AMJ
ISSN: 0005-2523

ISSN: 0005-2523
Volume 63, Issue 01, January, 2023

Analysis of Ground Support Equipment (GSE) Failure Modes at PT. Gapura Angkasa Makassar

A. Ferina Herbourina Bonita[1], Lalu Muhammad Saleh[2], Masyita Muis[3]

Postgraduate Student, Department of Public Health, Faculty of Public Health, Hasanuddin University, Indonesia[1]
Department of Occupational Health and Safety, Faculty of Public Health, Hasanuddin University, Indonesia[2]

Keywords:
GSE, FMEA, RPN, BTT, BCL

ABSTRACT

This research aimed to identify and detect each existing failure mode based on probability and severity and provide solutions using the Failure Mode and Effect Analysis (FMEA) method. A company known as PT. Gapura Angkasa in Sultan Hasanuddin Airport was used, which has hundreds of workers in the Ground Support Equipment (GSE) Division, and its operation is fraught with danger and risk. This research identified the cause of the GSE damage, ensuring the safety of workers and the smooth operation of the aircraft and passengers. A qualitative approach was used to examine the condition of the equipment, with the researcher serving as the primary instrument. To obtain information about the failure modes of the GSE at PT. Gapura Angkasa Makassar, the FMEA method was used. This was carried out by determining the risk rating, which is represented by the Risk Priority Number (RPN). The results showed that there were two types of GSE damage, namely BTT and BCL. The engine indicator component in the BTT and the steering column in the BCL had the highest damage, with RPN of 240 and 160, respectively. Routine maintenance is recommended on components with a high probability value to improve their reliability, while special attention should be paid to components with a high RPN level.

1. Introduction

The presence of hazards and the emergence of work-related risks cannot be separated from Industrial development in various fields [1]. Sources of accident risk include human factors (work behavior), work environment factors, equipment, material factors, and work method. The Fault Mode and Effect Analysis (FMEA) was used to identify and detect failure modes based on probability, severity, and detection ease and provide solutions [2]. Inductive analysis identifies the cause of the damage and determines how it can exist or occur. In addition, the FMEA describes the damage, the cause, and its effects on the system. It can also be used for product design details, such as identifying and eliminating the flaws in a product [3].

FMEA is a systematic method that identifies and implements solutions for problem prevention in processes

and products. It is divided into design and process and focuses on prevention, improving workers' safety, and increasing customer satisfaction [3]. Failure mode occurs when a product fails during the manufacturing process. Each failure mode has potential causes and effects arising from the failure and each has its risks. Furthermore, FMEA is a method for identifying failures, effects, and risks of processes or products and solutions that reduce the failures [4].

PT. Gapura Angkasa Makassar has hundreds of workers, including 44 operators in the Ground Support Equipment (GSE) Division, each of whom is responsible for a GSE [6]. Based on the processes used during operation, hazards and risks which may cause damage to equipment used to operate aircraft services are inevitable [7]. Secondary data from the PT. Gapura Angkasa Makassar in 2020-2021 showed that the GSE Division has the greatest risk due to unsafe actions and conditions. According to the 2020 and 2021 accident data, work accidents continue to occur, with the highest number occurring during the GSE operation and fluctuating the most when compared to other work processes. In the 2020 to 2021 damage data, 98 out of the 265 damaged tools were caused by various factors ranging from the age of the equipment to lack of compliance with the Standard Operating Procedures (SOP).

Companies need to maintain the GSE with ground support equipment service before handling placement operations, loading and unloading, and during and after carrying out operations [8]. A reduction in the quality of the equipment will result in a decrease in production and lead to losses in the company [9]. In addition, GSE damage can hinder work productivity and result in losses due to maintenance costs, repairs, and purchasing new equipment. Frequent damage also hampers productivity to the point of causing economic instability for the company due to poor services that reduce customer satisfaction.

2. Method and Material

A qualitative approach was used to examine the conditions of the equipment, with the researcher serving as the primary instrument [5]. FMEA was used to obtain information about failure modes on GSE at PT. Gapura Angkasa Makassar using the results of observations through unsafe acts and conditions by determining the risk rating, which is represented by the Risk Priority Number (RPN). This research was conducted from September to October 2022. Research informants are subjects who understand the research and provide information about GSE failure modes at the company. The snowball sampling technique was conducted by triangulation to retrieve informants, where the researcher was the primary instrument, and the sampling of data sources was carried out purposively [10]. Furthermore, inductive or qualitative data analysis was used in this qualitative research to emphasize meaning rather than generalizing results [11].

Data processing was performed using SPSS and AMOS applications to see direct and indirect effects through the intervening variables using path analysis. The results of the study will be presented in the form of tables and narratives. This study has received approval from the health research ethics commission (KEPK) Faculty of Public Health, Hasanuddin University with protocol number: 29822062187 and letter number: 10245/UN4.14.1/TP.01.02/2022.

3. Results

From the interview results and the existing failure modes, several types of damage were found in the GSE, with two having the highest frequency of damage. These include Baggage Towing Tractors (BTT) and Belt Conveyor Loaders (BCL). Furthermore, there were several causes of failure in these equipments, including component, construction, and electrical failures.

Table 1. The Failure Modes of the Baggage Towing Tractor (BTT) at PT. Gapura Angkasa Makassar

AMJ
ISSN: 0005-2523
ISSN: 0005-2523
Volume 63, Issue 01, January, 2023

Failure Mode	Effect of Failure	Failure Cause	Current Control	Failure Effect			Failure Detection	Corre
				Local Effect	Next Higher Efect	End Effect		
ailure in onstruction, Ianpower jured	Perforated and thin construction hence the operator can fall	Broken, Perforated (leaking), worn tires	Inspection of frames and tires before use, manpower uses PPE according to SOP	Distractions when operating, hence manpower can slip and fall	Performance is reduced, and fingers can be broken due to being pinched and injured	BTT cannot be used and manpower may be harmed by a damaged component	There are rust, cracks, corrosion on the frame, thin, punctured, and worn tires	Perform maintena frames, toolbox before w
ailure in onstruction, Ianpower jured	Perforated construction hence the operator can be bumped into objects	Broken, Perforated (leaking), and torn	Checking door and hinge construction and ensuring manpower is using PPE according to SOP	There is an impact on the components of the front cover, hence manpower can be hit and squashed	Disturbances in operation and manpower may be impacted by exposed components	Effects on other components, and manpower can get injuries from the head to the eye	There are rust, cracks, and corrosion on the frame	Replacer construc conducti meetings begins
omponent ilure, Ianpower hurt	When the instrument does not work, the operator may crash into something	Broken, Perforated (leaking), and dented components	Checking components before the operation, manpower uses PPE according to SOP	Component performance is reduced, hence, manpower can be injured	Interference, when manpower is operated, can cause minor injuries such as collisions	System malfunctions can cause head abrasions and bruises	Components do not work, and rusty	Mainten replacem parts, toolbox before w
ailure on the river's seat, Ianpower jured	The drive set cannot be used and the operator may be crushed by the part	Broken, Ripped	Checking components before use, manpower uses PPE according to SOP	Interference when in operation, indicating that the driver's seat is not ergonomic	Component performance is reduced and the body of manpower can be dislocated	Breakage on the driver's seat hence manpower can be affected by LBP to MSDS	Tears, wear on the seat frame	Replacer driver's replacem conducti meetings begins
ailure of the iling guard, anpower may e splashed with ud and other bstances	Injure the manpower, causing the skin of the manpower to become infected	Broken, dented hollow components	Checking the railing guard before using the tool, manpower uses PPE according to SOP	Interference when in operation hence the manpower can be hit and crushed.	The gear guard and accessory may come loose and injure the manpower	Injure man power hence it can get abrasions and bruises	Broken, cracked, or broken accessory	Replacer compon conducti meetings begins
ailure in onstruction and anpower may ll	Broken/non-functioning to the point of injuring the manpower	Broken and porous, causing damage to the tool when damaged when the damage is fatal	Checking indicators before using the tool, manpower uses PPE according to SOP	Performance is reduced, thereby endangering road users and disrupting traffic	Disturbances in operation may lead to injuries and falling of man power	There are porous parts, causing fatal damage to the tool, manpower can be seriously injured, sprained, and pinched	Fractures or corrosion in the construction	Replacer compon drones complet use of w
ailure in onstruction and anpower can be ushed by the abin	manpower can become hurt	Broken, Perforated (leaking)	Inspection of component construction, manpower using PPE according to SOP	Interference during operation, causing manpower to be crushed by the cabin	The effect on other components, manpower, fell from above and was crushed by the cabin body	Front glass detached/broken, causing injuries to the head and body of manpower.	Rust, corrosion, or cracks in the cabin	Replacer hollow parts, us carry ou
ailure of the rotective glass nd manpower ay hit the indshield	It can hurt manpower	Break, Crack	Inspecting the front glass before use, manpower using PPE according to SOP	Interference when in operation, manpower can be injured	Performance is reduced, manpower is hit by splashes of windshield shards	It can get into the skin and eyes and cause Injuries.	Broken, mossy glass	Glass replacem conducti meetings begins
omponent ilure and the oor may open ddenly	The door lock does not work, endangering manpower	Broken, not working	Lubricating and inspecting door locks, manpower using PPE according to SOP	Interference during operation and manpower may fall out	The door lock does not work/was stiff, and can cause the manpower to slip, fall, and get injured	Door lock does not work, manpower can be fatally injured	Stiff, not working	Lubricat lock conducti meetings begins
ailure in ectrical omponents, orkers do not heck cables	Troubleshooting that endangers manpower	Wiring and clamp broken	Component inspection to avoid troubleshooting, manpower uses PPE according to SOP	Performance is reduced, manpower may be exposed to the cable	Wiring break/troubleshooting, causing sparks that endanger manpower	The components cannot be used, therefore, manpower is electrocuted and burnt	Broken cable, broken clamp	Replacer and conducti meetings begins
ailure of omponents, orkers	Troubleshooting and endangering manpower when the lamp is broken	Broken, Troubleshooting	Component inspection to avoid troubleshooting, manpower uses PPE according to SOP	Performance is reduced and manpower cannot see the light code while operating	The lights do not work, manpower falls and hits an object	Interfering with BTT operation, manpower gets injured and falls down	The light does not turn on	Electrica replacem toolbox before w
ailure of the iling guard	There is no safety on the lamp, endangering manpower when the lamp is broken	Broken, Cracked	Inspecting the railing guard before using the tool, manpower uses PPE according to SOP	Broken bracket, manpower cannot see the lights while operating because the light bracket is broken	The lamp may break	Disturbances when operated, manpower can get injured and fall	Broken	Replacer damaged toolbox before w
ailure of omponents and	Meters and switches do not	Broken, Troubleshooti	Check meter and switch before use	Reduced performance,	Disturbances when operating, the machine	BTT could not be operated and	The component indicator is not	Periodic replacem

anpower is xposed to ectricity	work, endangering man power	ng		exposed cables, and damaged meter indicator	shuts down suddenly and traffic disturbances, manpower is electrocuted	manpower was electrocuted and hit by another device	working	parts, meetings begins
ailure of omponents and anpower is xposed to ectricity	Engine indicator does not work, endangering manpower	Broken, Troubleshooting	Check the indicators on the tool	Reduced performance, exposed cables, and damaged meter indicator	Machine indicator items cannot be detected, sudden and traffic disturbance, manpower can be electrocuted	BTT could not be operated, manpower was electrocuted and was hit by another device	The component indicator is not working	Periodic replacem parts, meetings begins
ailure in omponents, ausing lower sibility for anpower	The wiper motor and blade not working, endangering manpower	Component not working	Check the wiper motor as well as the blade before operating	The wipers are not working optimally, the glass is foggy and makes tool operation errors	Disturbances during operation, tools get hit and manpower gets hit	The system is not working, manpower is injured	The wipers stiff and not moving	Wipers replacem rubber, meeting begins
omponent ilure, high abin pressure	Overheat, injury to manpower	Porous, Stuck	Check and clean the air conditioner before use	Performance is reduced, compromising manpower	Overheat engine, leads to shortness of breath	Injuries and causes lack of oxygen and heat pressure to manpower in the cabin	Engine Overheating and temperature increases	Cleaning conditio installati meeting begins
omponent ilure	Defroster not working, endangering manpower	Broken, Troubleshooting	Component inspection to prevent troubleshooting	The defroster does not function optimally, the glass is cloudy due to condensation and causes tool operation errors	Operation is disrupted, tools get hit and manpower gets hit	The system does not work	Using a Frosted glass surface	Replacer parts, meetings begins

Table 2. Risk Priority Number (RPN) of the Baggage Towing Tractor (BTT) Ground Support Equipment (GSE) at PT. Gapura Angkasa Makassar Service

No	Component Name	*Severity* (S)	*Occurrence* (O)	*Detection* (D)	R P N (SxOxD)	*Risk Level*	Ranking
1	*Frame and Tire*	4	4	2	32	*Low*	9
2	*Door and Hinge*	2	4	3	24	*Low*	13
3	*Instrument Panel and Floor*	2	4	1	8	*Very Low*	16
4	*Driver Seat*	1	4	1	4	*Very Low*	17
5	*Head Guard and Accessory*	3	7	3	63	*Low*	6
6	*Indicator Plate*	8	6	4	192	*High*	2
7	*Steel Cabin*	2	8	2	32	*Low*	10
8	*Front Glass*	3	5	1	15	*Low*	15
9	*Door Lock*	4	4	1	16	*Low*	14
10	*Wiring and Clamp*	4	8	1	32	*Low*	11
11	*Lamp*	6	7	4	168	*High*	4
12	*Lamp Bracket*	5	5	3	75	*Low*	5
13	*Meter and Switch*	5	5	2	50	*Low*	8
14	*Indicator Engine*	8	6	5	240	*Very High*	1
15	*Wiper Motor and Blade*	2	5	3	30	*Low*	12
16	*Air Conditioner*	7	6	4	168	*High*	3
17	*Defroster*	3	7	3	63	*Low*	7

Source: Primary Data, 2022.

Table 3. Failure Modes of the Belt Conveyor Loader (BCL) at the PT. Gapura Angkasa Makassar

ISSN: 0005-2523
Volume 63, Issue 01, January, 2023

Failure Mode	*Effect of Failure*	*Failure Cause*	*Current Control*	*Failure Effect*			*Failure Detection*	*Correcti*
				Local Effect	*Next Higher Effect*	*End Effect*		
Component failure, manpower injured	Components become worn out and unusable, causing operators to fall and tip over	Corrosion, broken, perforated (leaking) tires until they wear out	Checking components before using the tool, manpower uses PPE according to SOP	Interference when operated, causing manpower to slip and fall	Effects on other components, breakage of manpower fingers due to being pinched and injured	CBL could not be operated, manpower was hit by a damaged component that dislodged it	There is rust, tear or wear	Perform maintena conduct t meetings beginnin
Failure in the electrical system, manpower s injured by electricity	Troubleshooting may result in an electric shock to the operator	Human error/age	Checking the assembly before operation, Use of PPE according to SOP	Interruptions in operation, can expose cables and damage the electrical system	Short circuit exposes workers to high-voltage currents,	Fire can cause burns	Faulty electrical appliance	Maintena ement conduct t meetings work beg
Failure of the steering components causing the manpower o injure his hand	Stiff/non-functional steering may cause the operator to sprain his hand	Corroded/broken	Checks are conducted before components are used, manpower uses PPE according to SOP	Performance is reduced, manpower can bump and crush on components	Stiff when operated on, which can result in minor injuries such as sprains	CBL cannot be operated and causes manpowerabrasions and bruises	Stiff steering	Perform maintena conduct t meetings work beg
Failure of components manpower s injured nd exposed o components	Broken/not working, hence the operator is hit by a component	Corroded, broken, perforated, and leaking	Cabin inspection before CBL is enabled, manpower uses PPE according to SOP	Disturbances during operation, hence, manpower can collide and be crushed by the body of the cabin	The left/right indicator lights do not work causing manpower to fall and hit something	The side cabin is detached/broken and manpower is injured in the head and body, hence, it fell down	Rusting in constructi on	Carry maintena replacem drones t the com the use of
Failure of the hydraulic system, manpower s injured nd can be crushed by components	The belt system does not work, causing the operator to hit objects	Broken/no power	Hydraulic oil dampers are provided, manpower uses PPE according to SOP	The hydraulic system is inefficient, manpower can be crushed by luggage	Effects on other components, and manpower components fall from above and are crushed	The system malfunctions and injures manpower, leading to head abrasions, bruises, and body injuries that render them unconsciousness	Oil seepage on the piston	Perform maintena conduct t meetings work beg
Failure on the front lifting causes njury to manpower who can be crushed by components	Front lifting does not work, hence, the operator may hit objects	Broken/not working	Check the bracket before using the tool, manpower uses PPE according to the SOP	The lifting system does not work, it can be crushed by the baggage that is in operation	The lifting construction is broken, hence, manpower can fall from above and get crushed	The belt assembly does not work, resulting in head abrasions, bruises, and body injuries, leading to unconsciousness	There is rust on the pole	Periodic the use o inspect complete use of wo
Failure in rear lifting, manpower s injured nd can be crushed by components	Rear lifting does not work, hence the operator may hit objects	Broken/not working	Inspecting rear lifting used, manpower using PPE according to SOP	The lifting system does not work, it can be crushed by the baggage that is in operation	The lifting construction is broken, hence, manpower can fall from above and get crushed	The belt assembly does not work, resulting in head abrasions, bruises, and body injuries, leading to unconsciousness	There is rust on the pole	Periodic the use o inspect complete use of wo

Failure of anti-slip, manpower was injured by falling, overturning, and hit	The slip sticker does not work, hence the operator can slip on the component	Torn/worn out	Examination of the sticker used and ensuring the use of PPE by manpower according to SOP	Non-slip, hence, the operator can fall due to slipping feet	A slippery floor can cause minor injuries such as sprains	Injures manpower and can cause swollen hands and feet	Wear and tear on the slip sticker	Make replacem conduct meetings work beg
Belt failure, manpower s injured and may be crushed	The belt loader does not work, causing the operator to collide with objects	Cracks/ corrosion	Inspecting the belt used and ensuring that manpower uses PPE according to SOP	Reduced performance and falls could occur from overcharged objects	The bracket belt can break, and the manpower could fall from above and get crushed	The system does not work, manpower can cause head abrasions and bruises, body injuries, and disrupt the	The belt loader is not efficient	Periodic maintena drones to the comp using PP at height
						baggage distribution process		
Failure in manufacturi ng, manpower njured	Perforated construction, hence operator can be squashed and burnt by components	Cracks/ corrosion	Inspecting components before use and ensuring that manpower uses PPE according to SOP	Impact of the components of the front cover, eye irritation due to gas components	Disruption in operation, manpower fingers can be broken, pinched and injured, and eye damage	Injures manpower, the eyes become sore and can interfere withvision	Corrosion on the surface of the cover	Maintena ement conduct meetings work beg

Source: Primary Data, 2022.

Table 4. Risk Priority Number (RPN) of the Belt Conveyor Loader (BCL) Ground Support Equipment (GSE) at PT. Gapura Angkasa Makassar

Component Name	***Severity* (S)**	***Occurrence* (O)**	***Detection* (D)**	**R P N (SxOxD)**	***Risk Level***	**Ra**
Chassis Assembly andTire	6	5	2	60	*Low*	
Electrical System Assembly	8	4	3	96	*Medium*	
Steering Column	8	5	4	160	*High*	
Open Style Cab	2	7	2	28	*Low*	
Hydraulic System Assembly	4	5	5	100	*Medium*	
Front Lifting Bracket Assembly	4	8	1	32	*Low*	
Rear Lifting Bracket Assembly	4	6	4	96	*Medium*	
Anti-Slip Sticker	3	4	2	24	*Low*	
Belt Bracket Assembly	6	6	1	36	*Low*	
Cover Weldment	2	5	3	30	*Low*	

Source: Primary Data, 2022.

4. Discussion

There are several causes of failure in the workplace, ranging from low failure modes to high hazards which have been calculated with risk priority numbers [12] Failure can be avoided when the risk factors are properly and thoroughly identified through unsafe acts and conditions [13] Based on the results of interviews with the GSE operator supervisors and mechanics up to SSQ, who are responsible for local

ISSN: 0005-2523
Volume 63, Issue 01, January, 2023

safety, it was discovered that the damage to the equipment was due to several factors, such as workers' hastiness and carelessness. Other factors include environmental factors such as lack of equipment maintenance and road conditions. Furthermore, BTT has 17 main components, while BCL has 10. The BTT is used to transport passengers' luggage from or to the plane and serves as a towing or coupling vehicle for other GSE equipment such as Baggage Cart, Cargo Dolly, and GPU.

The BTT Failure Mode with the highest RPN value was the Indicator Engine component with a value of 240, indicating that it had a very high risk. The high category ranged from 168-192 and included indicator plates, lamps, and air conditioners. Furthermore, the low category ranged from 15-75, consisting of frames and tires, doors and hinges, heard guards and accessories, steel cabins, front glass, and door locks. It also included wiring and clamps, lamp brackets, meters and switches, wiper motors, and blade and defroster. The very low category had a range of 4-8, consisting of instrument panels and floors, and driving seats.

The Failure Mode with the BCL type with the highest RPN was the Steering Column with a value of 160, placing the system in the high category based on the RPN ranking. The Medium category ranged from 96-100 and comprised an electrical, a rear, and a hydraulic systems assembly. Furthermore, the low category of the RPN ranged from 24-60, consisting of chassis assembly and tire, open style cab, front lifting bracket assembly, anti-slip sticker, belt bracket assembly, and cover weldment.

5. Conclusions and Recommendations

Based on this research, the failure modes with the highest risk were the BTT indicator engine component and the BCL steering column, with RPN values of 240 and 160, respectively. According to the RPN ranking, these systems were included in the high-risk category. It is recommended that supervision from manpower and SSQ workers should be carried out routinely and on a scale because several incidents of equipment damage caused by GSE operators can result in work accidents for operators and their surroundings. Furthermore, components with a high probability value need routine maintenance to increase their reliability, while those with high RPN levels require more attention.

6. Acknowledgment

This article is part of the thesis for the magister program on public health science. The authors extend their biggest gratitude to all parties who were involved and helped throughout the process of this research.

7. References

[1] Lalu M. Saleh, et al. Faktor Risiko Kejadian Penurunan Ambang Dengar Pada Karyawan Bagian Proces Plant PT. Inco Soroako. Jurnal MKMI. 2010: Vol. 6 (2), pp. 96-101.

[2] Sinaga, et al. Identifikasi Dan Analisa Risiko Kecelakaan Kerja Dengan Metode FMEA (Failure Mode And Effect Analysis) Dan FTA (Fault Tree Analysis) Di Proyek Jalan Tol Surabaya – Mojokerto. Jurnal Teknik Pomits. 2014; Vol 1(1).

[3] Susilo, et al. Analisis Kegagalan Operasional Mesin Chiller dengan Metoda FTA dan FMEA. Jurnal UM Palembang. 2019; Vol 2(3): 19-29..

[4] Kartika, Windhi, et al. Usulan Perbaikan Produk Cacat Menggunakan Metode Fault Mode and Effect Analysis Dan Fault Tree Analysis Pada PT. Sygma Examedia Arkanleema. Jurnal Online Institut Teknologi Nasional. 2016; Vol 1(4): 2338-5081.

[5] Sugiyono. Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta; 2014.

[6] Fikra Wahyuni, Gambaran Pengetahuan Sikap dan Tindakan Tentang Penggunaan Alat pelindung Diri pada Pekerja di Bagian Apron di PT. Gapura Angkasa Bandar Udara Sultan Hassanudin Makassar. 2019.

[7] Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 174 Tahun 2015 Tentang Pembatasan Usia Peralatan Penunjang Pelayanan Darat Pesawat Udara (Ground Support Equipment/GSE) Dan Kendaraan Operasional Yang Beroperasi Di Sisi Udara. Jakarta; 2015.

[8] Pariaji, Danang. B. Pengenalan Umum GSE (Ground Support Equipment). Ilmu Terbang. 2017.

[9] Paciarotti. C., Mazzuto. G., D'Errotte. D. Quality Paper A Revised FMEA Application To The Quality Control Management. International Journal of Quality dan Reliability Management. 2014; Vol.31 No.7.

[10] Nasution, S. Metode Penelitian Naturalistik Kualitatif. Bandung: Tarsito; 2003.

[11] Moloeng, Lexy J. Metode Penelitian Kualitatif. Bandung: Rosda; 2004.

[12] Stamatis, D. H. Failure Mode and Effect Analysis: FMEA from Theory to Executoion. New York: ASQC Press; 1995.

[13] Tejaskumar S, Parsana, dan Patel M T. A Case Study: A Process FMEA Tool To Enhace Quality And Efficiency Of Manufacturing Industry. Bonfring International Journal of Industrial Engineering and Management Science. 2014; Vol 4(3): 145-152.