Autonomous Maintenance for Milling Machine

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Abstract – *This paper is prepared to show the result of the AM implementation (first step: initial cleaning) on milling machine at Institut Kemahiran Mara (IKM). The focus of the project is to eliminate any abnormalities (fuguai) which not needed for milling machine. The abnormalities or fuguai is hidden enemy for milling machine which had reduced the machine effectiveness and machine breakdown. The result found that most of abnormalities can be eliminated without special technical requirement. In addition, the implementation of AM had improved user satisfaction on milling machine operation.*

Keywords – *Autonomous Maintenance, Abnormalities (Fuguai), IKM, Milling Machine, KONDIA.*

I. INTRODUCTION

Production organizations are usually concerned with converting inputs such as raw materials, labour and processes into finished products of higher value at minimum cost satisfying the customer needs. In order to achieve maximum return on investments the production systems must be able to minimize plant downtime, increase productivity, improve quality and deliver orders to customers. This has brought the role of maintenance into an important issue [1].

The increased emphasis on equipment availability, performance, quality, environment conditions and safety considerations has rise up maintenance functions. Total Productive Maintenance (TPM) is a maintenance program which involves a concept for maintaining plants and equipment. TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. According to Venkatesh [2], the goals of the TPM program is to markedly increase production, to hold emergency and unscheduled maintenance to a minimum, and at the same time, increasing employee morale and job satisfaction. One of the important factors in TPM is Autonomous Maintenance (AM). This type of maintenance encouraged operator to sense any abnormalities on the machine and maintain common problem by him/herself. By this way, the machine will always be in its idle condition while the operator learns more and feel sense of ownership about the machine.

Milling machines are very useful in manufacturing engineering. Its price is quite high that worth to maintain it rather than to buy a new one. In order to prevent it from deteriorating, correct applications of maintenance works are essential. This type of machines are available in every

Manufacturing Department in five Institut Kemahiran MARA (IKM) located in Jasin, Melaka; Pekan, Pahang; Johor Bahru, Johor; Lumut, Perak; and Kampung Pandan, Kuala Lumpur. In each IKM, twelve milling machines are being use by their students. Total of sixty milling machines have costs Majlis Amanah Rakyat (MARA) millions of ringgit. This project was planned to develop a pilot activity of AM Program in Manufacturing Department, IKM Jasin, Melaka.

II. AUTONOMOUS MAINTENANCE

Autonomous Maintenance (AM) is one of the TPM pillars called *Jishu Hozen* in Japanese. The success of TPM in long term is depending on how far the pillar major task is fulfilled. If the sub-division of pillar's task continuously improves, so does the TPM itself. To clearly define AM, the term autonomous maintenance 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.

Pomorski [3] defined that "AM is the process by which equipment operators accept and share responsibility (with maintenance) for the performance and health of their equipment" as AM definition, while Shirose [4] define AM the creation of 'expert equipment operators' for the purpose of 'protecting their own equipment'.

Unfortunately, most equipment operators lack a feeling of ownership. Usually operator of the machine thinks that they only use the machine to produce the product. When any trouble happened to the machine such as broke down, cracked, jammed or suddenly shut down, the operator will called a person from maintenance department to settle down the problem. The older the company, the more rooted this mind-set becomes and the more difficult it is to change. AM targeted the operator as the asset owner, focus for routine maintenance and central figure in overall equipment effectiveness.

III. RATIONALE OF CHOOSING MILLING MACHINE

There are several reasons of choosing milling machine. In manufacturing industries, there are many types of machines have been used. Milling machine is used by the user to produce product, component, and maintenance work. In the other word, milling machine is useful and it is needed for any manufacturing operations. Based on the reasons, IKM has bought several number of milling machines for education purpose as well as added value for student in using Milling machine. Milling machine needs a greater maintenance for those three axes controller; X, Y, and Z, precisely. According to above matters; milling machine was selected for case study in order to establish AM. However, the project is just focussed on fuguai elimination which considered the first step in AM implementation.

IV. KONDIA KP-90 VERTICAL MILLING MACHINE

KONDIA KP-90 Vertical Milling Machine was manufactured by KONDIA Machinery in Elgoibar, Spain. One of the machines is available in Institut Kemahiran Majlis Amanah Rakyat (IKM) in Jasin, Melaka. It was bought at the price of RM101,915.00 by Majlis Amanah Rakyat (MARA) in July 1993 to be used by their manufacturing engineering trainees (students). Figure 1 shows the KONDIA KP-90 Vertical Milling Machine in its real location. See Figure 2 and Figure 3 at Appendix for machine overall dimension.

V. MACHINE MAPPING

For initial cleaning, the KONDIA KP-90 Vertical Milling Machine has been divided into five main area (see Figure 1):

1. Part A: variable speed head compartment;
2. Part B: overarm, column and switch box;
3. Part C: machine table and vice;
4. Part D: saddle; and
5. Part E: coolant reservoir, knee and machine surrounding.

Part A, the variable speed head compartment consists of variable speed head motor, drawbar to hold the tool, braking handle to decelerate the pulley speed, high-low pulley transfer to align with the speed selector position that range from 60 rpm to 4250 rpm. It also has two grease cup for lubricating purpose, slanting device that can align-off the head up to 45 degree to the left and right, manual feed lever for Z-axis movement, quill, and the arbour on its below.
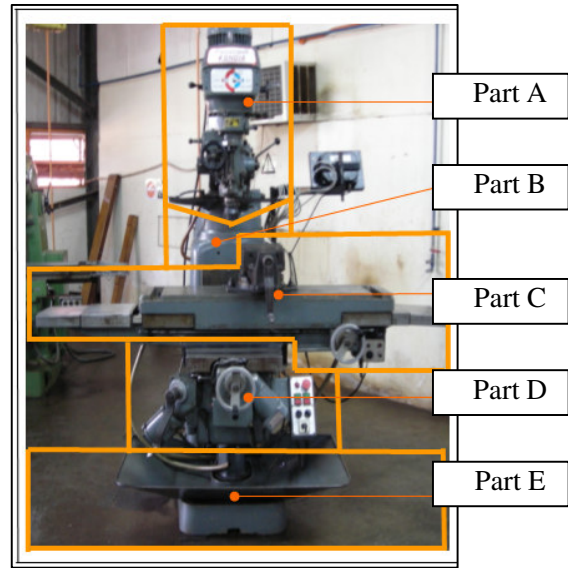

Figure 1: KONDIA KP-90 Vertical Milling Machine

Part B, which consist of overarm, column, and switch box part, there are overarm that supported by 4 mounting screws into column, coolant outlet hose, switch box that contains all electrical control for the machine, variable speed head power source, machine power switch, column opener, and 3-phase power supply switch lever.

Part C for machine table and vice parts. There are a vice and its jaws, flat surface of machine table with tee-shape slot and its support, sideways covered by U shape sheet metal to provide protection, left and right limit switch to avoid over travel of X-axis, manual feed handle, auto travel speed control and its motor, and two coolant hose inlet to enable coolant circulation to the reservoir.

Part D is saddle, which located between machine table and its knee. Among its parts are Y-axis and Z-axis auto travel movement motor, hand wheel for both Y and Z axes manual movement, slideways for Y-axis, lubrication pump lever, and locking nuts to enable machine rigidity during operation. It also has a control panel that consists of on and off switch button, tool rotation changer, and an emergency stop button.

Part E is for the bottom of machine is coolant reservoir, knee and machine surrounding.

VI. ABNORMALITIES

Abnormality will give negative effect for machine, product, equipment, operator and environment. The abnormality can be divided into three categories; safety, function and physical which involved four types of common *fuguai*; dirty, broken / loose, misplace and others. Table 1, Table 2, and Table 3 describe the abnormality type with the effects.

Table 1. Abnormality type: Dirties

Dirty	Description	Effects
Machining chips	Small metal particles as a result of work piece machining. Sharp and curly, around 2mm - 4mm length.	Safety– can cause small wound to operator's hand or scratch finished work piece surface. Function- can clogged the coolant inlet hose Physical- reduce machine neatness
Coolant waste	A mixed of oil and water use in machining process to enhance cutting condition.	Safety- can cause slippery. Physical- promotes corrosion on uncoated surface. Bad odours.
Oil leakage/ spill	Oil in unwanted area such as on the table or floor because of the inefficient container or transferring process.	Safety- can cause slippery. Function- reduces the lubrication efficiency. Physical- reduces machine neatness.
Corrosion	Reactions of metal surface properties when exposed to its surroundings. Thin film of reddish or brown color that deteriorate metal surface condition.	Safety- promote unwanted hole and reduce material strength. Function- increase friction force between moving parts Physical- deteriorate surface condition
Dust	Fine particles come from surrounding. Easily stick to wet or oily surface.	Function- reduces lubrication efficiency. Physical- reduces machine neatness.

Table 2. Abnormality type: Broken/Loose

Broken/Loose	Description	Effects
Broken accessories	Tear off, broken or being detached because of excessive usage	Safety- sensitive machine parts were exposed to foreign objects. Function- Decreased machine equipment efficiency. Some of the machine parts totally out of use. Physical- reduces machine neatness.
Loose	Un-tighten screw between mating parts cause by lack of maintenance or parts wear off	Function- reduce parts efficiency Physical- reduces machine neatness.
Lost	Some accessories of part were missing	Safety- can harm the machine and operator if accessories being malfunction. Function- some accessories were out of service. Physical- reduces machine neatness.

Table 3. Abnormality type: Misplace

Misplaced	Description	Effects
Strange objects	Strange material place on the machine	Safety- can scratch machine surfaces. Physical- reduce machine neatness.
Machine accessories	Machine accessories located not on its proper place	Safety- can cause harm to another machine parts. Function- malfunction of certain accessories. Physical- reduce machine neatness.
Tools	Tools were not arranged in its proper location or compartment.	Safety- can cause harm to another machine parts. Physical- reduce machine neatness.

VII. RESULT & DISCUSSION

AM in the first step implementation is focused on initial cleaning or the other word, eliminating existed abnormalities. This step is very crucial to analyse current machine's performance without abnormalities. For data collection, eight week observations were conducted. The result of the observations presented in Table 4. Table 4 shows the frequency table of abnormalities which divided into abnormality type, machine part and abnormality categories.

Table 4: Frequency of abnormality Based On type, Part, Category in Eight Week Observations

		Week								TOTAL
		1	2	3	4	5	6	7	8	
Type	Dirty	17	9	12	9	7	5	4	4	67
	Broken/ loose	9	5	1	1	2	3	2	1	24
	Misplace	4	2	2	2	1	0	0	1	12
	Others	2	0	0	1	2	1	1	1	8
	TOTAL	32	16	15	13	12	9	7	7	111
Part	A	3	1	0	1	3	0	2	1	11
	B	10	4	2	2	1	1	2	3	25
	C	7	6	4	5	1	4	0	0	27
	D	6	2	4	3	4	0	0	1	20
	E	6	3	5	2	3	4	3	2	28
	TOTAL	32	16	15	13	12	9	7	7	111
Category	Safety	5	2	1	2	2	1	1	0	14
	Function	7	4	4	4	4	3	3	3	32
	Physical	20	10	10	7	6	5	3	4	65
	TOTAL	32	16	15	13	12	9	7	7	111

From this finding, it can be said that the abnormality are most discovered in week 1. Although, the result shows that the abnormality are steady decrease in week 8.

In terms of abnormality type, dirty with the frequency score of 67 become the highest abnormalities which involved machining chips, coolant, oil leakages and dust. With different of 43 for dirty frequency score, broken/loose is also considered a serious problem. Subsequently, as shown in Table 4, misplace and other abnormality types were contributed 12 and 8 respectively.

For machine part, Table 4 shows that there are average numbers of abnormality for each. Part E had most abnormality meanwhile Part A had least abnormality.

Table 4 shows that physical category of abnormality become the highly critical abnormality and need more attention from machine users. In addition, in 8 week of observations, obviously shown in Table 4, just over a half of total identified abnormalities are physical abnormality. Although, the frequencies of function and safety fuguai are less than physical abnormality, it may reduce machine effectiveness.

VIII.   CONCLUSION

In the nutshell, the project concludes that implementation of Autonomous Maintenance (AM) is very useful for machine, user and IKM itself. Most of abnormalities (*fuguai*) have been eliminated through AM and improved the efficiency of the milling machine. Besides, AM had improved the environment and increased the user discipline during milling operation.

ACKNOWLEDGMENT

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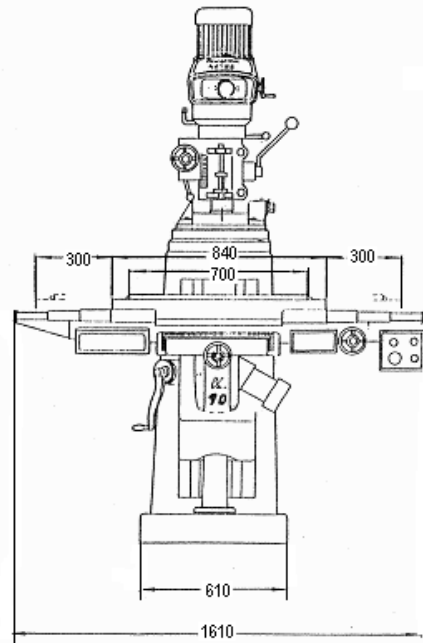[4] Shirose, K. (1992). TPM for Operators. Portland, OR. Productivity Press.
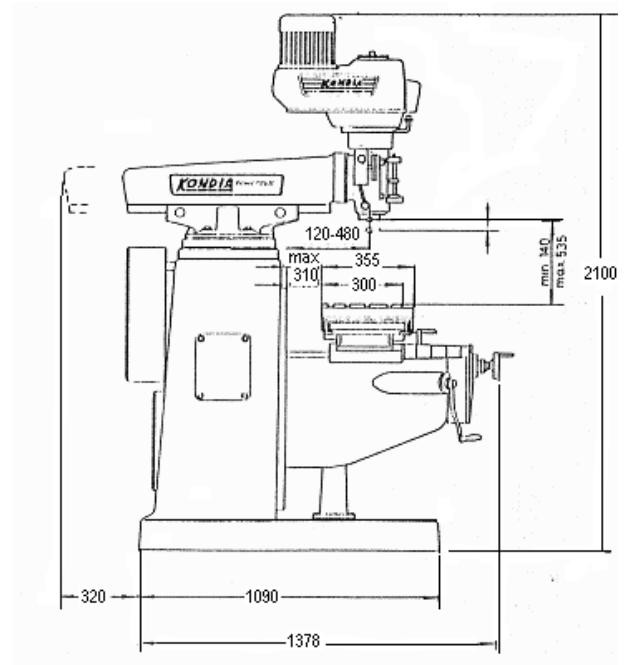
APPENDIX

Figure 2: Front View Dimensions

Figure 3: Side View Dimensions