EFFECT OF SOME OPERATIONAL FACTORS ON THE EFFICIENCY OF WHEAT MILLING PROCESSES

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ABSTRACT: The present study was conducted to evaluate the performance of milling process under different operational factors including feed rate, inclination angle of sieves and air suction for cleaning and feed rate and roll clearance for milling process.

The obtained data showed that the proper conditions which gave high cleaning efficiency were 12 Mg/h feed rate, 12^0 inclination angle and 1kPa air suction, while milling process was efficient under feed rate of 9 Mg/h and roll clearance of 1.95mm for first break, 1.50mm for second break, 0.80 mm for third break, 0.75mm for fourth break and 1mm for fifth break.

Key words: Wheat milling, feed rate, inclination angle, air suction, roll clearance, break release

INTRODUCTION

Wheat is one of the most adaptable of plants and is grown in many parts of the world. Its wide range of cultivation, both as regards latitude and elevation, is probably greater than that of any other crop. Wheat is nutritionally valuable and because it can be grown under so great a variety of conditions, it has become one of the major staple foods for man. In Egypt, the cultivated area is in the range of 1.6 million fed., producing 2.67 Mg/fed. The academic and applied researches indicated that high flour quality affected by the wheat characteristics and the performance of the milling system industry machines. The wheat milling process is many thousands years old and has steadily changed from simple grinding to complex industry it is today.

The flour milling process including reception and storage of wheat, cleaning and preparing wheat for milling, milling the wheat, and packing and storage of the finished products.

The performance of milling process depends on different factors including physical properties and operational factors:

Mohsenin (1970) mentioned that the physical properties of the materials such as size, volume, shape and surface area are important in many problems associated with design of specific machine, analysis of the behavior of the product in handling of the material, and stress distribution in the material under load. Accurate estimates of the frontal area and the related diameter are essential for the determination of terminal velocity, drag coefficient and Reynolds number.

Berlage *et al.* (1984) stated that the seed crops contain assorted contaminants when harvested. This include weed seeds, unwanted crop seeds, broken plant parts, fungal bodies, and soil particles. The function of seed conditioning or seed cleaning operations is to remove or reduce these contaminants to a level that meets industry – wide purity standards. Machines that take advantage of various physical property differences that occur between crop seed and their contaminants typically remove contaminants. Commonly used properties are length, width, thickness, shape, density, and terminal velocity.

Matouk *et al.* (1985) reported that in roller mills wheat grain pass through break rollers and the pass through many pathways plus the plan sifter and purifiers. In order to get the flour at the extraction rate of 87.5% or higher, the millers have to recombine the throughout of the different passages of the plan sifters to obtain the required amount of flour.

Kozmin (1988) classified the types of milling equipment as cutting machines; pressing (crushing) machines, and machines acting by free impact, milling equipment may depends upon one or a combination of two or more of these types.

Gorial and O'callaghan (1991) said that separation of mixture of particles in a vertical air stream is only possible when the aerodynamic characteristics of the particles are so different that the light particles are entrained in the air stream and the heavy particles fall through it. Threshed crop material contains grains together with contaminants such as straw, chaff threshed heads, and weeds, each of the materials spans arrange of aerodynamic priorities.

Seki *et al.* (1995) found that milling tests were performed for a gradual reduction mill at three levels of grain moisture content and three set roll-gaps. The effects of milling conditions and input product condition on the streams after milling were investigated by multivariate analysis. The results clarified the significant relationship between each milling condition and output production condition. It is shown that it is possible to calculate output product condition by using the milling condition parameters.

Fang and Campbell (2003) stated that the extended breakage functions were used to predict milling of unseparated feed samples at different roll gaps and moisture contents. In addition, mixtures of hard wheat at 14% moisture and soft wheat at 20% moisture mixed in different proportions, were milled and the resulting particle size distributions compared with predictions. Excellent predictions were obtained in all cases. This confirms the independent breakage of kernels during first break milling, and demonstrates the potential of the breakage function approach for interpreting single kernel data in terms of predictions of milling performance.

This study aimed to

1. Choose the proper conditions to operate milling technique.
2. Obtain high-grade flour production.
3. Minimize total flour loss during milling process.
4. Optimize machines variables for cleaning and milling processes.

MATERIALS AND METHODS

The experiments were carried out at El–Mona wheat mill in Abo-Hammad, Sharkia Governorate during the summer season of 2003.

Materials

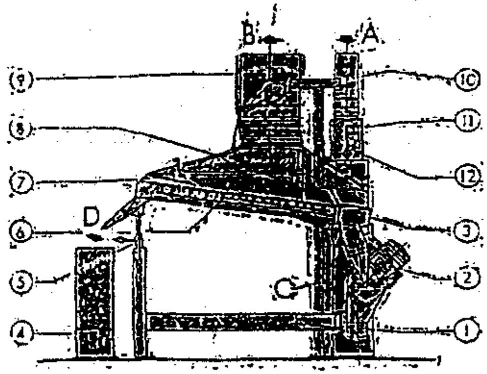
The experiments were conducted using wheat grains (Sakha 69-variety) which was cleaned using Satake dry stoner and milled by Simon milling machine

Satake dry stoner (cleaning system)

Dry stoner is used to separate impurities which are very similar in size and shape to wheat but differ in weight , such as stones, mudballs, pieces of metal other than iron, glass, concentrating ergot, with the specifications as shown in Fig. 1.

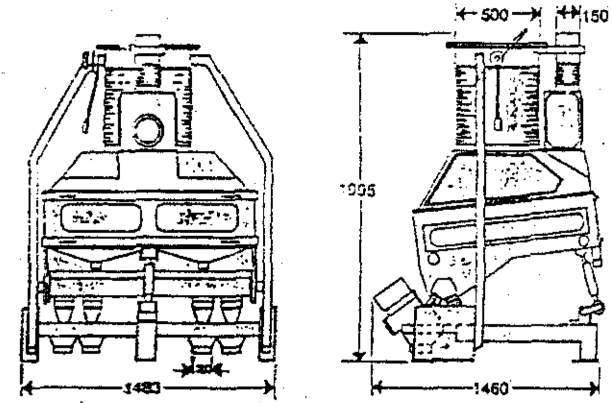
Simon milling machine (milling system)

The machine described and illustrated in Fig. 2 is the Simon type H four – roller mill. Like all four –roller mills, it is really two separate two- roller mills placed back to back in the same frame; each half is fed and driven independently and can; if required, be used for entirely different purposes.



A- Feed inlet
B- Exhaust
C- Product discharge
D- Stone discharge

Part No.	Name	Part No.	Name
1	Support structure	7	Stone removal adjustment
2	Vibrator motors	8	Exhaust hood
3	Oscillating deck	9	Manometer
4	Stone container	10	Butterfly valve
5	Working deck angle adjustment	11	Feed control device
6	Working deck	12	Spring setting for air-tight operation

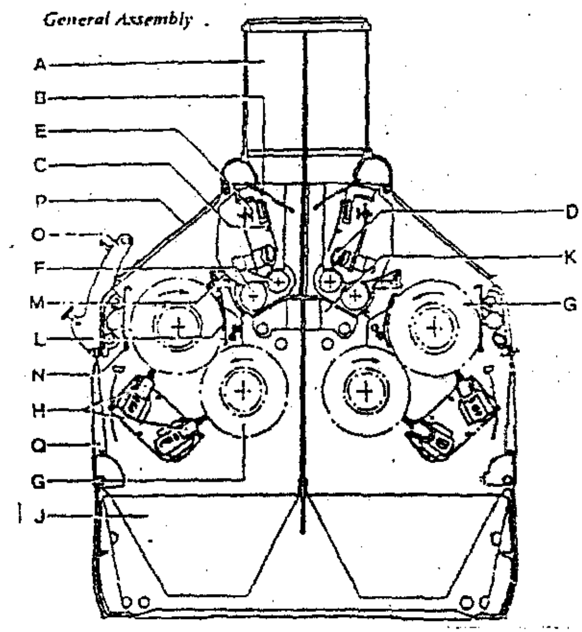


Elevation Side View

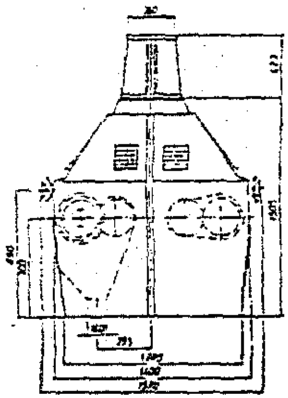
Model	A1600
Capacity, Mg/h	12-20, Mg/h
No. of motors	2
Motor power kW	5, kW
Motor speed, rpm	1000, rpm

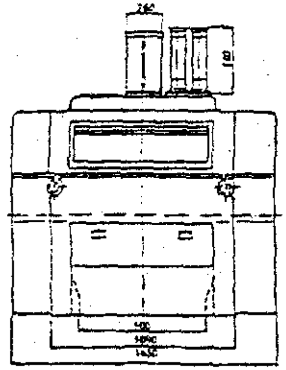
Dims. in mm.

Fig.1. Dry stoner.



Part Symbol	Name	Part Symbol	Name
A	Feed inlet	J	Hopper
B	Feed plate and pivot bar	K	Centre stretcher assembly
C	Guard plate	L	Roll guard assembly
D	Feed gate	M	Finger guard assembly
E	Tappet feed rolls	N	Top roll guard
F	Double feed rolls	O	Throw-out lever
G	Fluted main rolls	P	Top inspection door
H	Roll cleaning brushes	Q	Bottom inspection door


Side View


Elevation

Roll length, mm	800. mm
Roll Diameter, mm	250, mm
Drive pulley diameter, mm	350. mm
Drive pulley width, mm	140, mm
Speed Max, rpm	650. rpm
Mass, kg	2800. kg

Dims. in mm.

Fig.2. Simon milling machine.

Sieves

To conduct the sieving process, it used different sieves with various meshes (grooves diameters) have certain numbers confirm each stage of break stages as follows:

Number of break stage	Sieve mesh, μ
First break (B1)	1050
Second break (B2)	1050
Third break (B3)	950
Fourth break (B4)	300
Fifth break (B5)	350

Methods

To choose the proper conditions which have high efficiency of cleaning and milling processes, the following experiments were conducted.

Cleaning stage

The first experiment was carried out to evaluate the performance of dry stoner cleaner under three levels of air suction named (1, 1.26 and 1.52kPa), three feed rates of (12, 14 and 16 Mg/h) and three sieves inclination angles are (10, 12 and 14 degree).

The performance of cleaner was calculated using the equation as follows:

$$CE = \frac{Mt-Mi}{Mt} X 100 ,\%$$

Where: CE - the cleaning efficiency,%; Mt- total mass of wheat sample, g. and Mi-mass of impurities such as stone and dust, g.

Milling stage

The second experiment was run to evaluate the effect of feed rate and roll clearance on efficiency of milling process using Simon milling machine on break system which include five stages.

Tests were conducted using three levels of feed rates (8,9 and 10Mg/h) under three roll clearances for each stage of break stages as follows:

First break (B1) (1.65, 1.95 and 2.25mm),

Second break (B2) (1.20, 1.50 and 1.80mm),

Third break (B3) (0.50, 0.80 and 1.10 mm),

Fourth break (B4) (0.45, 0.75 and 1.05mm) and

Fifth break (B5) (0.70, 1.00 and 1.30mm).

Efficiency based on the percentages of pass P and break release Br through the different sieve sizes for various stages of milling and compared them with the optimum values for each stage.

The optimum values for each stage are as follows

Number of break stage	P ,%	Br ,%
B1	30	70
B2	50	50
B3	55	45
B4	20	80
B5	30	70

RESULTS AND DISCUSSION

The obtained results were discussed as follows:

Effect of Some Factors on Cleaning Efficiency

Inclination angle

Results were shown in Fig. 3 cleared that the highest values of cleaning efficiency were obtained under inclination angle of 12° compared to the other angles, these values were 99.46, 99.35 and 98.8% in case of feed rate of 12 Mg/h, while they were 99.38, 99.2 and 98.7% and 99.35 , 99.17 and 98.5% under feed rates of 14 and 16 Mg/h under air suction of 1,1.26 and 1.52 kPa, respectively.

Feed rate

From Fig. 4, it can be noticed that the increase of feed rate from 12 to 16 Mg/h followed with a reduction in the cleaning efficiency under different inclination angles of 10, 12 and 14° and air suctions of 1, 1.26 and 1.52kPa. This is may be due to that the use of little amount of grains gives a good chance to the cleaning device for working with more efficiency and increase its ability of cleaning.

Air suction

The results in Fig. 5 cleared that the increase of air suction was accompanied with a decrease in the cleaning efficiency, whereas, the highest values of cleaning efficiency were obtained in the case of using air suction of 1kPa compared to the others, these values which obtained under inclination angles of 10, 12 and 14°, respectively, were 99.2, 99.46 and 99.35% under feed rate of 12 Mg/h, 99.1, 99.38 and 98.97% under feed rate of 14 Mg/h and 98.8, 99.35 and 98.75% under feed rate of 16 Mg/h.

Effect of Feed Rate and Roll Clearance on Milling Process

Efficiency of milling process based on the percentages of pass P and break release Br through the different sieve sizes for various stages of milling and compared them with the optimum values for each stage.

Feed rate

The effect of different feed rates of 8, 9 and 10 Mg/h on the milling efficiency expressed by percentages of pass and break

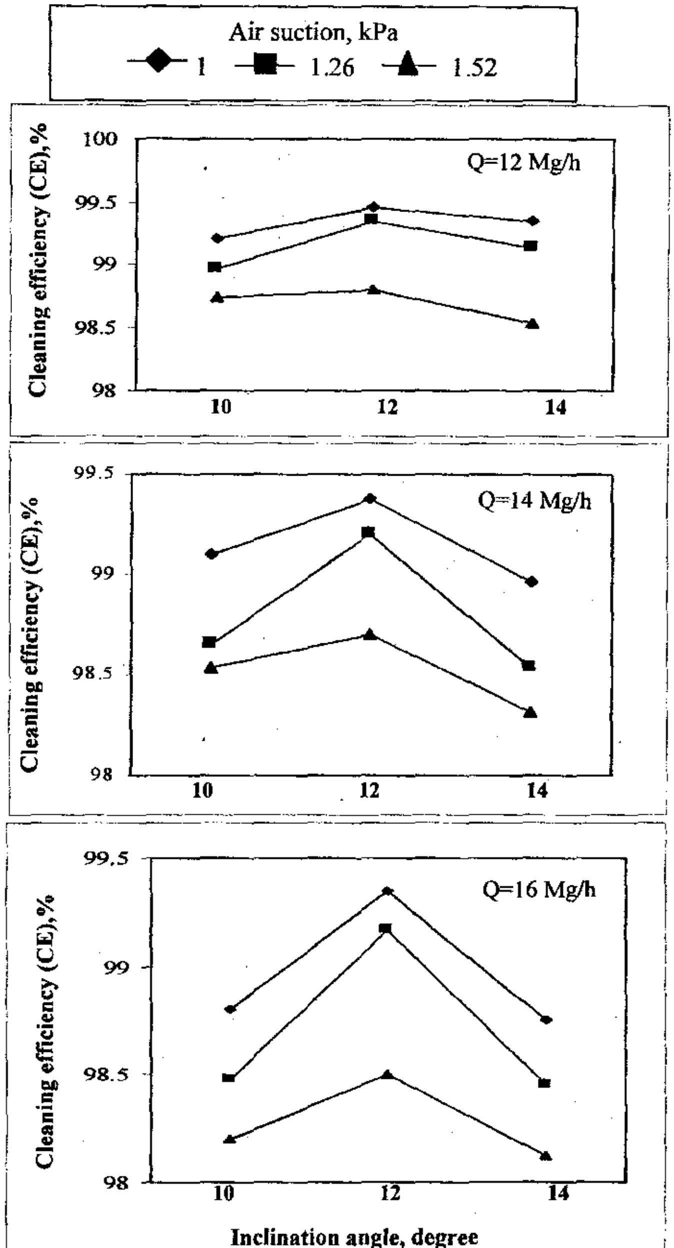


Fig. 3. The effect of inclination angle on cleaning efficiency under different air suctions.

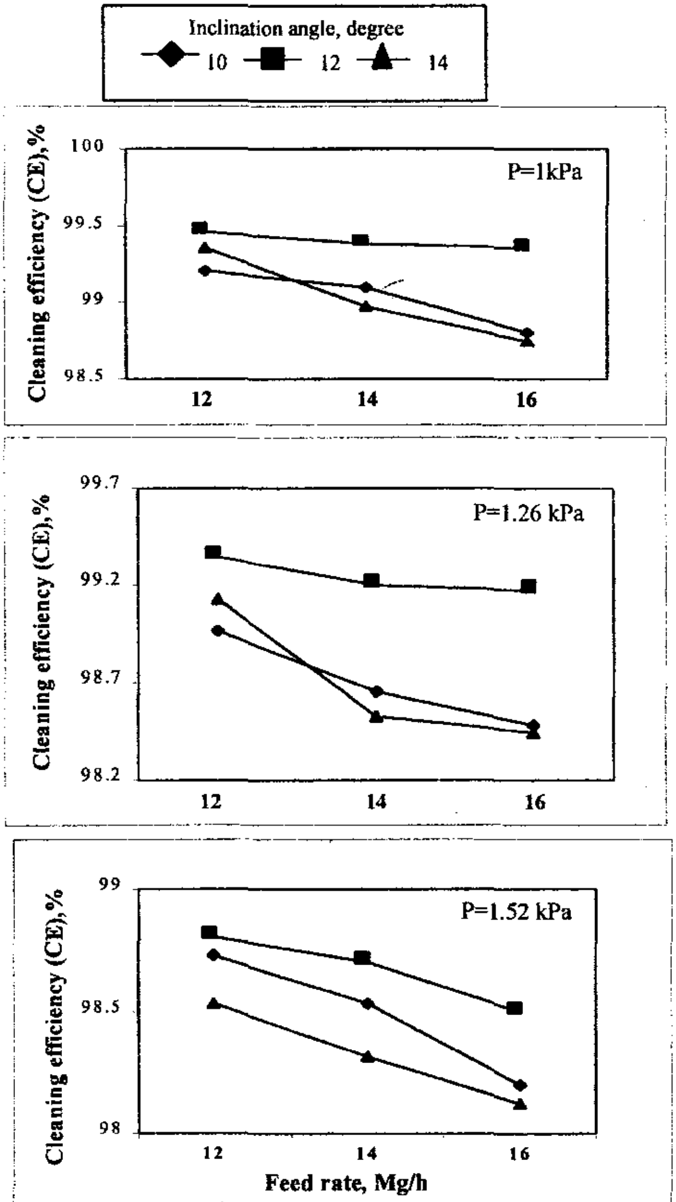


Fig. 4. The effect of feed rate on cleaning efficiency under different inclination angles.

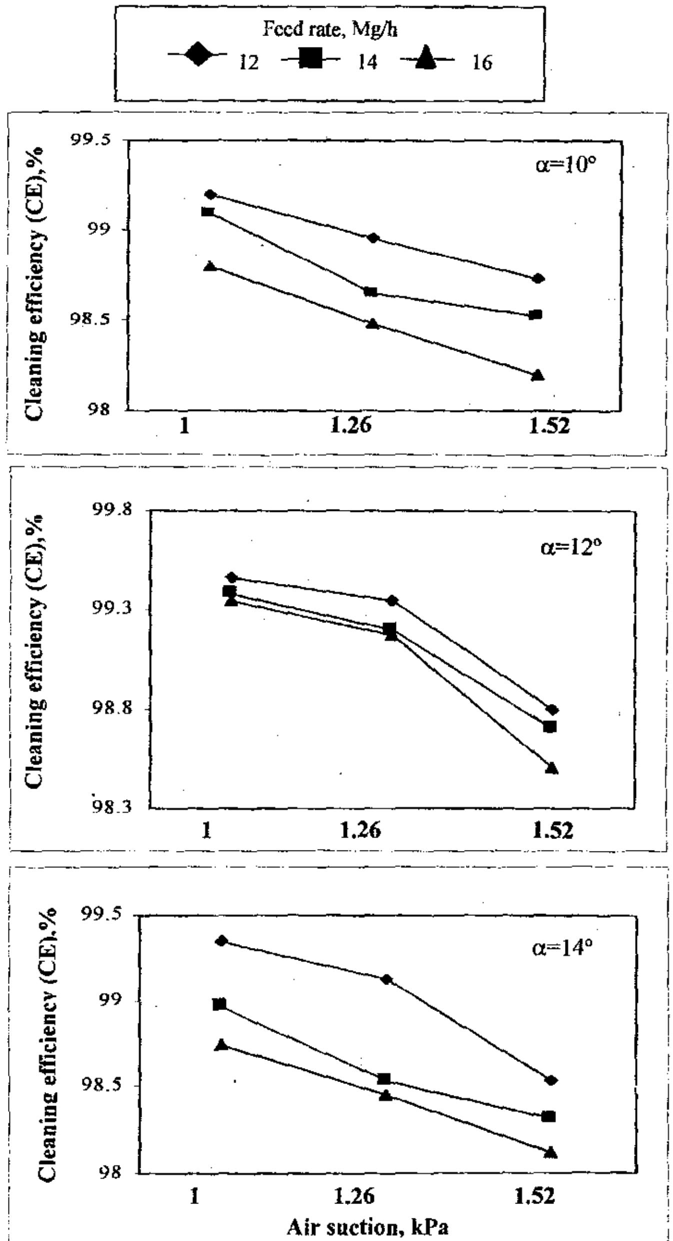


Fig. 5. The effect of air suction on cleaning efficiency under different feed rates.

release and different roll clearances was showed in Figs 6 and 7 for various stages.

It is noticed that under the mentioned feeding rates for first stage, the values of pass percentages P and break release percentages Br were 37, 25 and 31% and 63, 75 and 69% respectively under roll clearance of 1.95 mm.

By comparing these results with optimum value of P 30% and Br 70%, it can be observed that the use of feed rate of 9 Mg/h gives the best milling efficiency.

For second stage with optimum pass and break release of 50% and 50%, the nearest value to the mentioned percentages were obtained in the case of using feed rate of 9 Mg/h under the roll clearance of 1.2, 1.5 and 1.8mm.

The same trend was recorded for the third stage with optimum P and Br of 45% and 55%, respectively, with feed rate of 9 Mg/h.

For fourth stage with standard P of 80% and Br of 20%, the proper values for both of p and Br were recorded in the case of feed rate of 9 Mg/h, these values were 22, 21 and 10% for p and 78, 79 and 90% for Br under the roll clearances of 0.45, 0.75 and 1.05mm.

For fifth stage the use of feed rate of 8 Mg/h gave values were the nearest of pass and break release percentages comparing to the standard values of 30% for P and 7% for Br for fifth stage.

Roll clearance

The effect of roll clearance in the milling efficiency was studied through the different stages of milling as shown in Figs 8 and 9.

For first stage and comparing to the standard p and Br, the proper values were obtained under roll clearance of 1.95 mm in comparison of the others 1.65 and 2.25 mm under feed rates of 8, 9 and 10 Mg/h.

The values of P were 53, 52 and 57% and Br of 47, 48 and 43% were obtained under roll clearance of 1.50mm for second stage, these values represented the nearest ones to the standards values .

For third stage, the nearest values of P and Br compared to the standard ones were recorded under clearance of 0.80mm.

For fourth stage, the proper values for both of P and Br were recorded in the case of roll clearance of 0.75mm.

At last for fifth stage, it can be observed that the use of roll clearance of 1.00 mm gives the best milling efficiency compared to the others.

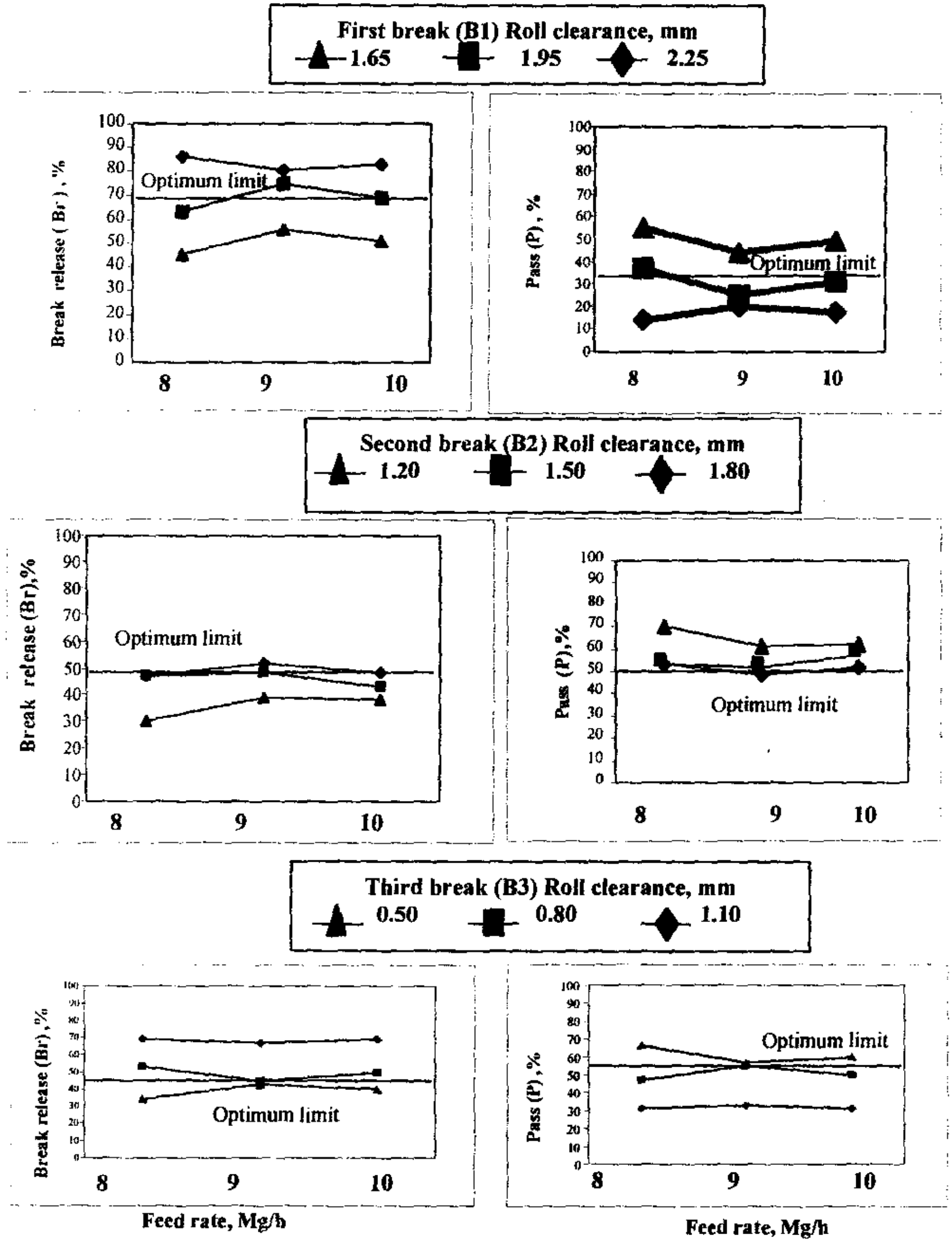


Fig. 6. The effect of feed rate on milling process performance under different roll clearances of breaks.

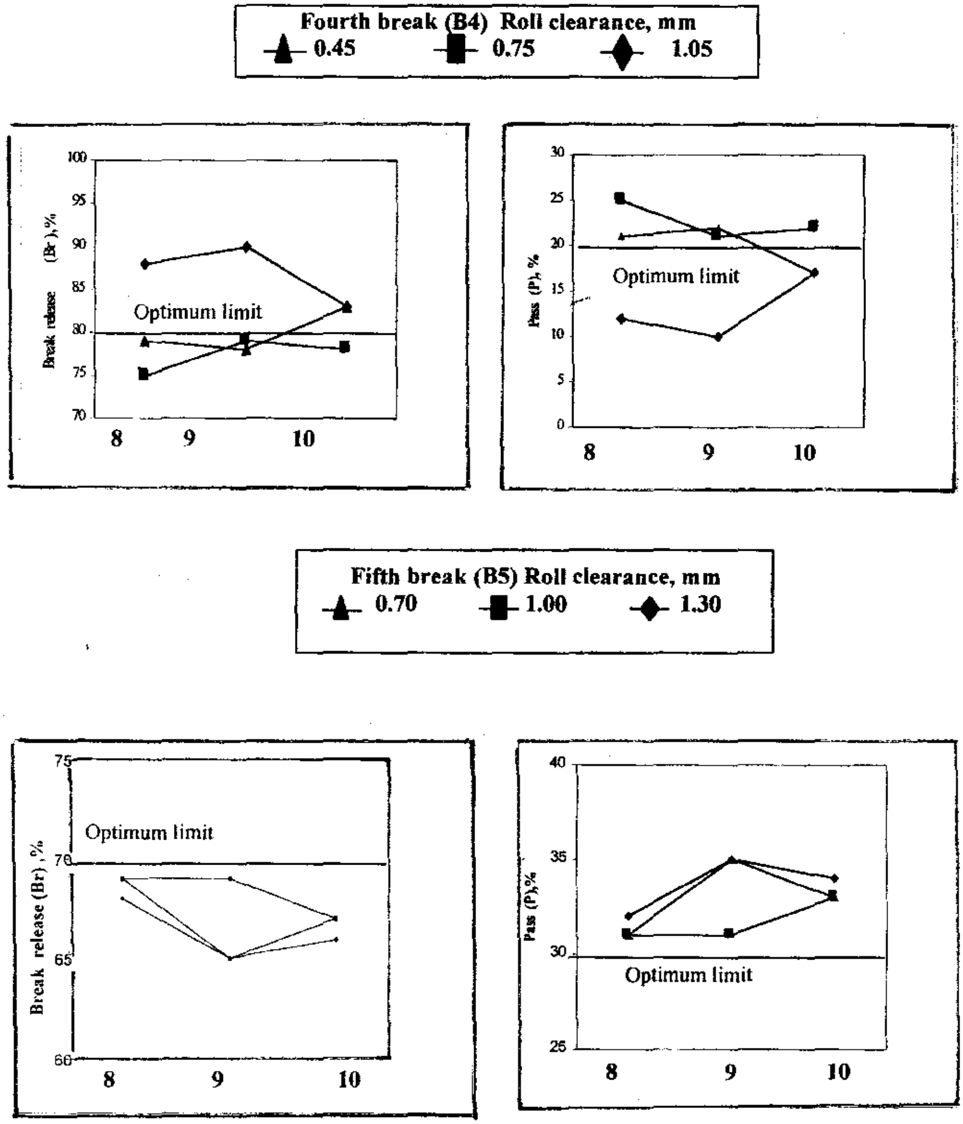


Fig. 7. The effect of feed rate on milling process performance under different roll clearances of breaks.

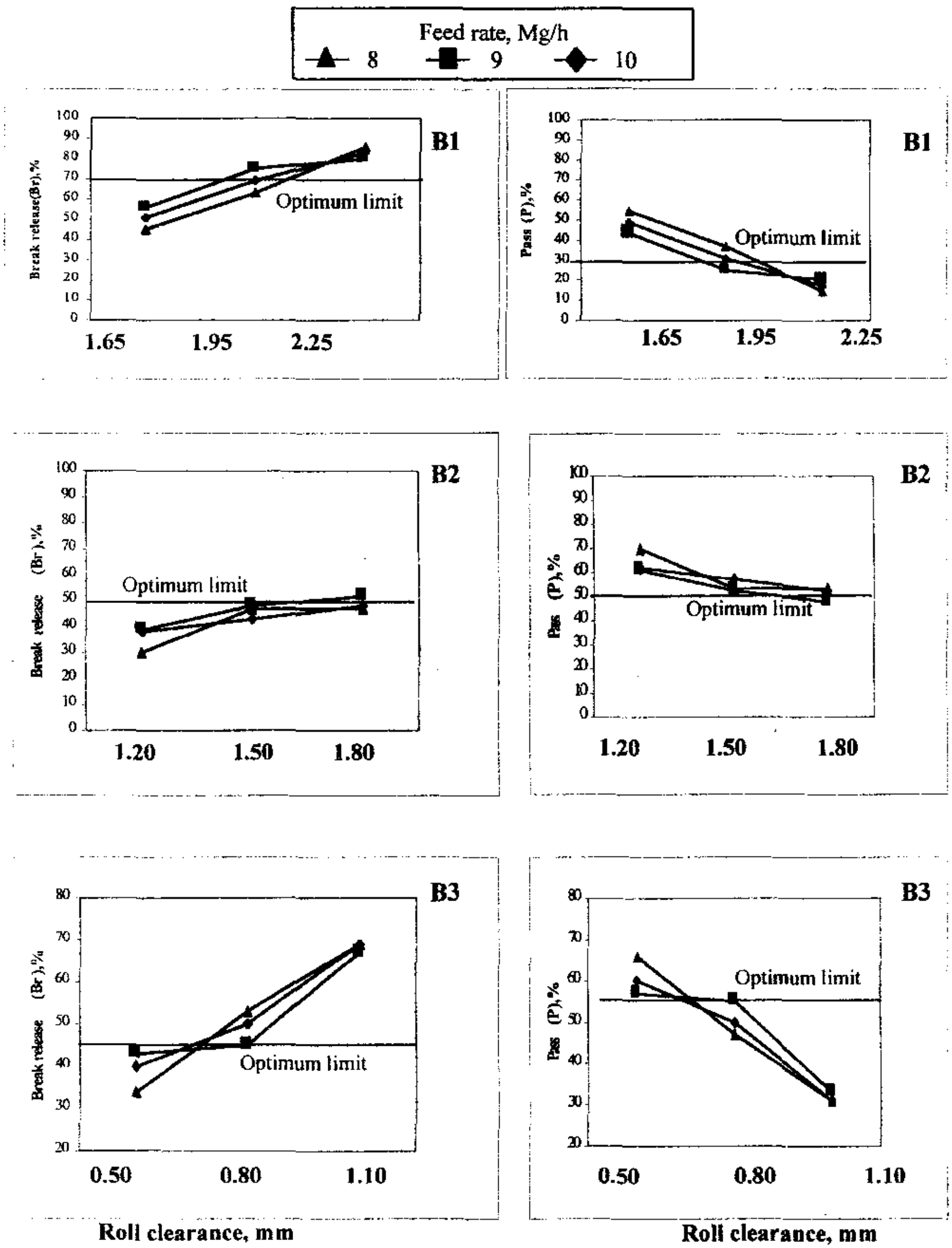


Fig. 8. The effect of roll clearance on milling process performance under different feed rates of breaks.

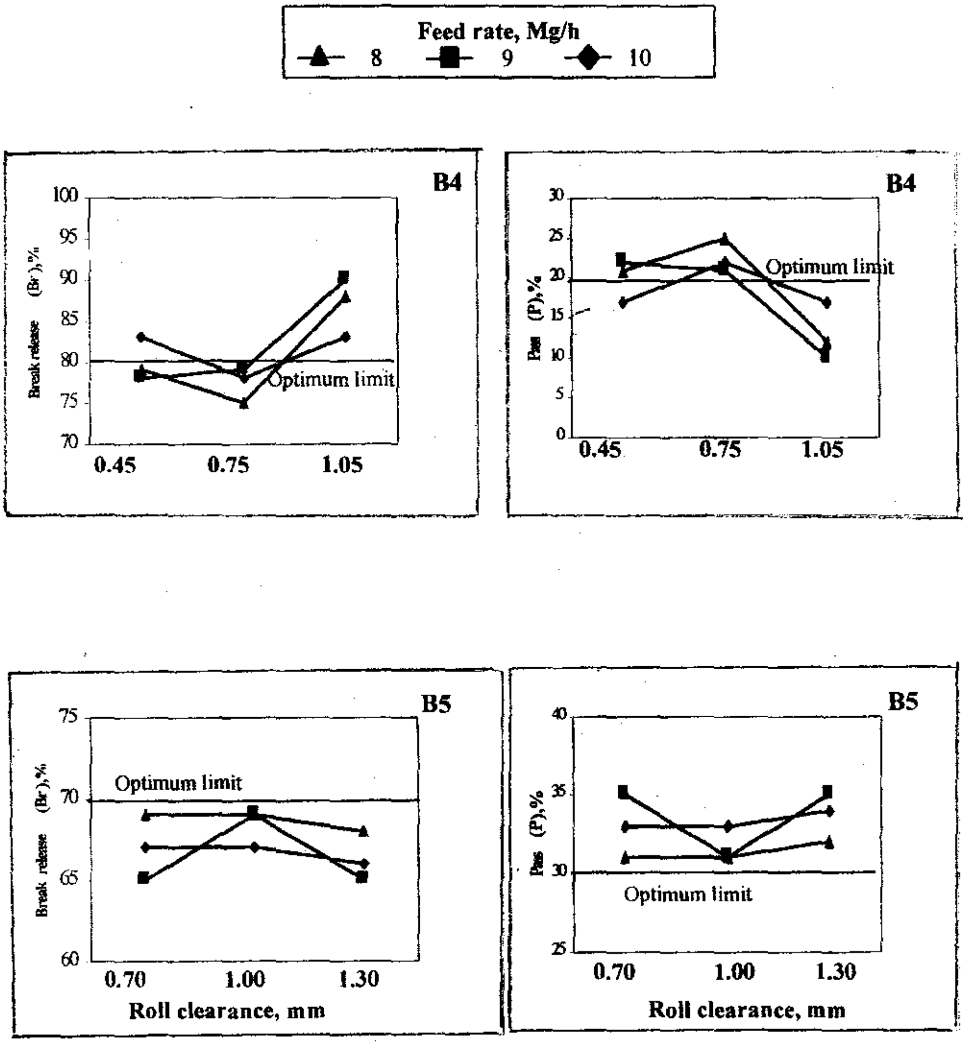


Fig. 9. The effect of roll clearance on milling process performance under different feed rates of breaks.

CONCLUSION

From the conducted experiments and the obtained results, it can be concluded that:

The cleaning system can be operated more efficient in the case of adjusting the sieves under inclination angle of 12°, use of air suction of 1 kPa, and feeding the wheat grains with rate of 12 Mg/h.

Wheat milling efficiency can be improved by using feed rate of 9 Mg/h for all stages and adjusting the clearances between the rolls at 1.95, 1.50, 0.80, 0.75 and 1mm for 1st, 2nd, 3rd, 4th and 5th stage, respectively.

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تأثير بعض عوامل التشغيل على كفاءة عمليات طحن القمح

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اجرى هذا البحث فى مطحن المنى بمحافظة الشرقية وذلك لتقييم اداؤه فى عملية طحن القمح تحت ظروف تشغيل مختلفة بغرض تحديد انسب ظروف يمكن من خلالها الوصول الى أعلى كفاءة تشغيل لكل من منظومة التنظيف والطحن فى المطحن. وقد شملت عوامل الدراسة كل من زاوية ميل الغرابيل وضغط الهواء ومعدل التلقيم وذلك فى مرحلة التنظيف وتم حساب كفاءة التنظيف بغرض تحديد أعلى كفاءة. كما تمت عملية الطحن تحت قيم مختلفة لكل من معدل التلقيم والخلوص بين الدرافيل بغرض اختيار أنسبها والذى يضمن أعلى جودة للطحن. وقد تم التقييم على أساس المقارنة بقيم قياسية لكل من الطرد والمرور خلال مراحل الطحن المختلفة.

ومن النتائج التى تم الحصول عليها يمكن القول بأن:

- عملية التنظيف يمكن ان تتم بكفاءة عالية اذا ما تم ضبط الغرابيل عند زاوية ١٢° وضغط الهواء عند ١ كيلوباسكال والتلقيم بمعدل ١٢ ميجا جرام/ساعة
- أما بالنسبة لعملية الطحن ومن خلال المراحل (الطحنات) المختلفة فإن أنسب معدل للتلقيم يقارب ٩ ميجا جرام/ساعة والذى يمكن من خلاله الحصول على أعلى كفاءة لعملية الطحن وذلك عند ضبط الخلوص بين الدرافيل عند مستويات ١,٩٥، ١,٥٠، ٠,٨٠، ٠,٧٥، ٠، ١مم وذلك للطحنة الاولى والثانية والثالثة والرابعة والخامسة على الترتيب.