

# FUGUAI MAPPING: THE USEFUL METHOD FOR PROBLEM SOLVING

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## ABSTRACT

*Fuguai in Japanese word also called abnormality. The abnormality is unneeded thing which located at the wrong places or situations. In most conditions, the abnormality affected physical, functional and safety problems especially for machines. This paper discusses the application of Fuguai Mapping in order to identify the abnormality at grinding machine as a preventive action to sustain the machine condition. Through the study, it shows that many abnormalities were found. As a result, most of the abnormalities at machine were reduced and had improved the machine efficiency.*

**Keyword:** *Fuguai Mapping; Grinding Machine; Problem Solving*

## INTRODUCTION

Most industrial production systems are subject to deterioration with usage and age. Such system deterioration may lead to higher production costs and lower product quality and the increased possibility of breakdown. Therefore, a well-planned maintenance management program is important to reduce costly breakdowns. In some cases, system failure leads to uncountable costs, for example, the failure of an airplane engine during flight may bring property damage and loss of life. Therefore, extensive maintenance is necessary to improve the system availability.

Total Productive Maintenance (TPM) is a proactive and cost-effective approach to equipment maintenance which is widely adopted in Japanese industries with successful results [1]. The successful implementation of TPM depends on a number of factors, such as a culture of mutual trust, operators agreeable to providing basic care to their machines, and maintenance personnel trained in management and people skills.

One of the TPM Pillars is Autonomous Maintenance (AM), called as *Jitshu Hozen* (JH) in Japanese. The success of TPM, to a large extent, depends upon the success of AM. This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating [3].

Grinding machine is extensively used in the Machine Shop Laboratory, University Teknikal Malaysia Melaka (UTeM) to perform the task given especially in manufacturing practice subject. The machine is exposed to the breakdown as it is not well maintained. Maintenance and machine could not be separated to each other. Machine needs maintenance like human needs water. Daily maintenance, although it is simple but still could improve the effectiveness and expand the life time of the machine. This paper will emphasize the application *fuguai* mapping to identify abnormalities towards autonomous maintenance programme and problem solving method.

## GRINDING MACHINE

Grinding is a chip removal process that uses an individual abrasive grains as the cutting tool [4]. A grinding machine is a machine tool used for producing very fine finishes or making very light cuts, using an abrasive wheel as the cutting device. Malkin and Guo [5] define that grinding is an essential process for final machining of components requiring smooth surfaces and precise tolerances. As compared with other machining processes, grinding is a costly operation that should be utilized under optimal conditions.

For this paper, grinding machine (Model: BO 300A) was selected for case study (see appendix (figure 5) for orthographic drawing). The grinding machine (Model: BO 300 A) is double wheeled, single speed, circumferential, designed for manual grinding of metal parts. Its spindle is seated in two double-row swivel bearings, clamped in screw bodies, driven by electric motor over two pair V-belts. Starting and stopping follows through push buttons. The grinding machine is equipped with adjustable rests, regulator and safety glass plates. It has suction plant, putting off surface and anchoring and is delivered with standard accessories.

The technical data of Grinding Machine BO 300 A is shown in Table 1.

Table 1: Technical Data of Grinding Machine

Specifications	
External and internal diameter and width of grinding wheels	300 / 76 - 40 mm
Wheel spindle speeds	1600 Rev / min
Outputs and revolutions of the main driver motor	2.2, 1440 kW, rev / min
Max. noisiness of the machine	78 dB
Weight of the machine	130 kg
Weight of the machine with standard equipment and packing	160 kg

## FUGUAI MAPPING

*Fuguai* is a Japanese word means contamination or abnormalities. Fuguai mapping is machine map used to differentiate abnormalities focus area on the selected machine which normally covers the front of the machine, right view, left view, over view, back view, and base. However, this study only focussed on three main areas of grinding machine. There are front, right and left view (see appendix (figure 6) for details). To perform fuguai identifications (data collection), fuguai tag (F-Tag) was used. Patra *et. al.* [6] stated that employees have the ability to “detect abnormality” with regard to services and equipment, based on a feeling that “there is something wrong” on work. This is a continuous cycle and fuguai tags were used for abnormality identification. This step is absolutely vital for proper improvement of productivity.

## F-TAG

Fuguai tag is used to represent the big eyes. There are two types of fuguai tag, red tag and yellow tag. Red tag used to represent fuguai which required highly technical knowledge while yellow tag used for simple fuguai which not required highly technical knowledge. Figure 1a and 1b are the example of fuguai tag which used for data collection. The following are the descriptions of the items on the fuguai tag.

Figure 1a: Red tag for technical requirement

Figure 1b: Yellow tag for self maintenance which not needed highly technical knowledge

1. **Physical:** abnormalities on the machine that can be seen by naked eyes, not hazardous but important to pay attention to.
2. **Function:** abnormalities on the part of the machine that could lead to the machine / the part of the machine not perform it function.
3. **Safety:** abnormalities on the machine that could lead to hazard and danger to the user.
4. **Contents:** the detail explanation about the *fuguai*.
5. **Date:** the date of the *fuguai* happened must be stated in this column for analysis purpose.
6. **Machine:** by stating the machine name, the analysis or maintenance is easier to detect which machine is in *fuguai*.

For data collection, inspection checklist was applied. Table 2 describe the inspection checklist for data collection.

Table 2: Inspection checklist for Grinding Machine (Model: BO 300A)

No	Inspection Description	Remark
1	Look: € Have chips or coolant contaminates the motor?	Yes
2	Listen: € Are there any strange noises (whining? groaning? sound or slippage?) from the motor brake, or belts?	No
3	Touch while in operation: € Is there any hear or vibration from motor or brake?	No
4	Turn off the machine, then touch again: € Are safety guards fastened securely?; € Are the motor and brake mounting bolts tight?	Yes Yes
5	Remove cover and verify: € Are belt tensions satisfactory? € Are belts or pulleys worn? € Is there any play in the pulley set bolts or keys?	Yes No No

## RESULT & DISCUSSION

The result is based on 7 weeks observations that have been performed on the selected grinding machine and only focus on three main machine area (front view; right view; left view) based on fuguai mapping. The following sub-titles will describe the analysis of fuguai.

### Fuguai Characteristic

There are eight *fuguai* that have been identified on the Grinding Machine (Model: BO 300A) including dust, coolant spill, corrosion, cobweb, scratches, broken hose, misspelled label and misplace items (see table 3 for details). The declaration of criteria for each *fuguai* is important because when one *fuguai* is found, due to its characteristics, the *fuguai* could be classified to its class / type.

Table 3: The Standard type of *Fuguai*

Type of <i>fuguai</i>	Description
1. Dust	Minute solid particles with diameters less than 500 micrometers. Dry ferrous dust generated from grinding process.
2. Coolant spill	A coolant, or heat transfer fluid, is a fluid which flows through a device in order to prevent its overheating, transferring the heat produced. Coolants can quickly become contaminated with foreign materials, causing coolants to lose effectiveness and develop foul odours and colours.
3. Corrosion	Also known as rust. Breaking down of essential properties in a material due to reactions with its surroundings (a loss of an electron of metals reacting with water and oxygen). Affects metallic materials.
4. Cobweb	"Cobweb" is referred to a web inside a house, where dust has gathered on the sticky silk, forming long, hanging streamers.
5. Scratches	A thin shallow cut or mark on (a surface) with a sharp instrument.
6. Broken Hose	The condition of the hose is not in shape, broken at the end of the hose therefore the dust scattered around the dust collector
7. Misspelling Label	Example: the spelling of "PEDELSTAL" is wrong. It should be spelled as "PEDESTAL".
8. Misplace item	The item that should not place on the area.

### Analysis

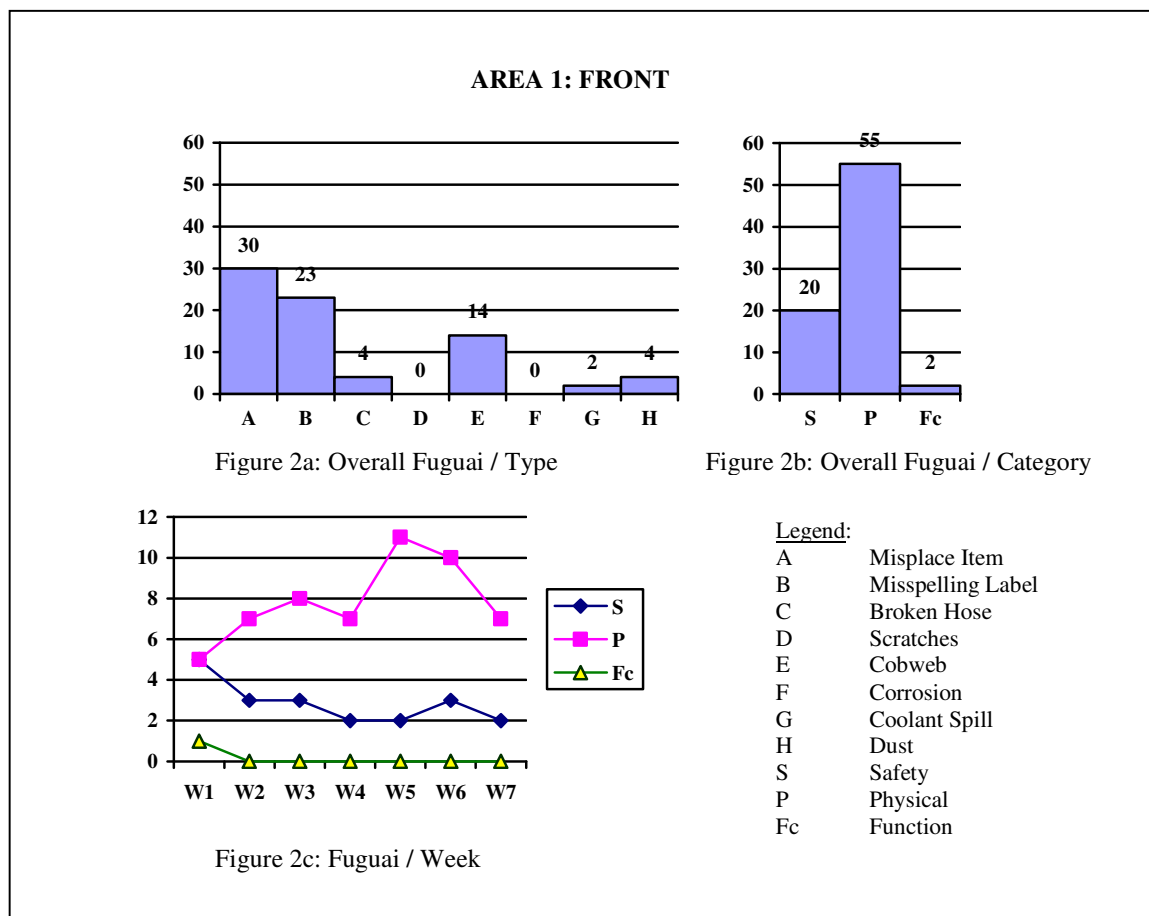
For analysis purpose, bar chart and trend chart were used. The charts are used to summarise the result in proper way for comparison and similarity analysis. Figure 2 represent the data collection for front view, Figure 3 for right view meanwhile Figure 4 represent left view.

The fuguais have been divided into three categories; safety, physical and function. These categories are considered to clarify the fuguai status. Safety is considered the high risk fuguai which can affect the machine user. In addition, the safety fuguai may cause hazardous factor which is opposite with laboratory rule and regulation. One of the prominent fuguais for safety is coolant spill. A few of coolant spill is considered physical fuguai, besides when it become more serious, the coolant spill will be considered safety fuguai which may cause an accident and mistake on the machine. The other point is that, the coolant spill may cause functional fuguai when the liquid enter the wrong place on the machine.

According to Figure 2a, misplace item and mislabelling are two types of major fuguai that identified on the front of the machine. The result is similar for the right view and left view which stated that misplace and mislabelling are considered major fuguai (please see figure 3a and figure 4a). Through fuguai mapping, it can be seen that front view is the critical part should be focussed. The result is expected since the machine users have to face the front of the machine and always be used for finishing purpose after performing other machining process.

Figure 2b, 3b and 4b shows the result of overall fuguai / category. Base on the figures, it shown that physical fuguai is major category of fuguai on the machine especially on the front side which contributed 55 fuguais, followed by safety and functional.

Figure 2c, 3c and 4c shows the trend analysis on 7 weeks fuguai observation on the machine. For the knowledge, through this study every identified fuguai on the previous week will be eliminated before proceed to the next observation except red tag fuguai which required highly skill and knowledge. This is very crucial to analyse the trend of the fuguai towards autonomous maintenance programme. The trend charts show that most fuguai are found on week 1 for all areas. Without machine user awareness on the machine maintenance and the fuguai, the physical fuguai was dramatically rising until week 5. However, it was steady decreased on week 6 and week 7. Furthermore, safety fuguai for the front of the machine was reduced. For functional fuguai, only 1 fuguai was found on the front and 1 on the right side. Unfortunately, the fuguai on the right side cannot be eliminated due to highly technical problem.



**AREA2: RIGHT**

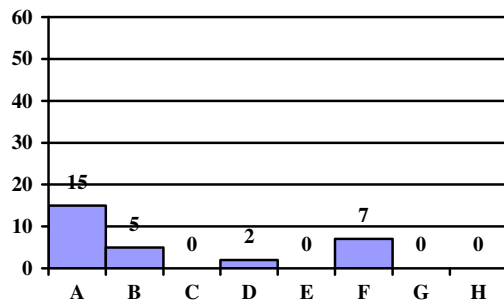


Figure 3a: Overall Fuguai / Type

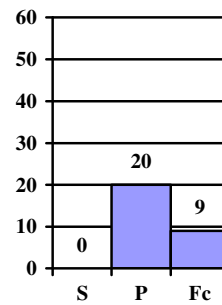


Figure 3b: Overall Fuguai / Category

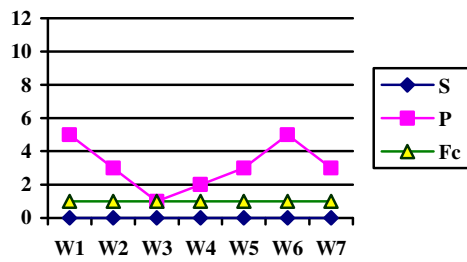


Figure 3c: Fuguai / Week

**AREA3: LEFT**

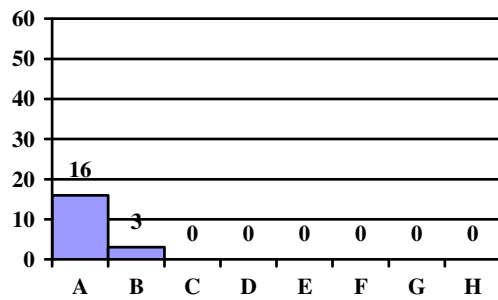


Figure 4a: Overall Fuguai / Type

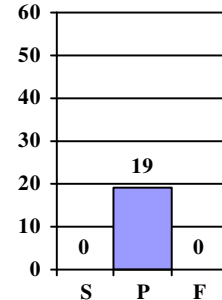


Figure 4b: Overall Fuguai / Category

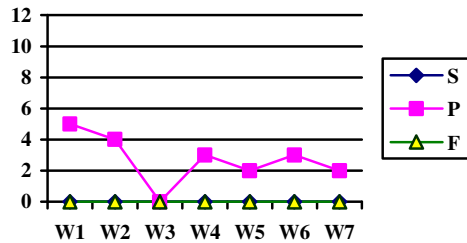


Figure 4c: Fuguai / Week

## CONCLUSION

In the nutshell, the authors conclude that the study was proved fuguai mapping is very useful techniques to focus what have to be done in order to overcome the abnormalities. In addition, fuguai tag is important method to support the fuguai mapping in data collection. Without fuguai tag to represent the big eyes, the processes of fuguai identification become more difficult. The other point is that, to perform fuguai mapping, focus area should relevant, precise and have ability to represent the overall of the machine condition. For the future study, more machines will be selected as case study to demonstrate the effectiveness of the fuguai mapping towards fuguai elimination.

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**APPENDIX**

**FUGUAI MAPPING**

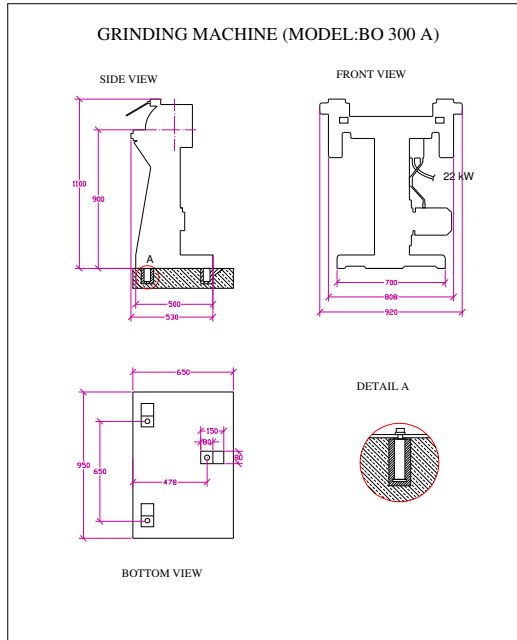


Figure 5: Orthographic

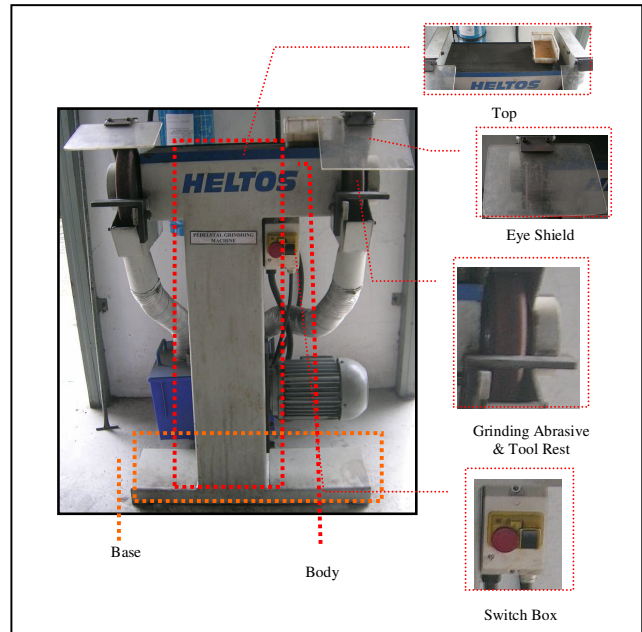


Figure 6a: Area1 (Front)

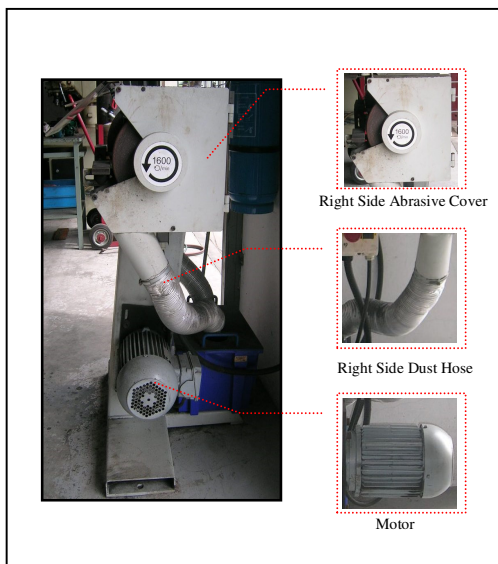


Figure 6b: Area2 (Right)

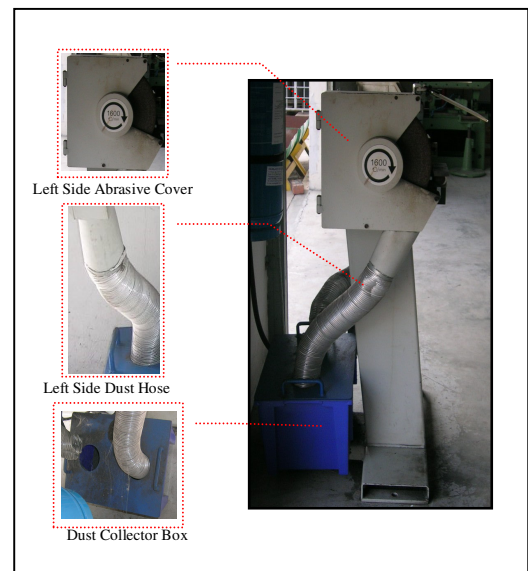


Figure 6c: Area3 (Left)