Efficiency Improvement of Rice Polishing Cylinder Used as Metakaolin Binder by Centrifugal Machine Casting Process

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Abstract*— The objective of this research is to improve the effective of rice polishing cylinder which used metakaolin for binder replacement. In the present, the binder is calcined magnesite cement that imported from foreign. Therefore, this research used metakaolin to replace as 37% in order to reduce cost and used agricultural technology by centrifugal machine to improve the casting process instead original from hand which is based on the experience of the technician. The experimental design and evaluated by Minitab Release 14 from function factorial design. There have two factors which study were the velocity of centrifugal machine has separated three levels : 120, 130, 140 rpm and the saline degree has separated three levels: 28, 30, 32 degree. The response has two items which evaluated effective were average wear rate and average broken rice percent. From the evaluation, It found optimum condition as velocity: 130 rpm and saline degree as 30 degree. When used this optimum conditions to cast cylinder, It found the average wear rate was 3.86 g/hr and average broken rice percent was 24.31%. While compared with rice polishing cylinder from metakolin by hand casting, it found average wear rate was 7.27 g /hr and average broken rice percent was 32.53%. Therefore, it found the effective of rice polishing cylinder which casted by centrifugal machine had higher effectiveness than rice polishing cylinder which casted by hand.

***Index Terms*— Centrifugal machine, metakaolin, agricultural technology, rice polishing cylinder.**

I. INTRODUCTION

In the last decades, rice milling machine have been used as the agriculture based machinery for Thai agriculturists. Currently, a small rice milling machine which has capacity as 1-2 ton per day is widely used by agriculturists since a small rice milling machine uses less production time and more convenient to use in household. Normally, a small rice milling machine has two different types: vertical axle and horizontal axle. Generally, the horizontal axle which is driven by electric motors is extensively used because it has low price and it can be easily purchased locally. The quality of peeled rice depends on several factors such as types of paddy, grain shape and size, paddy moisture content, and processes of shelling and polishing [1]. The process of rice polishing is an important step and the percentage of good peeled rice rely on the quality of rice polishing cylinder [2-3]. In general, the rice polishing cylinder consists of two composite materials which are abrasive material and binder material [4]. The abrasive material consists of the emery grain stone and silicon carbide. The binder material comprises calcined magnesite cement and magnesium chloride.

For the casting process of rice polishing cylinder, it brought shaft that made by cast iron to crack the damaged cover and casted by mixing between calcined magnisite cement and abrasive material in a ratio as 1 : 5 by weight [4]. After, pour magnesium chloride has degree of saline as 30 and mixing everything together. Then, brougth the ingredients has tough for casting by hand to cover the shaft allow by vertical has a thickness around 1 inch that show in Fig.1. The time to dry around one day. After, brought rice polishing cylinder to grind the surface allow by size requirement. For the casting process development of rice polishing cylinder, some factory used agricultural technology by centrifugal machine to improve instead by hand [5]. This process used motor to propel which speed between 120 – 140 rpm that show in Fig.2. The velocity of machine is an important factor that affect the invariability of the air gap between the stone and mortar. It will improve the problem of casting process by hand that difficult control the hardness of mortar [6]. In addition, the degree of saline has important factor that affect the hardness of mortar and used between 28 – 32 degree normally [7].

Nowadays, calcined magnesite cement was imported from foreign [8]. In order to reduce the amount of the imported calcined magnesite cement, using the domestic pozzolan material which is an agricultural waste such as rice husk ash, bagasse ash, and metakaolin as a part of binder material can reduce the production cost and improve the desired properties of cement [9]. Boonkang et al. [10] have applied metakaolin from northeast of Thailand used as binder mixed with calcined magnesite cement in the casting process of rice polishing cylinder. The proportion suitable of

metakaolin was replaced as 37%. However, it found that average broken rice percent and average wear rate have higher than rice polishing cylinder which used binder by calcined magnesite cement only.

Fig. 1 The casting process by hand in vertical

Fig. 2 The casting process by centrifugal machine

Therefore, in order to improve the efficiency of rice polishing cylinder used metakaolin binder. It has the concept for apply centrifugal machine to cast instead. It has affect the hardness consistently. This condition to improve the efficincy of rice milling and to reduce the wear rate of rice polishing cylinder. Therefore, it has the reason of this research.

II. Experimental Procedures

A. Material Preparation and Equipment

Control factors were metakaolin from Udonthani province as 37% and calcined magnisite cement as 63% by weight. Metakaolin was baked at 800 °C around six hours in an electrical furnace. After that, it was mashed and screened by the sieve size 325 following the ASTM C618 standard. The casted rice polishing cylinder used the abrasive material: binder material as 5:1. The horizontal axle rice milling machine was used to test the rice milling. Rice for testing was Jasmine Rice 105 and paddy moisture content was controlled not to be exceed 14%, and all scraps were removed. Each testing batch consisted of 20 kilograms of Jasmine Rice. Minitab Release 14.00 program was used to evaluate the experimental results and design of experiment by factorial design function.

B. Design of Experiments

The experiment was separated into two parts as below

1) Study of the optimum conditions for increasing the efficiency of metakaolin rice polishing cylinder by centrifugal machine casting process. Two factors are involved were velocity of centrifugal machine has separated three levels : 120, 130, 140 rpm and the saline degree has separated three levels: 28, 30, 32 degree. The response has two items which evaluated effective were average wear rate and average broken rice percent.

2) Comparison testing of rice milling efficiency between metakaolin rice polishing cylinder which casted by centrifugal machine and by hand . Includes a comparison test with rice polishing cylinder that casted from imported calcined magnesite cement only. The response has two items which evaluated effective were average wear rate and average broken rice percent.

III. Result and Discussion

A. Result of optimum condition for efficiency improvement of the metakaolin rice polishing cylinder which casted by centrifugal machine

When evaluated by Minitab Release 14 from function factorial design, we found optimum conditions were saline degree as 30 degree and machine velocity as 130 rpm. This conditions have average wear rate minimum as 3.857 g/hr and average broken rice percent minimum as 24.33% that showed in Table 1. After that, we used this condition to cast metakaolin rice polishing cylinder and compared with metakaolin rice polishing cylinder that casted by hand.

Table 1 Average wear rate and average broken rice percent of two factors

No.	Saline Degree	Machine Velocity	Average Wear Rate	Average Broken Rice Percent
1	28	120	9.573	33.033
2	28	130	10.143	33.833
3	28	140	8.630	25.167
4	30	120	6.750	27.333
5	**30**	**130**	**3.857**	**24.333**
6	30	140	5.807	26.250
7	32	120	8.390	28.333
8	32	130	7.133	34.000
9	32	140	7.487	34.833

B. Result of the rice milling efficiency comparison and cost in the production

When compared the metakaolin rice polishing cylinder (MRPC) that casted by centrifugal machine with by hand by T-Test for two sample function in Minitab Release 14, we found MRPC that casted by centrifugal machine has average broken rice percent as 24.31% that lower than MRPC that casted by hand has average broken rice percent as 32.53% in significantly level 0.05 that showed in Fig. 3

and Fig. 4. In addition, we found the average wear rate of MRPC that casted by centrifugal machine as 3.86 g/hr that lower than MRPC that casted by hand has average wear rate as 7.48 g/hr in significantly level 0.05 that showed in Fig. 5 and Fig. 6. After that, we compared the result with the rice polishing cylinder that casted from import binder by hand. The comparison that showed in Table 2.

T-Test for Two-sample of Broken Rice Percent

	N	Mean	StDev	SEMean
By Machine	9	24.31	0.542	0.18
By Hand	9	32.53	1.56	0.52

Estimate for difference: -8.21333
95% CI for difference: (-9.45684, -6.96982)
T-Test of difference = 0 (vs not =): T-Value = -14.94
P-Value = 0.000 DF = 9

Fig. 3 T-test for two-sample of broken rice percent

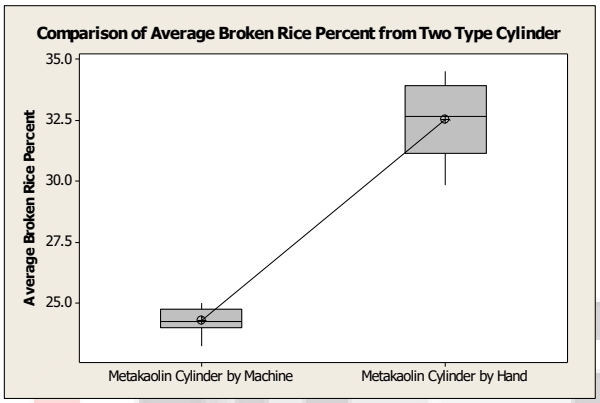

Fig. 4 Comparison of average broken rice percent from two types cylinder

T-Test for Two-sample of Wear Rate

	N	Mean	StDev	SE Mean
By Machine	9	3.86	0.589	0.20
By Hand	9	7.27	1.87	0.62

Estimate for difference: -3.60778
95% CI for difference: (-5.08659, -2.12897)
T-Test of difference = 0 (vs not =): T-Value = -5.52
P-Value = 0.000 DF = 9

Fig 5. T-Test for Two-sample of Wear Rate

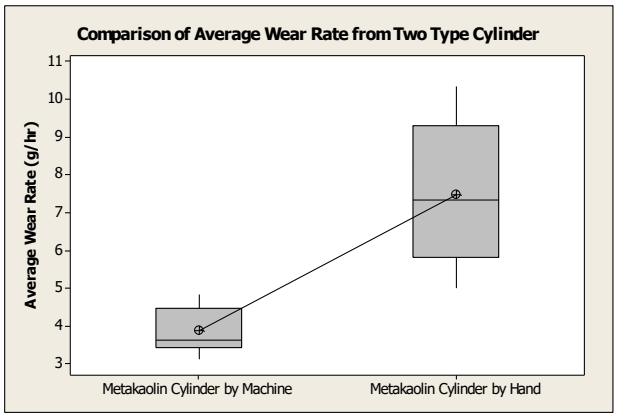

Fig. 6 Comparison of average wear rate from two types cylinder

Table 2 Efficiency comparison result of three types cylinder

Detail of evaluation	Metakaolin rice polishing cylinder by centrifugal machine casting	Metakaolin rice polishing cylinder by hand casting	Rice polishing cylinder from import binder [8]
Average broken rice percent	24.31	32.53	26.65
Milling time / rice 20 kg.	32	36	53
Average wear rate (g/hr)	3.86	7.27	5.26
Average milling quantity percent	67	68	60.32
Material cost (baht)	799	984	1,016

From the comparison test of the metakaolin rice polishing cylinder (MRPC) by centrifugal machine casting and by hand casting, it was found that the MRPC by centrifugal machine casting has the average broken rice percent decreased as 8.22%, consistent with the research of R. Chaiyachet and et.al [8]. This research has improved the broken rice percent by centrifugal machine and found broken rice percent decreased as 11.32%, it has same direction and nearly value. For the comparison of wear rate from two type cylinder, it was found the MRPC by centrifugal machine casting decreased as 46.91%. This condition has consistent with the research of T. Boonkang and S. Lee [7] who studied the factors that affected with the wear of rice polishing cylinder. This research showed MRPC by centrifugal machine casting has the average wear rate decreased as 50%. It has same direction and nearly value. In addition, it found milling time and material cost of two types cylinder have lower than rice polishing cylinder from import binder. Therefore, the using centrifugal machine to cast rice polishing cylinder has effect the efficiency higher because this process helps to control the harness consistency of the MRPC. This condition has affects the efficiency of rice milling higher finally.

IV. CONCLUSION

1) The optimum conditions for metakaolin rice polishing cylinder casting by centrifugal machine were the saline degree as 30 degree and velocity of machine as 130 rpm. At this condition, the lowest average wear rate as 3.86 g /hr and the lowest average broken rice percentage was 24.33%.
2) When used optimum conditions to cast the metakaolin rice polishing by centrifugal machine casting and compared with the metakaolin rice polishing by hand casting and the rice polishing by import binder casting. It was found the average broken rice percentage decreased by 33.81% and

8.78% , while the average wear rate decreased by 48.13%. 26.24% respectively.

3) The metakaolin rice polishing cylinder casting by centrifugal machine has the cost lower than the metakaolin rice polishing by hand casting and the rice polishing by import binder casting as 18.80% and 21.36% respectively.

4) In the development of centrifugal machine casting, cating mold has an important tool that affect the quality of casting. Therefore, it should improve the cating mold by use material has smooth highly and flexible highly instead steel mold. It help the process of assembly is easily and reduce the loss rate of product.

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