception on Behavioral Intention to Use

■ "Yes, I intent to use 3D printer. I think it is one of the most interesting technologies in the market. I can do so much more with this tool." - (Participant B)

■ "It provides an innovative way of making bakery. We can serve wild range of consumers. I definitely intend to use 3D printer." - (Participant F)

Those participants who did not intend to use 3D printing technology mostly concerned about the speed and costs of commercial grade 3D printer.

Negative Perception on Behavioral Intention to Use

■ "I think it is a great innovation. I can notice lots of benefits from using this technology. But it is quite expensive and, you know, the technology changes rapidly. I might wait for newer technology that offers at lower cost." - (Participant C)

■ "Even though, I can offer more varieties for my customers; but the speed of production and cost of investment in 3D printer are major my concerns." - (Participant G)The finding supported the importance of job relevance, perceived ease of use, and perceived usefulness in TAM. In this particular case, perceived usefulness played an importance role for behavioral intention to use 3D printing technology which supported by Adam (1992) and Ng et al. (2013). The reasoning behind the relative strong correlation of perceived usefulness and behavioral intention could be caused by performance of the technology. In the case of 3D printing technology, speed of production was the major concern for adopting this technology. However, the original TAM and the research studies yielded results that supported the idea that of primary factors influencing behavioral intentions.

J. Conclusion

The purpose of this study was to indentify the factors which influence users' behavioral intentions for the willingness to adopt 3D printing technology. With the development in new technology to simplify the process and reduce costs, the subject of user acceptance arises. This study has provided some insights into the intention to accept 3D printing technology by manager of XYZ Bakery and Coffee. Since the implementation of this technology can be costly and face some users' unwillingness to accept this technology. Thus, it is important to study the behavioral intention to use of the intended users. TAM was adapted as the research framework. The qualitative interviews from eight participants indicated that job relevance (JR), perceived usefulness (PU), and perceived ease of use (PEU) had a direction relationship with the intention to accept and use 3D printer, our findings were similar with other scholars (Venkatesh & Davis, 2000; Liang et al., 2003; Moores, 2012; Holden and Karsh, 2010; Chang & Chen, 2016). Four participants respond that they intend to use; one participant appeared to be indecisive; four participants did not intend to use. To conclude, the management of XYZ Bakery and Coffee should carefully consider how best to adopt the 3D printing technology for their business based on the feedback of their staffs.

Implication

The implication of this study is to understand the determinants of behavioral intention to accept 3D printing technology in Bakery industry. 3D printing technology has many advantages; such as creating more complicated design for food's appearances, innovative textures and flavors, as well as make customizations to tailor for personal needs. Hence, the major benefit of this technology is to enable healthy life style of eating. The business can promote specific foods for specific consumer targets, for example; sugar free items for people with diabetes; gluten free items for those who are allergic to wheat and low carb diets for people who wants to control/lose weight. As for the elderly, selections of soft texture foods with high nutritional value could be offered. As for children, they can offer a creative way for luring kids to eat vegetables by providing more an alluring appearance to attract their appetite. As the many benefits this technology offers, there are certain downsides, the speed of production is limited therefore it might not be able to suit the needs for mass productions to the demands. In the rapid world of technology, today's ever-changing developments are rapid; therefore, businesses must be able to keep up in order to gain competitive advantages.

K. Limitations and Futrure Research

The results and their implications come from one Bakery Company; hence, results may not be generalizable to other Bakery companies. Future research could address the limitation by conducting similar studies at a number of other Bakery companies to assess the degree to which the current findings are represented in other environments.

The qualitative study was conducted with only eight participants, so it is inappropriate to generalize the finding. Future research could combine both qualitative and quantitative research methods.

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PAPER FORMAT

Format

- Articles not more than 15 pages in length, single-sided A4 paper, margins (top, bottom, left, right) are 1 inch (2.54 cm)
- Abstract and References set to single columns, content is set to double column, first line indent 1 cm (0.39 inch)
- English font is **Times New Roman**, as follows:

Content	Font Size	Labeling
Title	24 (CT)	bold
Author	11 (CT)	bold
Author's affiliation amd E-mail	11 (CT)	regular
Content	10 (LRJ)	regular
Footnotes	8 (LJ)	regular
Table title (indicated above the table)	8 (CT)	regular
Table content	8 (LJ)	regular
Figure caption (indicated in the figure below)	8 (LJ)	regular
References Head	10 (CT)	regular
References	8 (LJ)	regular
Math and Equation : Please use either the Microsoft Equation Editor or the MathType add-on (http://www.mathtype.com) for equations in your paper		

CT = Centre Text, LJ = Left Justified, RJ = Right Justified, LRJ = Left & Right Justified

Composition of the article

1) Article title
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   4.1) Academic articles, should have introduction, content and conclusion
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1. **Cited in the main text**. Indicate the reference by name-year before or behind the cited content. For example, noted author, year of publication and page. Such as: Joe Smith (2014: 147) or (Newman & Cullen, 2007: 18-19) or (Joe Smith and team, 2014: 217-219)
2. **Cited after the article**. Put all bibliographicalreferences after articles, and order according to the author's name, please refer APA format. Such as:

Basic format for books:

[1] J. K. Author, "Title of chapter in the book," in *Title of His Published Book, x*th ed. City of Publisher, Country if not

[2] USA: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

Examples:

[3] G.O.Young,"Syntheticstructureofindustrial plastics,"in *Plastics,*2nd ed., vol. 3, J. Peters, Ed. New York: McGraw-Hill,1964,pp.15–64.

[4] W.-K.Chen,*LinearNetworksandSystems.*Belmont, CA:Wadsworth, 1993, pp. 123–135.

Basic format for periodicals:

[5] J. K. Author, "Name of paper," *Abbrev. Title of Periodical*, vol. *x,* no. *x,* pp. *xxx-xxx,* Abbrev. Month, year.

Examples:

[6] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959.

[7] E. P. Wigner, "Theory of traveling-wave optical laser," *Phys. Rev*., vol. 134, pp. A635–A646, Dec. 1965.

[8] E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propagat*., to be published.

Basic format for reports:

[9] J. K. Author, "Title of report," Abbrev. Name of Co., City of Co., Abbrev. State, Rep. *xxx*, year.

Examples:

[10] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.

[11] J. H. Davis and J. R. Cogdell, "Calibration program for the 16-foot antenna," Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

Basic format for handbooks:

[12] *Name of Manual/Handbook*, *x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, year, pp. *xxx-xxx.*

Examples:

[13] *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44-60.

[14] *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.

Basic format for books (when available online):

[15] Author.(year,monthday).*Title.*(edition)[Typeof medium].*volume (issue).* Available: site/path/file

Example:

[16] J. Jones.(1991, May 10). *Networks.*(2nded.)[Online]. Available:http://www.atm.com

Basic format for journals (when available online):

[17] Author. (year, month). Title.*Journal.*[Typeof medium].*volume (issue),* pages. Available: site/path/file

Example:

[18] R. J. Vidmar. (1992, Aug.). On the use of atmospheric plasmasaselectromagneticreflectors. *IEEETrans. PlasmaSci.*[Online].*21(3),*pp. 876–880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

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