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ACOUSTIC ANALYSIS OF RICE MILLING PROCESS

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ABSTRACT

The main objective of this study was to test the sound monitoring of rice milling process by the machine sound generated from milling chamber .The sound data were analyzed by Fast Fourier Transform of Signals (FFT). The values of frequency (Hz.) and the power spectrum density (P.S.D. w/Hz.) were affected by the milling stage as well as whitening characteristics of different stages through milling process. Also investigating included the relation between the milling degree, rice temperatures, amount of rice in the milling chamber and sound analysis. The peak frequency was analyzed in order to determine the coefficient of variation (c.v.) during milling stage. The result showed that in the last stage (c.v.) percent became smaller than other stages. Also, data showed change in frequency through time as the value of peak changed from 212 to 403 and 318 Hz. as the time changed from stage No. 1 to stage No. 6 and stage No. 12. Respectively. Statistical analysis showed that there is significant different on the frequency through milling stage

[Keywords] Sound analysis, milling process, (FFT), milling degree, vertical machine, Rice, whitening characteristics, power spectrum, frequency,

INTRODUCTION

The output of milled rice and its quality are highly affected by the milling degree to remove the outer layer of the rice (bran). The milling degree required arrangement from 100 to 60% for all rice milling products. The whitening was carried out using (vertical DB-25-C) machine with a computerized system adjusted to work about five hours to have milling degree about 70%. The control system used in this machine depends on reduction in the rice weight as related with the milling degree. This study was an attempt to examine the sound produced by the rice moving and the milling grinder changes, the frequency of the milling sound changes with progress of milling time. The final aim in the future is to produce sound control system for the rice-milling machine. First experiment for sound monitoring of milling process was prepared by Matsuda (1986). He used abrasive type milling machine (Satake,TM05) and analyzed sound data by

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FFT and MEM .the results showed that there are some changes in the power spectrum with the time .

MATERIALS AND METHODS

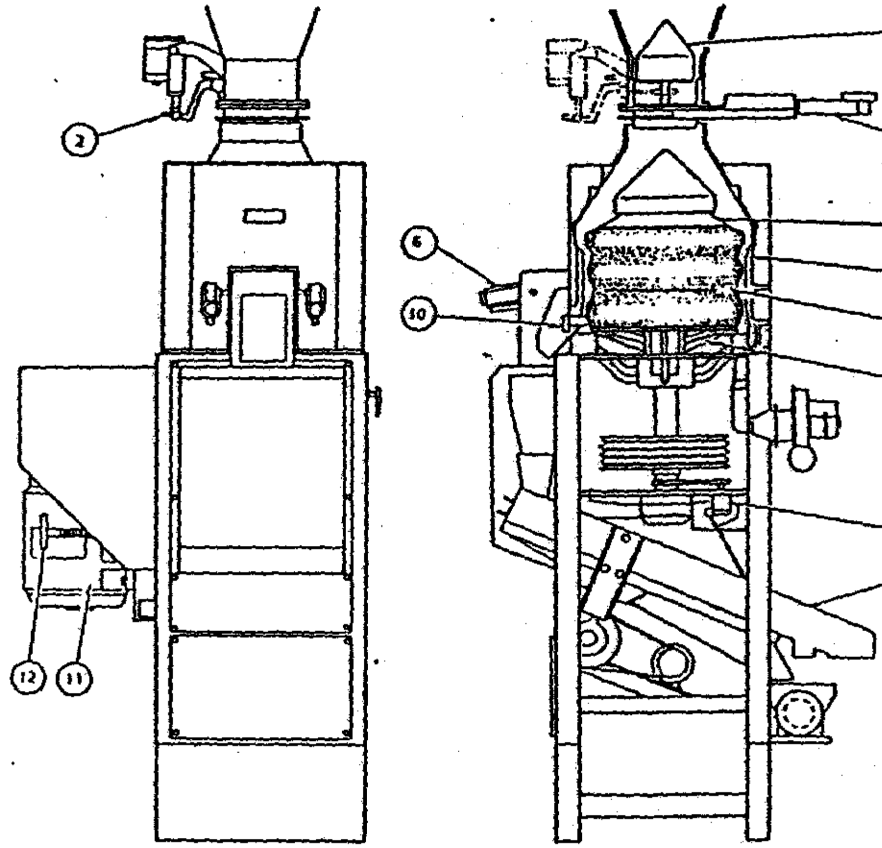
This investigation was carried out at Gekkeikan Company, Japan. The modern abrasive whitening machine model (Vertical DB-25-C) was used in this research. The machine was adjusted by control system to work about five hours. This time includes about twelve stages. Each stage was adjusted to have a percent of milling degree to reach in the end to about 70 %. During this time at the milling processes, the sound produced from the milling chamber, which has a special design, has twice the milling surface of conventional units, and also very high milling capacity in minimum of floor space. Table (1) and figure (1) showing the specification of whitening machine, rice variety (Nihonbare) short grain, brown rice having moisture content about 13.4%. The sound detected by microphone ECM66S/66SF has frequency response from 40Hz to 20 kHz, amplifier type SRP-X6004 having frequency response from 20 Hz to 20 kHz, laptop (Sony), and sound card including (A/D converter).

Table (1): Specification of whitening machine (vertical DB-25-C)

Type	DB-25-C	Revolving speed of main machine	450-900 rpm.
Required power	18.5 kw.	Diameter of abrasive roller	560 mm
Feeding mass	1800 kg.	Net mass	1100 kg

Experimental apparatus and methods

The microphone was placed in the top milling chamber machine at the distance about 1 cm. vertically from the top. Sound was recorded each 5 sec. and break for 60 sec. through five hours directly to have about 340 wave file .Software used included many programs to analyses wave. The program GRAM. Spectrogram analyzed frequency Hz. and signal level dB. The program VOLUME



1-Supply valve 2-Level handle 3-Outer cylinder 4- Pressing board 5-Abrasive roller 6-Automatic weight 7-Base disc 8-Tachometer 9-Vibration type sieve 10-Adjusting metal on discharge port 11-Motor 12-Handle 13-Feeding tank shutter

Fig. 1: Abrasive whitening machine (vertical DB-25-C).

was used for recording and converting the input signal with 16 bit accuracy at 44.1 kHz. Sampling rate. It also converted wave to ASCII file. The author to run ASCII file through (FFT) program and Fast Fourier Transform of Signals (FFT) program to get a logarithmic power spectrum up to 22 kHz modified data prepared by program. Frequency. This program have many algorithms, (FFT) size was used $N=2^{18}$ also change (FFT) size to $N=2^{13}$ in order to make 26 part. Each part calculate the mean, standard deviation and coefficient of variation for the peak frequency as modified by the author. Fig.(2) shows the flow diagram of wave data processing .The *Fourier transform*, in essence, decomposes or separates a waveform or function into sinusoids of different frequency which sum to the original waveform. It identifies or distinguishes the different frequency sinusoids and their respective amplitudes The Fourier transform of $f(t)$ is defined as basic function as follows :

$$F(s) = \int_{-\infty}^{\infty} f(t) \exp(-i\, 2\pi ts)\, dt.$$

Where $f(t)$ is function of t (time) and $F(s)$ is Fourier transform of $f(t)$

Discrete Fourier Transform DFT

Because a digital computer works only with discrete data, numerical computation of the Fourier transform of $f(t)$ requires discrete sample values of $f(t)$, which is called f_k. In addition, a computer can compute the transform $F(s)$ only at discrete values of s. That is, it can only provide discrete samples of the transform, F_r.

The *discrete Fourier transform (DFT)* is defined as

$$F_r = \sum_{k=0}^{N_{0-1}} f_k \exp(-i\, r\, {}_0 k)$$

Where Fr is *(r)* component of Fourier transform of fk

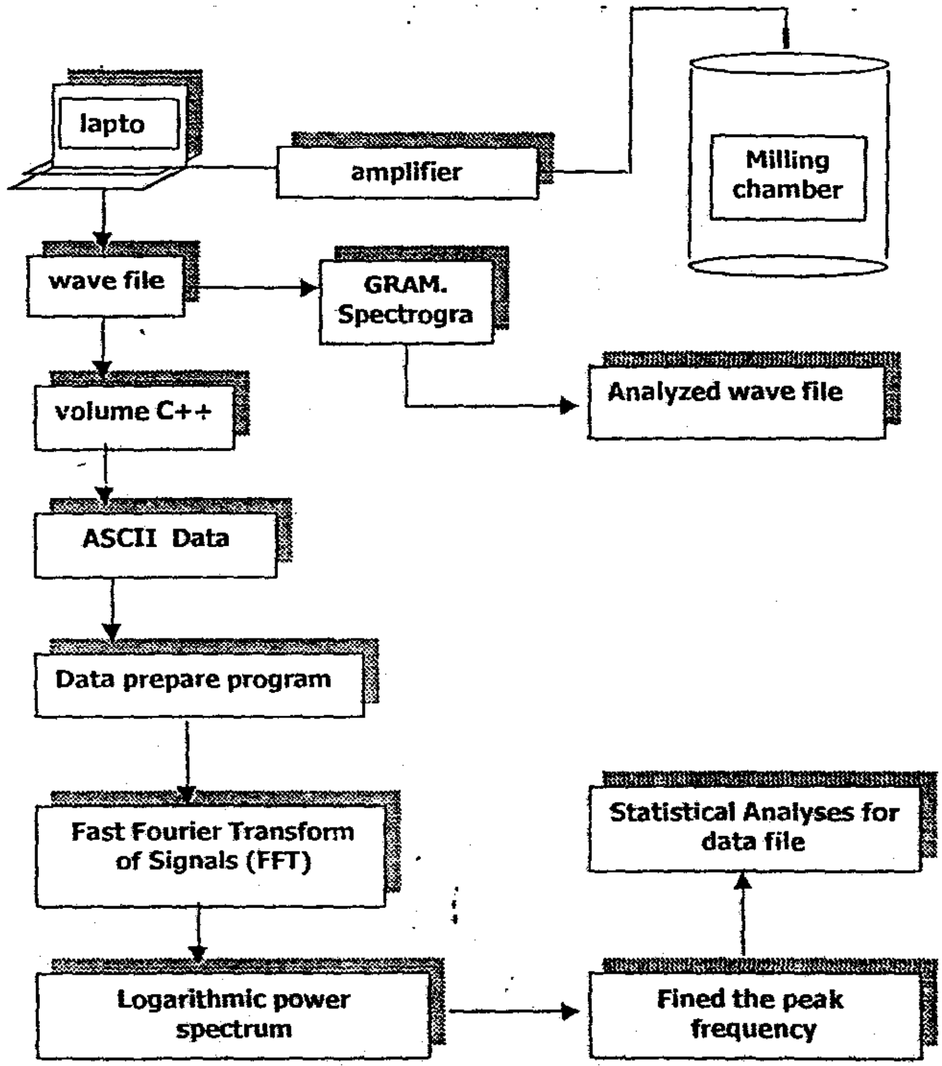


Fig.(2) :The flow diagram of wave data processing

RESULTS AND DISCUSSION

The paper mainly examines some changes in the frequency and the power spectrum during milling time, which appeared as the milling degree, rice temperatures, electrical current and amount of rice in the milling chamber. The control system was adjusted to work through twelve stages. Fig. (2.1) shows the relationship between the time and twelve milling stages. The results were analyzed statistically and are discussed as follows:

I-Wave and power spectrum analyses

Fig. (2.2) shows the frequency peak (Hz.). Distribution analyzed to determine coefficient of variation (c.v.)During milling stage. The result in the last stage (c.v.) 0.00542 became small than other stages. Also (c.v.) decreased from stage No.9 to stage No.10 from 0.314 to 0.0507 and the highest (c.v.) 0.3520 was at stage No.7

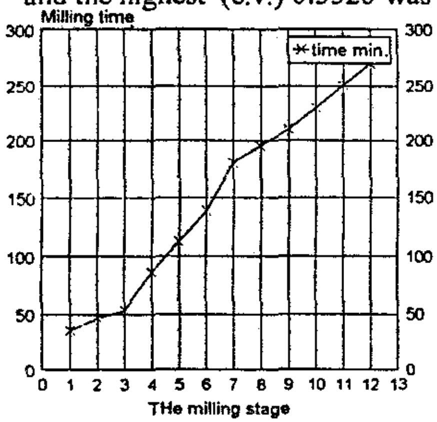


Fig. (2.1) Relationship between different milling stages and time.

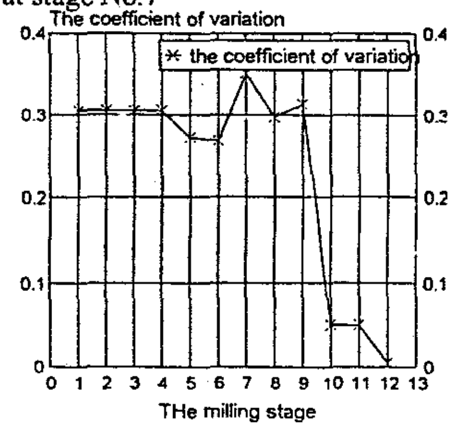


Fig. (2.2) Relationship between the coefficient of variation for frequency at different milling stag

Statistical analysis show that there is significant difference on the frequency through milling stages as recorded in table (2).

Table (2) ANOVA for the peak of frequency with milling time.

Source	SS	Df	MS	F	F 0.05
Columns	1.5E+005	2	7.502E+005	13.39	3.116
Error	4.201E+005	75	5602		
Total	5.702E+005	77			

Results in fig. (3.1) and (3.2) show amplitude as function of time through 1.49 sec. The average of reduction in the amplitude after loaded was 28.9%. It is difficult to find any differences from these sound waves shape so (FFT) program was applied for standard sine wave to get frequency information.

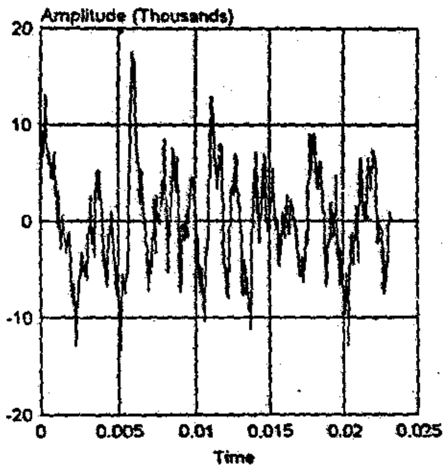


Fig. (3.1) Amplitude as function of time with no load.

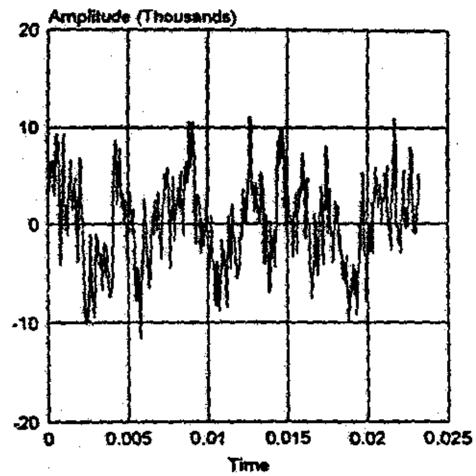


Fig. (3.2) Amplitude as function of time with load.

Fig. (4.1) and (4.2) show the power spectrum as function of frequency. From this graph we can find some peak is changed that is meant may have milling sound information. The peak decreased from 308 to 212 Hz. at no load and with load respectively

Also, the peak change at one file through 5 sec. at the FFT size was used at $N=2^{18}$ and change FFT size to $N=2^{13}$ in order to make one file to 26 part, to examine the distribution and variation for the peak through each part

Fig. (5.1) To (5.12) show the power spectrum density (P.S.D) as function of frequency through the milling stages .The obtained data show that the distribution of peak with FFT size was $N=2^{13}$, for one part from file for 0.5 sec. The peak increased from 212 to 403 Hz. at stage No.1 and stage No.4. The results showed also that there are no changes at the peak through stage No.4 to stage No.6.

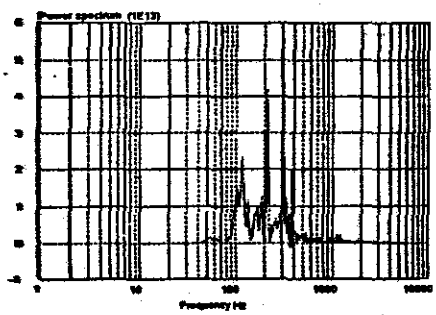


Fig. (4.1) showed the power spectrum as function of frequency with no load

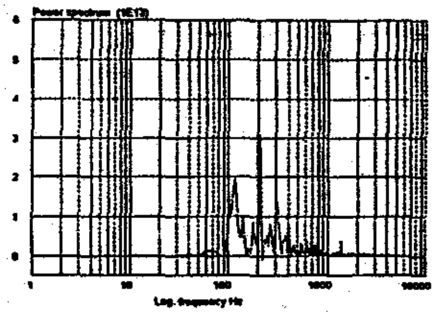


Fig. (4.2) showed the power spectrum as function of frequency with load

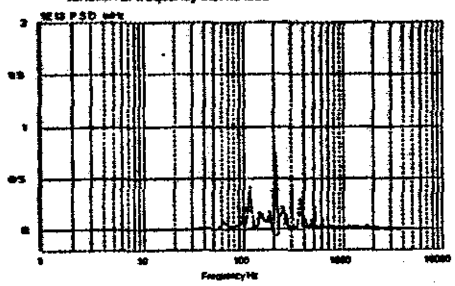


Fig. (5.1) showed the power spectrum density as function of frequency stage no. 1

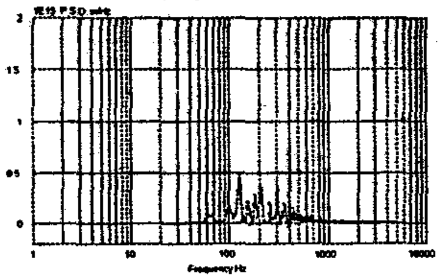


Fig. (5.2) showed the power spectrum density as function of frequency stage no. 2

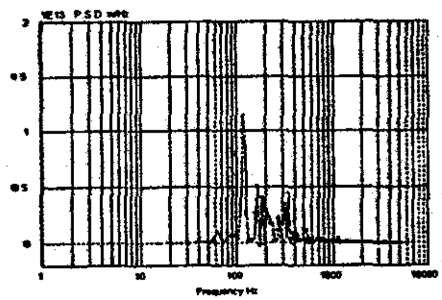


Fig. (5.3) showed the power spectrum density as function of frequency stage no. 3

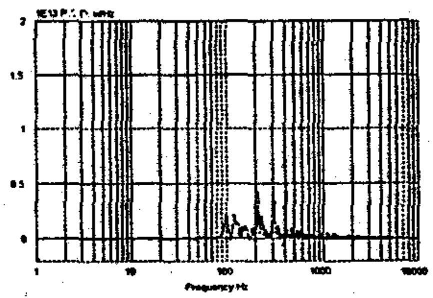


Fig. (5.4) showed the power spectrum density as function of frequency stage no. 4

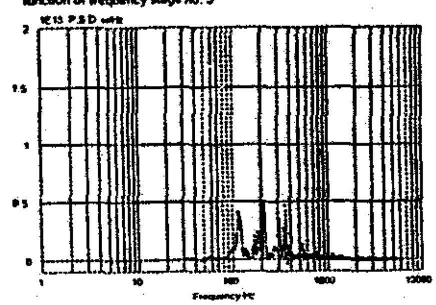


Fig. (5.5) showed the power spectrum density as function of frequency stage no. 5

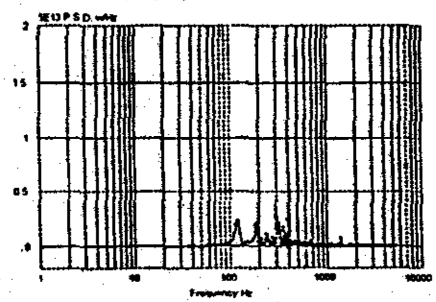


Fig. (5.6) showed the power spectrum density as function of frequency stage no.6

Meanwhile the peak frequency decreased from 403 to 168 Hz stage No.7 to stage No.9. At the stage No.10, the peak frequency increased to reach to 318 Hz at the stage No. 12. On the other hand, the power spectrum density changed from 7.48 e^{+12}, 8.52 e^{+12} and 1.89 e^{+13} w/Hz. At stage No.1, stage No. 9 and stage No. 12 respectively.

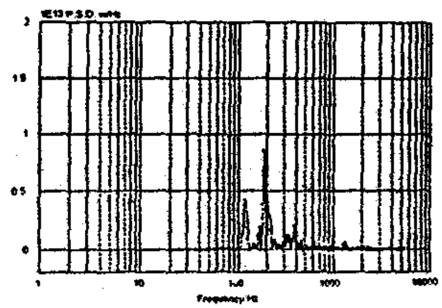


Fig. (5.7) showed the power spectrum density as function of frequency stage no.7

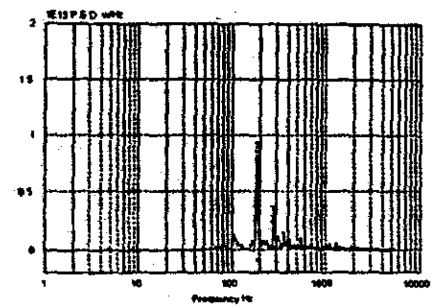


Fig. (5.8) showed the power spectrum density as function of frequency stage no.8

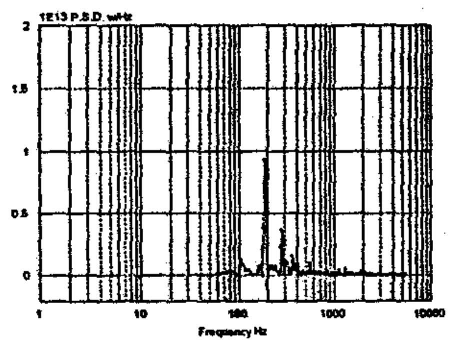


Fig. (5.9) showed the power spectrum density as function of frequency stage no.9

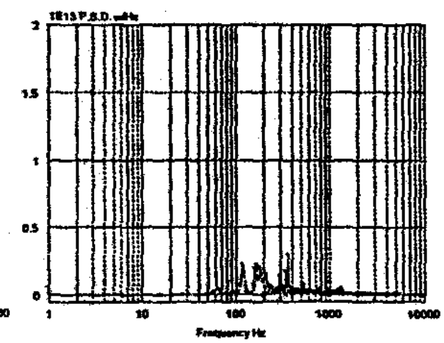


Fig. (5.10) showed the power spectrum density as function of frequency stage no.10

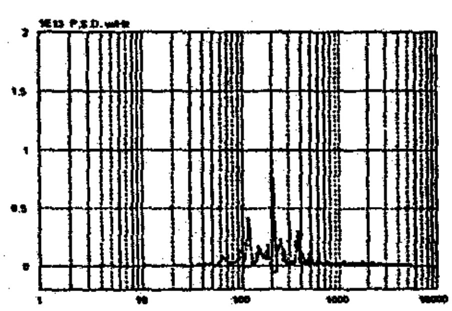


Fig. (5.11) showed the power spectrum density as function of frequency stage no.11.

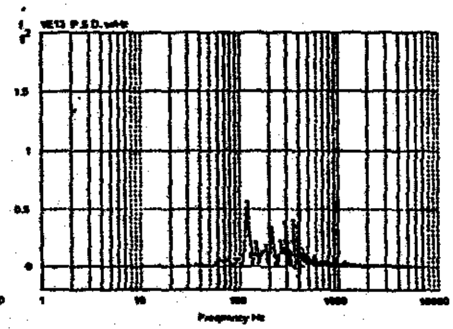


Fig. (5.12) showed the power spectrum density as function of frequency stage no.12

II - Wave, power spectrum and whitening characteristics

The first step tested machine in two cases. Table (3) showed the peak changed form 191 Hz with start point to 243 Hz after loaded

Table (3) the machine test from the start, and at full load

Time min.	State	F peak Hz	RPM	Milling degree %	Power spectrum w	Feeding mass kg	Temp. c°
1.16	Start	191	500	100	3.25E+13	152	20
35.4	Stage1	243	622	98	8.07E+12	1800	20

Results in figs. (6.1) to (8.2) show that increasing the milling time from 35.4 (stage No. 1), 138.73 (stage No. 6) and 269.88 min. (stage No. 12) decreased the milling degree from 98.00, 82.00 and 75.00 % respectively, as machine motor speed decreased from 622, 621, and 527 R.P.M. Amount of rice in milling chamber varied from 1800, 1459, and 1345 kg. and vice versa was noticed with the temperature increase from 20, 40 to 44 c°. ,while the average of increasing in power spectrum was 42.7%. Also frequency changed from 243 to 386 and 320 Hz

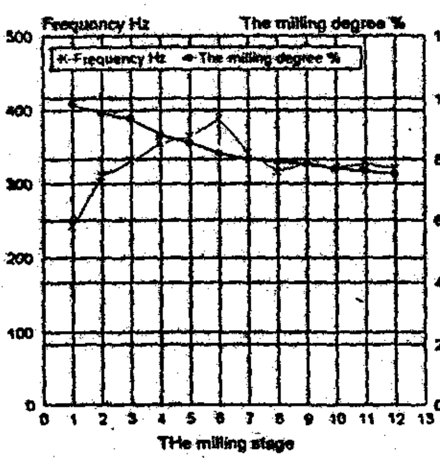


Fig. (6.1) Effect of milling degree(%) on the frequency (Hz) at different milling stages.

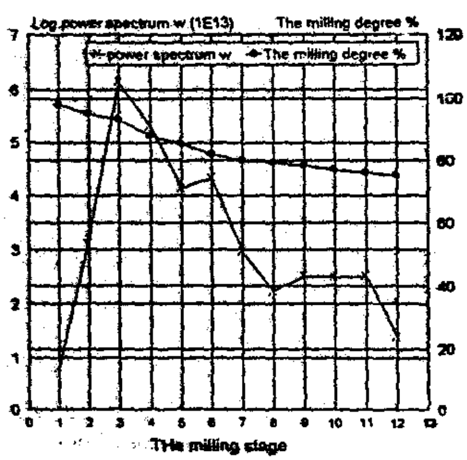


Fig. (6.2) Effect of milling degree(%) on power spectrum (w) at different milling stages.

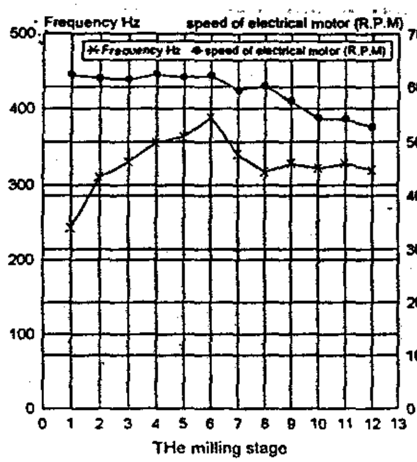


Fig. (7.1) Effect of speed of electrical motor (R.P.M) on the frequency (Hz)at different milling stages.

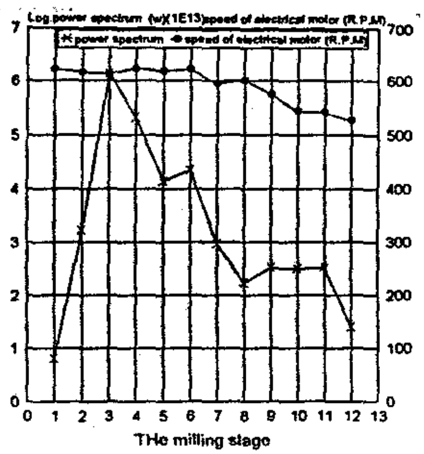


Fig. (7.2) Effect of speed of electrical motor (R.P.M) on the power spectrum (w)at different milling stages.

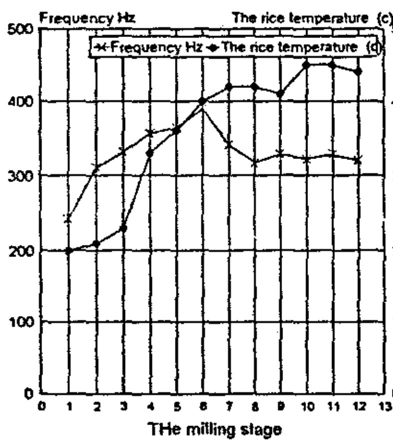


Fig. (8.1) Effect of rice temperature (c) on the frequency (Hz) at different milling stage

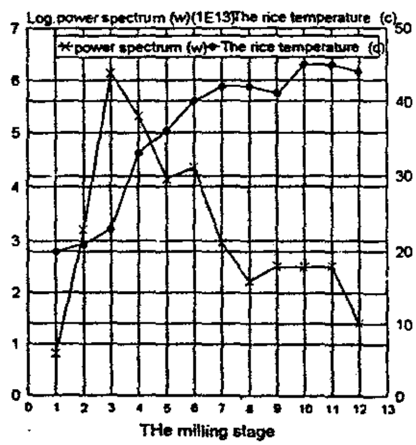


Fig. (8.2) Effect of rice temperature (c) on the power spectrum (w) at different milling stage

CONCLUSION

Whitening was performed in order to remove the bran in twelve stages was under control system to keep the decreasing in milling degree with sound analyses through the milling stages

We tested monitoring of rice milling process by the machine sound, which have much information about the status. Results show that there are significant differences in the round frequency through milling stage.

Referring to the effect of twice abrasive milling surface on the whitening performance and sound analyses through the milling time, result show that the milling degree decreased as milling time increased, and vice versa was noticed with the temperature, while the frequency and power spectrum, change from one stage to twelve stages.

This study is considered the first step to make sound control system for the rice milling machine

We recommend more research in the sound analysis of rice milling process to have more information to describe orientation of milling peaks.

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التحليل الصوتي لعمليات ضرب الأرز

طارق فوده*

هذا البحث يقوم باختبار الصوت الناتج من عملية تبيض الأرز ودراسة العلاقة بينه و بين عوامل التشغيل المختلفة باستخدام آله تبييض الأرز يابانية الصنع مود يل Vertical DB-25-C وصنف الأرز المستخدم Nihonbar . يتم التحكم في آلة التبييض بواسطة نظام يعتمد علي أستخدم الوزن كأساس للتحكم في نسبة التبييض لتصل إلـي 70% من خلال 12 مرحلة يتم ضبطها لكي تستغرق زمنا يتراوح من 5 إلى 6 ساعات.

تم قياس الصوت الناتج من عملية التبييض على مدار 21780 ثانية بواسطة ميكروفون دقيق مود يل ECM66S/66SF تم تسجيل SRP-X6004 متصل بمكبر للصوت مود يل. تم تحليل (Sony) laptop محمل على VOLUME C++ الصوت بواسطة برنامج Pentium IIII (P.C, يتم من خلالها الصوت بواسطة مجموعه من البرامج محملة على(wave file ASCII data إلى صور تحويل ملفات الصوت, ثم يتم أعداد هذه البيانات إلى صور FFT program صالحه لأجراء peak of frequency. للحصول على أعلى قيمه للتردد

وقد اشتملت الدراسة على المتغيرات التالية : درجة التبييض و درجة الحرارة داخل غرفة التبييض معدل التلقيم داخل غرفة التبييض وسرعة عمود التبييض على التردد و قدرة طيف الموجات الصوتية

أظهرت النتائج أن التردد أختلف أتختلف اختلافا معنويا خلال مراحل التبييض المختلفة أظهرت النتائج أيضا أن هناك تأثير من كل من درجة التبييض و درجة الحرارة داخل غرفة التبييض وسرعة عمود التبييض على التردد و قدرة طيف الموجات الصوتية.

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