

Autonomous Maintenance Program For Job Base In Technical University

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ABSTRACT

This paper discusses the implementation of Autonomous Maintenance (AM) program for job base in order to sustain the machine efficiency in Technical University (TU). Grinding machine was selected for case study. In TU, all engineering students especially will use grinding machine for producing very fine finishes or making very light cuts, using an abrasive wheel as the cutting device. As compared with other machining processes, grinding is a costly operation that should be utilised under optimal conditions. The result shows that the AM program had improved responsibility and alertness of the machine users on the machine condition as the standard. In addition, it reduced the total of the problems occurred on the machine and indirectly reduced the cost of breakdown maintenance.

Keyword: *Autonomous Maintenance, Grinding Machine, Fuguai (Abnormality).*

1.0 INTRODUCTION

TPM involves a restructuring of work relating to equipment maintenance. Being relieved of such routine tasks, the expertise in the maintenance unit can now be deployed to focus on more specialized activities such as major repairs, overhauls, tracking and improvement of equipment performance, and replacement or acquisition of physical assets. Instead of having to continuously *fire-fight* and attend to numerous minor chores, it can now devote its resources to address strategic issues such as formulation of maintenance strategies, establishment of maintenance management information systems, tracking and introduction of new maintenance technologies, training and development of production and maintenance workers.

Total employee involvements, autonomous maintenance, small group activities to improve equipment reliability, maintainability and productivity, and continuous improvement, or kaizen are the principles embraced by TPM [1]. One of the main arms of TPM is Autonomous Maintenance (AM), called as *Jitshu Hozen* in Japanese. The success of TPM, to a large extent, depends upon the success of AM.

Grinding machine is extensively used in the Machine Shop Laboratory (MSL), Universiti 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 separate 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. Currently, UTeM had bought 5 machines which used by students in MSL. Unfortunately, after 5 years operation, only 2 can be used. 3 out of total 5 cannot be used due to maintenance problems. The authors considered that the problem occurred because of improper maintenance program on the machine. In addition, the machine always be second priority compared to others machine. This paper discusses the initial step of AM implementation on the grinding machine towards machine zero breakdown and TPM for base in education practice.

2.0 MAINTENANCE

Maintenance is defined as activities intended to preserve or promptly restore the safety, performance, reliability, and availability of plant structures, systems, and components to ensure superior performance of their intended function when required. Levitt [2] defines maintenance as acting in the act of holding or keeping in a preserved state of the asset to avoid the failure. Maintenance also can be define as the combination of activities by which equipment or a system is kept in, or restored to, a state in which it can perform its designated function. Willmott and McCarthy [3], state that the definition of maintenance of a Japanese person from a world class manufacturing company as maintenance means maintaining and improving the integrity of our production and quality system through the machine, processes, equipment and people who add value to the products and services, that is the operators and maintenance of the equipment. Whereas, the maintenance definition to a typical Western manufacturing company as carry out planned servicing at fix intervals or fix it when it break down. According to Wireman [4], maintenance is a unique business process. It requires an approach that is different from other business processes if it is to be successfully managed. Levitt [5] define maintenance is war. The enemies are breakdown, deterioration, and the consequence of all types of unplanned event. Drury [6] describe maintenance is a complex part of the lifetime of a dependable embedded system. Design and maintenance must be simultaneously planned in order to ensure an efficient and cost-effective outcome over the life of the product.

2.1 AUTONOMOUS MAINTENANCE

The autonomous or composite work group was the first of the formal group concepts advanced for the conscious design of group work systems. Based upon socio-technical work design theory, the concept of the autonomous work group emphasised the organisational independence of the work unit. Work units were decoupled from organisational systems of monitoring and control (supervision) in order to internally self-regulate work tasks [7-8]. At the core of world-class maintenance performance is something called autonomous maintenance. In this context, the term autonomous doesn't mean performing maintenance in a vacuum or solely by the traditional maintenance department. Rather, it means that operators perform certain equipment maintenance activities and that maintenance crafts get closely involved in the daily operation of equipment. The focus of the operating team is on cleaning, inspecting, lubricating, monitoring and other such essential daily tasks traditionally within the domain of the maintenance department [9]. 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 [10]. According to Mobley [9], operators can make or break maintenance effectiveness. Without interrupting their production work, operators can easily prevent breakdowns, predict failures and prolong equipment life if they become more intimately familiar with the machinery they run every day. But to do this, they must become highly equipment-conscious, and that can require some intense training. Acknowledging the autonomous or

self-governing nature of performers and performance carries with it important implications for performance technology and performance technologists. Chief among them is that performance technology must be practiced and applied by workers and work groups in the course of configuring their work. In short, if worthy performance is to be engineered, workers and work groups must engineer it [11].

3.0 GRINDING MACHINE

Grinding is a chip removal process that uses an individual abrasive grains as the cutting tool [12]. 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 [13] 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

4.0 DATA COLLECTION

For data collection, fuguai mapping is performed to differentiate abnormalities focus area on the machine which normally covered 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.* [14] 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 F-tags were used for abnormality identification. This step is absolutely vital for proper improvement of productivity. F-tag is used to represent the big eyes. There are two types of F-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

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*.

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: <ul style="list-style-type: none"> □ Have chips or coolant contaminates the motor? 	Yes
2	Listen: <ul style="list-style-type: none"> □ Are there any strange noises (whining? groaning? sound or slippage?) from the motor brake, or belts? 	No
3	Touch while in operation: <ul style="list-style-type: none"> □ Is there any hear or vibration from motor or brake? 	No
4	Turn off the machine, then touch again: <ul style="list-style-type: none"> □ Are safety guards fastened securely?; □ Are the motor and brake mounting bolts tight? 	Yes Yes
5	Remove cover and verify: <ul style="list-style-type: none"> □ Are belt tensions satisfactory? □ Are belts or pulleys worn? □ Is there any play in the pulley set bolts or keys? 	Yes No No

5.0 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.

5.1 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.

5.2 FUGUAI 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 out of total 77 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.

The number of *fuguai* identified in first week is 22. The *fuguai* reduced to 19 on the following week and reduced significantly on week 3 to 13 *fuguai*. Nevertheless, the number of *fuguai* increased a little to 15 *fuguai* in week 4 and week 5. In week 6, the numbers of fuguai is climb to 22 *fuguai* and then decrease to 15 *fuguai* on week 7.

The inconsistent changes of *fuguai* frequency are closely related to the frequent use of the machine, and the student who use the machine. From the observation, during week 3, the numbers of students who use the grinding machine are modest compare to the other week. Besides, the students who use the machine are the final year students and second year students. These students are more likely know how to use the machine and habitually to clean the area of the machine before leave the lab.

The higher frequency of *fuguai* is dust, 61, followed by coolant spill, 31, scratches, 14, broken hose, 7, corrosion and misplace item both 4, and misspelling label and cobweb both 2. The dust is the most critical *fuguai* and appropriate solution should be planned to eliminate the *fuguai*. Although through weekly Initial Cleaning, the dust is really hard to eliminate. Coolant Spill also needs to pay attention as this *fuguai* is also likely to repeat on the next week. The non-critical *fuguai* include misspelling label and cobweb.

AREA 1: FRONT

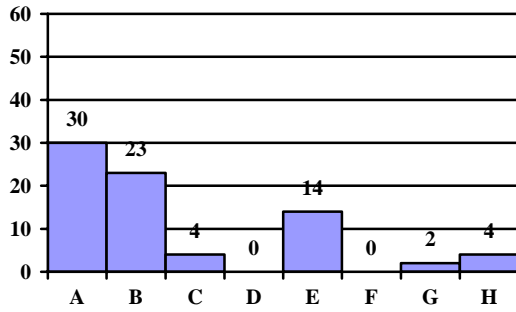


Figure 2a: Overall Fuquai / Type

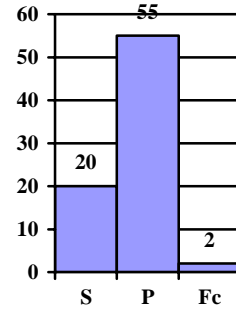


Figure 2b: Overall Fuquai /

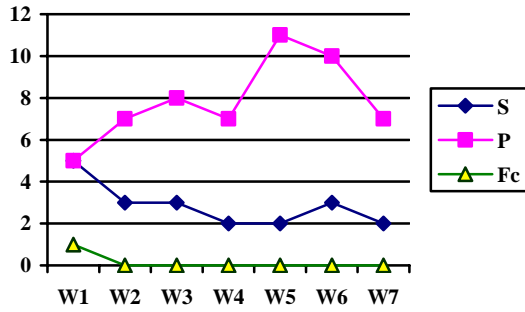


Figure 2c: Fuquai /

Legend:

- A Misplace Item
- B Misspelling Label
- C Broken Hose
- D Scratches
- E Cobweb
- F Corrosion
- G Coolant Spill
- H Dust
- S Safety
- P Physical
- Fc Function

AREA2: RIGHT

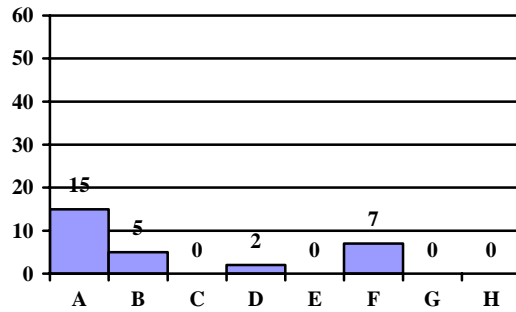


Figure 3a: Overall Fuquai / Type

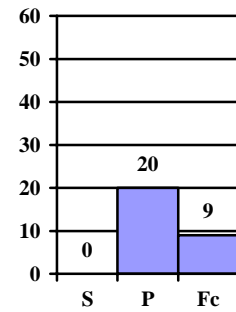


Figure 3b: Overall Fuquai /

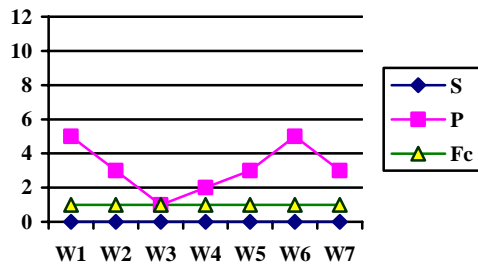
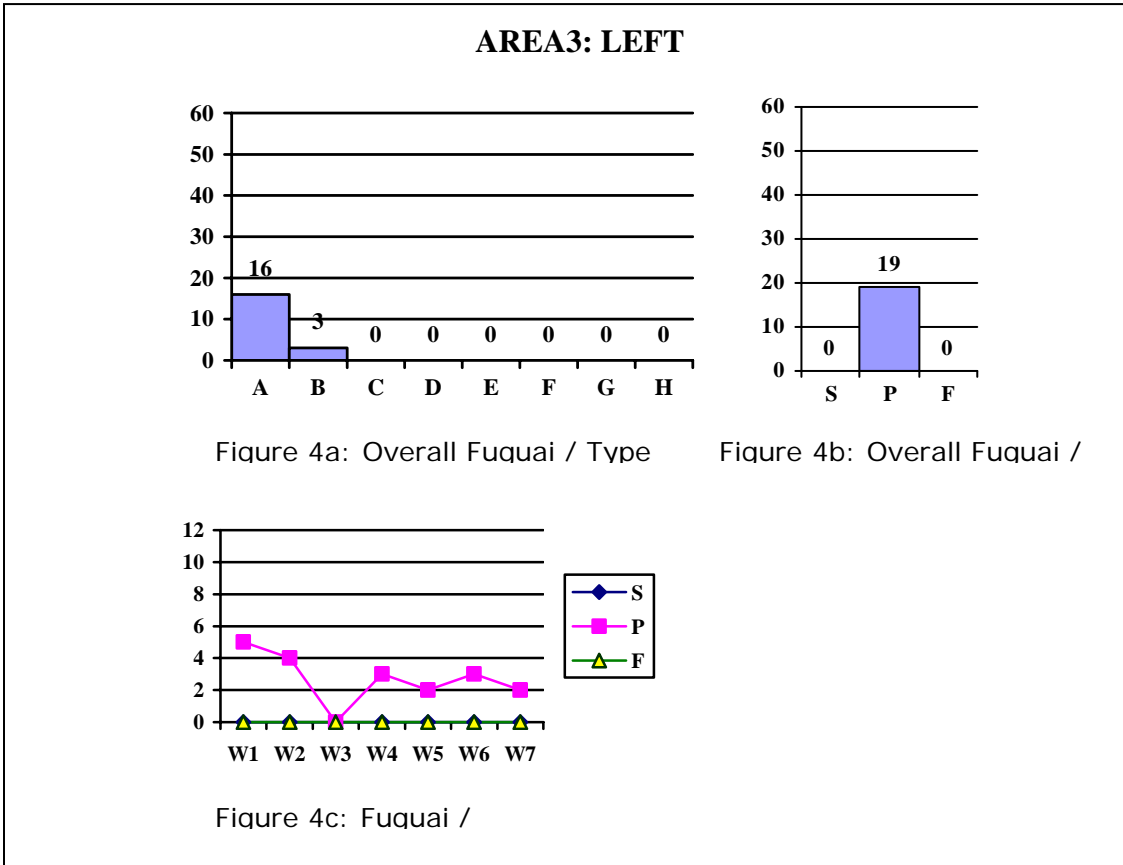


Figure 3c: Fuquai /



6.0 CONCLUSION

The objective behind this project was to perform an AM programme on the grinding machine (Model: BO 300 A). The study gives an insight into identifying and analyzing the abnormalities on the grinding machine (Model: BO 300 A). The findings were based on analysis of data collected after execute the first step of AM on the machine for seven weeks period of time. It was found that some of *fuguai* were cannot be eliminated however they were possible to be reduced. The most critical *fuguai* occurs on grinding machine was dust. This was brought about by the grinding process that produces ferrous dust as chips. The *fuguai* can be reduced by performing final clean before leave the lab and after use the machine. Meanwhile, the crucial area was the front of the machine. It could be due to the front was the work centre for grinding process and consists of many parts compared to right side and left side of the machine. In addition one of the significant findings in project was the physical is a very chronic type of *fuguai* that dominate each and every area of the machine. Some of physical *fuguai* were possible to eliminate by carry out the cleaning on the machine from time to time, but some were hard to be get rid of. On the other hand safety and function only rule tiny parts of the machine but these types of *fuguai* were acute therefore required high attention. These types of *fuguai* usually need high technical knowledge to be dealt with. The operators of the machine UTeM's students and they are different students who operate the machine in every week. Therefore, it was so challenging to build a solid AM programme on the

machine. That was the main reason why the *fuguai* could not be eliminated completely. Furthermore, the *fuguai* that occurred on the machine were repeated each week. It is undeniable that the implications of the findings are constrained by the period to perform AM program on the grinding machine (Model: BO 300 A). The seven weeks period is apparently insufficient to carry out a complete AM program on the machine. Moreover, the data was taken once a week, therefore it may have a small error and imprecise to the data. Furthermore this project is not applicable for other types of grinding machine. When performing AM on the machine, the importance of AM have become more apparent and radiance. Performing AM on the machine has built the awareness that even a tiny abnormalities on the machine could lead to the large impact on machine performance. Moreover, after performing Initial Cleaning on the machine, the workplace area became clean, uncontaminated, organized, and user-friendly.

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APPENDIX

FUGUAI MAPPING

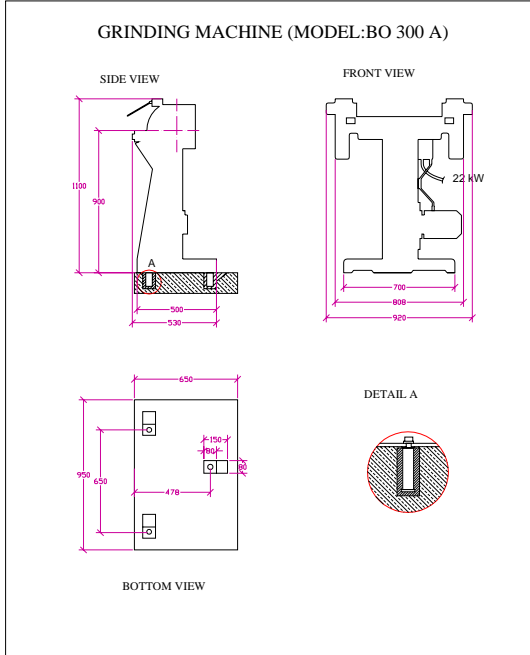


Figure 5: Orthographic

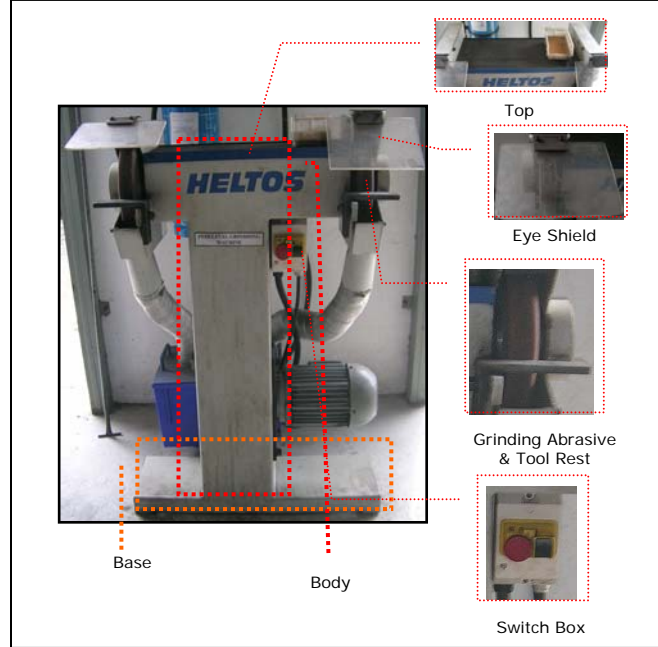


Figure 6a: Area1 (Front)

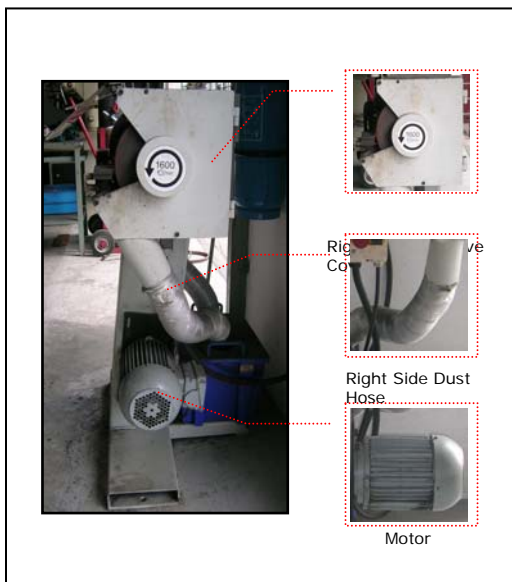


Figure 6b: Area2 (Right)

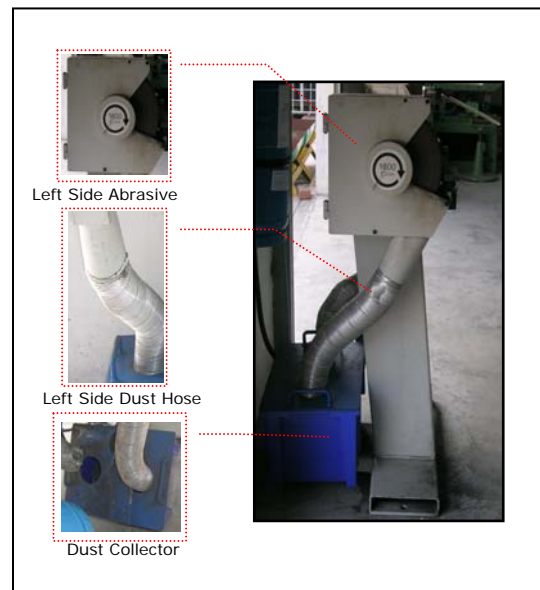


Figure 6c: Area3 (Left)