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MODIFICATION AND PERFORMANCE CHARACTERIZATION OF A NEW PROTOTYPE FOR CLEANING SEED COTTON

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ABSTRACT

The present investigation was conducted in October, 2007 at Rice Mechanization Center, Meet El-Deeba, Kafr El-Sheikh governorate. The modified prototype was fabricated at a small workshop in Kafr El-Sheikh city. The experimental results revealed that the seed cotton extractor (prototype) performance after modification was better than that before. Seed cotton wastage was minimized by 14 and 32.58% for the prototype before and after modification respectively. Also, cotton trash content was reduced by 8.87 and 35.75% for the prototype before and after modification successively. Its productivity was increased by 92.19 and 109.15% before and after modification respectively. Also, the increment in prototype productivity was of 28.24% by increasing feed rate from 0.60 to 0.75Mg/h. At all the investigated feed rates, the modified prototype had higher values of cleaning efficiency than that before. The increment in its cleaning efficiency was of 21.22% by raising feed rate from 0.60 to 0.75Mg/h. The prototype energy requirements were minimized by 42.59 and 47.02% before and after modification respectively. Cotton moisture content was reduced by 31.80% as the drying air temperature was raised by 11.63%. Total cost requirements for the modified prototype were slightly smaller by 0.66% than that before. Whereas, criterion function cost was smaller for the modified prototype by 16.77% than that before modification as seed cotton losses were effectively minimized after modification. The characteristics of cotton fiber quality were highly enhanced and strongly influenced by the investigated variables for the modified prototype than that before its modification.

INTRODUCTION

Cotton crop is considered as the most strategic crops in all over the world. In addition, it is the most exported crop in Egypt because of its high quality and lint properties. In Egypt, the cotton cultivated area has been decreased, through the last two decades, from about one to one half million feddans (Agricultural statistics, in Arabic, 2006). Increasing the cost of yield production and competition with other crops, especially the manual picking up operation which needs a great deal of labors, were the main reasons for reducing the grown area of cotton crop. To minimize the yield production cost, the mechanical picking up must be practiced. But the mechanical picked up seed cotton has a large amount of accompanied impurities, which in turn needs to be cleaned directly before its manipulation. So, by using the mechanically picked up seed cotton which followed by a pre-cleaning process, total cost production can be rapidly decreased (El-Yamani, 2007). In spite of this, mechanically picked up seed cotton contains substantial quantities of trash that must be removed in the early stages of ginning to promote efficient drying, trouble free gin-stand operation and satisfactory lint grades. So, cylinder type cleaners are generally employed for removing leaf material and other fine particulates. While extractor- type machine is used for removing large trash such as burs and sticks (Gillum and Armijo, 1997). Stick machines (separating sticks from the mechanically picked up seed cotton) are commonly utilized, at commercial cotton gins, for removing large vegetative trash components existed in mechanically harvested cotton. These machines extract burs and sticks from the cotton by utilizing the centrifugal forces created by rotating saw cylinders and the stripping action of round grids positioned about the circumference of each cylinder (Baker and Laird, 1986). A new-multistage extractor was designed and located at the most convenient position in a seed cotton gin's cleaning system. Laboratory studies indicated that the designed machine was substantially more efficient in removing burs and sticks from stripper cotton than that of conventional system which was composed of two successive extractors. Cleaned seed cotton by the multistage extractor contained about one-half of trash as compared with that cleaned by conventional machinery (Baker and Lalor, 1990). The identification and technical performance evaluation of some biobased products was presented and subjected. These are potential alternatives to the petroleum-based floor strippers. Two sets of experiments were performed. The first set of experiments involved laboratory scale experiments using different cleaning products and techniques. The second set of experiments involved pre-field tests conducted on a typical floor in the Toxic Use Reduction Institute laboratory. All experiments employed the standard operating procedures under different experimental conditions varying the temperature, soaking time, cleaning media (abrasive pads or cotton cloth) and the concentration of products. The cleaning efficiency for each of the biobased or green products used was based on the gravimetric analysis of the coupons. Performance of concentrated potential biobased floor strippers was in the range of 50 to 99% (Ephraim *et al.*, 2008). The model combination of gin-lint cleaner was improved by adding a solid wrapped brush between the gins saw and primary cleaning cylinder and adding cleaning bars around the gin saw. Cleaning efficiency of the experimented machine was better than that of standard saw-type lint cleaner. Also, lint quality properties of length and nap count tended to be better for cotton processed through the improved machine (Hughs *et al.*, 1984). A full-size prototype coupled lint cleaner on a small scale using first and second pick, and stripper-harvested upland cottons on a large scale was built and tested. For both tests, the ginned and cleaned fiber from the coupled lint cleaner had significantly less trash and higher grades, longer fiber and fewer short fibers and higher cleaning rates with less fiber breakage. The higher cleaning efficiency of coupled lint cleaner is more pronounced for the trashier counts but is significant even for cleaned cotton (Hughs *et al.*, 1990). Seed cotton cleaning system includes both of large trash and small extracting. A limited system of trash cleaning components out was performed based only on the extraction of large trash. The more extensive systems produced cleaner lint than that produced by the limited system. Seed cotton cleaning level did not, however, significantly affect fiber or yarn quality (Baker *et al.*, 1994). The self-cotton cleaning leading to the stain discoloration was quantified to assess the photo-activity of the clusters prepared under different experimental conditions. This process shows promise for the total removal of stains containing persistent colored pigments on the cotton fibers (Bozzia *et al.*, 2005). Cotton cleaning efficiency is increased by decreasing moisture content, but whenever the moisture is decreased to a great extent, the mechanical motion of detergents will damage cotton fiber and seeds during its cleaning. Therefore, the decrease percent in cotton moisture, desired to be cleaned, should be as the amount that does not affect a tangible effect on its cleaning efficiency (Youssef, in Arabic, 1992). Drying seed cotton, but most gin expose it to drying air for a very short period of time (10 to 20s) which is normally assumed to transfer insignificant amounts of moisture from the seed. Indeed, lint near the center of clumps may be hardly dried at all. Whereas, the exterior lint fibers may be over dried. This article will be concerned with the equilibrium moisture content of cotton lint. The up take of water by fibers is critical to textile manufactures (Abemathy *et al.*, 1999). Most of textile fibers are hygroscopic. They have the ability of absorption of humidity or giving it to around air. Crude cotton absorbs humidity from the around air faster when it is exposed to high air humidity and so its mass is increased quantitatively. Its endurance is increased and changing its other adjectives pursuiting this humidity. Cotton humidity was identified as a percent of water added to the sample mass (Nomeir, in Arabic, 1996). Seed cotton wastage and the extracted trash were gradually increased as the cleaning cylinder speed was also increased (El Awady *et al.*, 2005). The essential aim of the current study was to modify some parts in the seed cotton extractor with the purpose of raising its productivity and cleaning efficiency. The specific objectives were directed to the following two points:

a) To specify the optimum operating conditions of prototype before and after modification and
b) To minimize the energy requirements of prototype and its criterion function cost.

MATERIALS AND METHODS

EXPERIMENTAL PROTOTYPE:

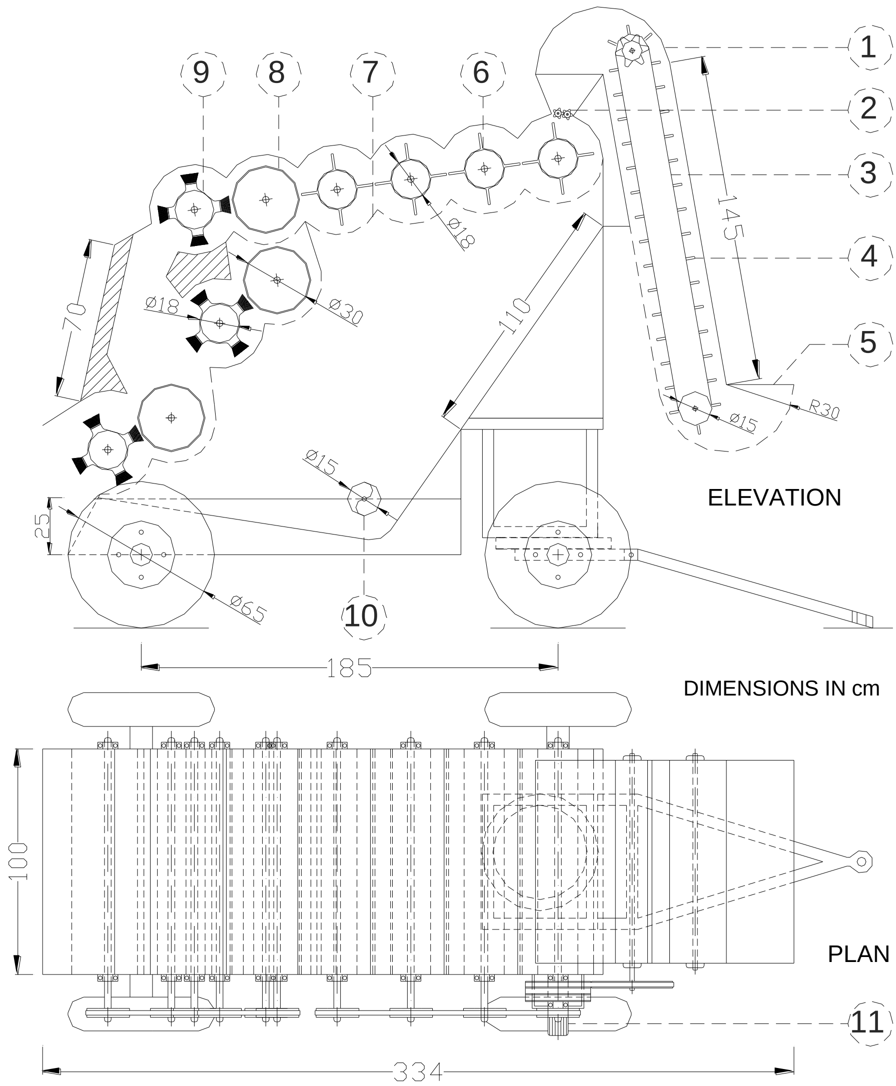
A new pre-cleaning prototype of seed cotton extractor was locally manufactured, by El-Yamani (2007), to be suitable for cleaning the Egyptian cotton varieties (extra-long staple) from the accompanied impurities after its picking up mechanically. Those impurities such as motes, undeveloped ovules, sticks, flower and branch parts, green leaf, burs, dust, sand, grass and rock parts. Extracting the impurities from seed cotton heaps, using the new prototype, was achieved through three successive stages as follows: The first stage was to feed seed cotton mixed with impurities to the extractor by the mechanical loader. In this stage, a pre-cleaning of seed cotton is occurred through its conveying by mechanical loader. Some of fine and large impurities can be extracted and removed away through a specific screen beneath the mechanical loader. The second stage was to get rid of fine impurities (small trash) by means of four impact drums. The third stage was to dispart large impurities and the rest of fine impurities. Three doffing and saw drums are involved in this stage to rotate in contrary directions that reduce bristle wear. Through the second and third stages, the extracted impurities are collected and separated away through a specific hose and conveyed out of prototype by means of the trash auger. The prototype was operated by means of the PTO of a 65hp tractor. A detailed description of the prototype construction can be found in El-Yamani (2007). Sketch of seed cotton extractor before modification is illustrated in Fig. 1.

Suggested Modification:

A sketch of the modified prototype is shown in Fig. 2. There are four main parts in the prototype can be modified. The mechanical loader of cotton heap was equipped with a specific drying unit for reducing the moisture content of seed cotton heap. The drying unit was mainly constructed to facilitate extracting seed cotton from the accompanied impurities and hence raising the cleaning efficiency in the following stages of prototype. Three electrical heaters were involved in the drying unit with the purpose of obtaining different levels of drying air temperature. Each heater had the power of 5kW. A fan of 25cm in diameter was fixed above the electrical heaters for delivering the heated air across the screen to meet with the raw seed cotton heap during its feeding. The mechanical loader breaks the cotton heap into crumbs during its feeding and consequently the subjected area of cotton crumbs to the heated airflow will be increased. This process will increase the cotton - heated air contact time and will facilitate extracting the accompanied impurities from the cotton heap. The heated air velocity of 10m/s was selected as the maximum one, in which beyond it will overcome the cotton feeding upward. From the primary trials, it was found that the higher heated air velocity, the lower cotton moisture content and the higher cleaning efficiency of the extracted seed cotton. The drying air velocity was constant at 10m/s for all treatments. The drying unit was provided with an insulator to minimize heat dissipation. The number of impact drums was reduced from four to three ones. It was observed, from the preliminary experiments, that extracting the majority of fine impurities (small trash) was achieved through only three impact drums. But the number of saw and doffing brush drums was increased to four drums instead of three ones. This can be attributed to that, through primary tests, those drums has revealed high effectiveness in extracting the large impurities and the rest of fine ones. A trash auger was replaced with the fan to facilitate delivering of impurities out of the prototype, and hence accomplishing the process at the lowest time possible.

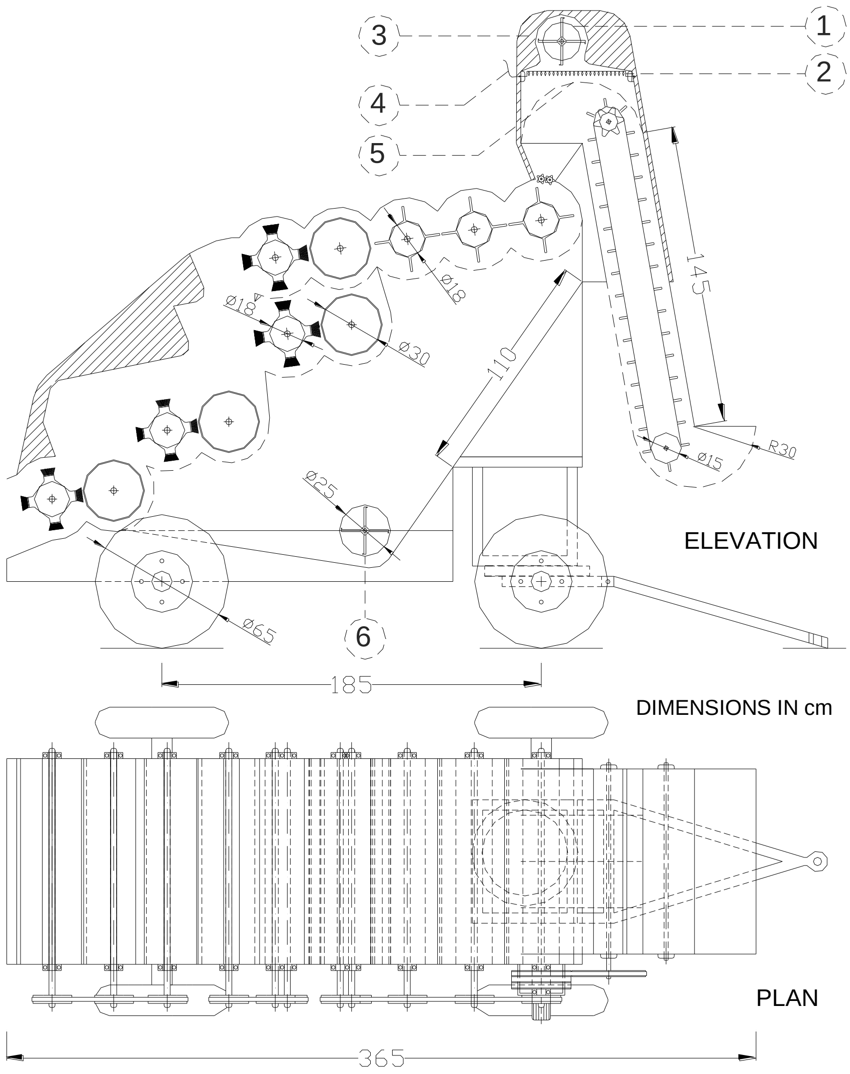
Investigated Variables:

Three levels of seed cotton heap moisture content were studied before modifying the prototype. Its values were of 6.31, 5.16 and 4.40%d.b. Those values were obtained by drying the seed cotton heap, directly after its picking up mechanically, inside a separated drying unit. After modifying the prototype, three different drying air temperatures of 318.15K (45°C), 338.15K (65°C) and 355.15K (82°C) were employed. The initial moisture content of seed cotton heap, which entering the modified prototype, was constant at 13%d.b. directly after its picking up for all investigated treatments. Three levels of saw drum speed of 5.97, 6.73 and 7.47m/s were selected and investigated before and after modifying the prototype.



1. Mechanical loader	5. Feed inlet	9. Doffing drum
2. Feed roller	6. Impact drum	10. Trash auger
3. Chain conveyor	7. Screen	11. Main driver
4. stripper	8. Saw drum	

Fig. 1: A geometrical drawing of the seed cotton extractor before modification (El-Yamani, 2007).



1. Blower	4. Electrical source
2. Electrical heater	5. Screen
3. Insulator	6. Trash delivering fan

Fig. 2: A geometrical drawing of the seed cotton extractor after modification.

Three different feed rates of 0.30, 0.45 and 0.60Mg/h were obtained before modification and three others of 0.39, 0.54 and 0.75Mg/h were achieved for the modified prototype.

Instrumentations:

The cotton moisture content was determined by the oven method. Two J-type thermocouples and a digital thermometer (Model: HH-26J-USA) were employed to record drying air temperature inside the modified prototype. Drying air velocity was measured by means of a hot-wire type anemometer (Model: SATO-SK-73D). A tachometer (Model: 3632) was used to measure saw drum speed in rpm and after that converted into linear velocity in m/s. The current strength and potential difference were measured using Ammeter and Voltmeter respectively. Readings of amperes and volts were monitored before and during each experimental treatment. Some empirical equations were developed to characterize the prototype performance.

Measuring Procedures:

Seed cotton trash content was determined by means of a fractionator instrument with a sample of 150g. It can be determined as a percentage of trash content using the formula of Youssef, in Arabic (1992):

$$Trash\ content, \% = {}^{\Sigma T_w}\!/_{W_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where;

ΣT_w is the sum of trash content masses, g and

W_o is the total mass of original sample, g.

Trash content output was collected, massed and re-separated into fiber and fiber foreign matter. The percentage of cotton wastage was calculated based on the collected cotton fiber in the sample to the total mass of sample.

Cleaning efficiency can be calculated according to the equation of Mangialardi (1986):

$$Cleaning\ efficiency, \% = \frac{Y_1 - Y_2}{Y_1} x 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where;

Y_1 is the total foreign matter content of specimen before extracting, % and

Y_2 is the total foreign matter content of specimen after extracting,%.

The amount of power required for operating the electric heater has been calculated according to Lockwood and Dunstan (1971):

$$Electric\ heater\ power,\ kW = \frac{1}{1000}(I\ x V\ x \eta_h) \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where;

I is the current strength, Ampere;

V is the potential difference, Volt and

η_h is the heater efficiency (assumed to be 85%).

The power consumption requirements are calculated according to the formula of Embaby (1985):

$$Power\ consumption, kW = \frac{FC\ x\ \rho_f\ x\ LCV\ x\ 427\ x\ \eta_m\ x\ \eta_{th}}{3600\ x\ 75\ x\ 1.36} \quad ....(4)$$

Where;

FC is the fuel consumption, l/h;

ρ_f is the fuel density (0.85 kg/l);

LCV is the lower calorific value of fuel (10000 kCal/kg);

427 is the thermo-mechanical equivalent, kg.m/kCal;

η_m is the engine mechanical efficiency, (assumed to be 80%) and

η_{th} is the engine thermal efficiency, (35-40% for diesel engine).

Total power consumption, kW = Electric heater power, kW + Power requirements consumption, kW……………………………………………….….(5)

$$Specific\ energy, kW.h/Mg = \frac{Total\ power\ consumption\,(kW)}{\Pr ototype\ productivity\,(Mg/h)} \quad ....(6)$$

Total cost requirements of prototype, LE/h: include fixed and operating costs. Declining balance method was used to determine the depreciation (Hunt, 1983).

Criterion Function Cost, LE/Mg = Unit operating cost, LE/Mg + Losses cost, LE/Mg………………………………….……………….……………………......(7)

$$Unit\ operating\ \cos t, LE/Mg = \frac{\Pr ototype\ \cos t\,(LE/h)}{\Pr oductivity\,(Mg/h)} \quad ....(8)$$

Losses cost, LE/Mg = value of cotton wastage + fewness in seed cotton price according to reducing seed cotton grade…………………….........……(9)

Laboratory Tests:

The cotton technology characteristics were determined at Cotton Research Institute, Giza, Egypt. The fiber properties were determined under the standard conditions of 65 ±2% relative humidity and 294 ±1K ambient air temperature. Fiber quality properties were analyzed after its cleaning as follows: A digital fibrograph (Model-630) was used to determine the 2.5 and 50% span fiber length (mm) according to May and Bridges (1995). Uniformity ratio was determined using the formula of Prakash (1962):

$$Uniformity\ ratio, \% = \frac{50\%\ span\ fiber\ length}{2.5\%\ span\ fiber\ length}\ x\ 100 \quad ....(10)$$

Where it was expressed in uniformity quantity between short and long fiber length. HVI 9000 instrument according to ASTM (D-1684-96) was used to estimate lint color (reflectance "*Rd*", % and yellowness "+*b*", unit from 5 to 17). Seed cotton strength (*g/tex*) was measured using stelometer instrument according to ASTM, designated D-1445-75, 1984. This instrument give elongation reading and hence cotton length strength can be determined using the formula of Nomeir, in Arabic (1996):

$$Strength\ for\ length\ unit, \% = 1.5\ x\ \frac{W_c}{W_s}\ x\ 100 \quad ....(11)$$

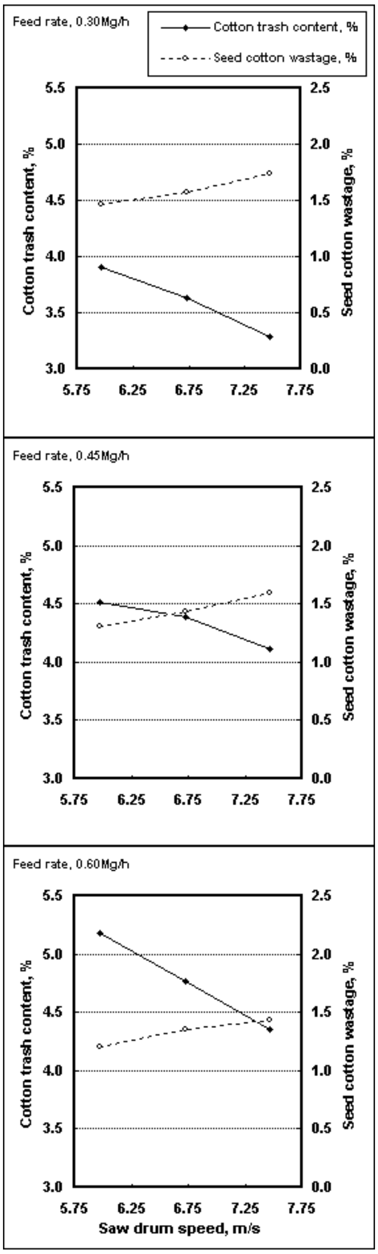
Where;
W_c is the cutting mass, kg and
W_s is the total mass of sample, mg.

RESULTS AND DISCUSSION

A preliminary procedure was done to analyze the experimental data and determine the optimum operating conditions of the seed cotton extractor before and after modification. It was noticed that, for all the operating conditions of the prototype before modification, the optimum operating conditions were coincided with the cotton moisture content of about 5.16%d.b. While the optimum ones were at drying air temperature of 338.15K for the modified prototype. Both of 5.16%d.b. fiber moisture content and 338.15K drying air temperature were selected as the trash content and cotton wastage have been reached their lowest values. Also, at these levels, both of cleaning efficiency and productivity were maximized but the unit energy was minimized. Therefore, performance of the investigated prototype will be characterized only under those optimum operating conditions.

Prototype Performance:

Fig. 3 shows the relationship between saw drum speed and both of cotton trash content and seed cotton wastage at moisture content of 5.16%d.b. and different feed rates before modification. The optimum operating conditions of the prototype were obtained at saw drum speed of 6.73m/s and feed rate of 0.45Mg/h. In general, seed cotton wastage was inversely proportional to feed rate and directly proportional to saw drum speed. While cotton trash content was directly proportional to feed rate and inversely proportional to saw drum speed. At constant saw drum speed of 6.73m/s, seed cotton wastage was decreased from 1.57 to 1.35% (-14%) and cotton trash content was increased from 3.63 to 4.77% (+31.4%) by increasing feed rate from 0.30 to 0.60Mg/h. On the other hand, at constant feed rate of 0.45Mg/h, seed cotton wastage was increased from 1.31 to 1.59% (+21.37%) and cotton trash content was decreased from 4.51 to 4.11% (-8.87%) by increasing saw drum speed from 5.97 to 7.47m/s. The effect of saw drum speed on both of cotton trash content and seed cotton wastage at different feed rates and drying air temperature of 338.15K after modification is illustrated in Fig. 4. The optimum operating conditions of the prototype were obtained at saw drum speed of 6.73m/s and feed rate of 0.54Mg/h. The trend of data obtained was almost the same as that before modification. But, after modification, the values of cotton trash content and seed cotton wastage were greatly less than that before modification. Also, the values of feed rates obtained after modification were higher than that before. At constant saw drum speed of 6.73m/s, seed cotton wastage was decreased from 0.89 to 0.60% (-32.58%) and cotton trash content was increased from 1.61 to 2.19% (+36%) by raising feed rate from 0.39 to 0.75Mg/h. Meanwhile, at constant feed rate of 0.54Mg/h, seed cotton wastage was increased from 0.64 to 0.82% (+28.13%) and cotton trash content was reduced from 1.93 to 1.24% (-35.75%) by increasing saw drum speed from 5.97 to 7.47m/s.



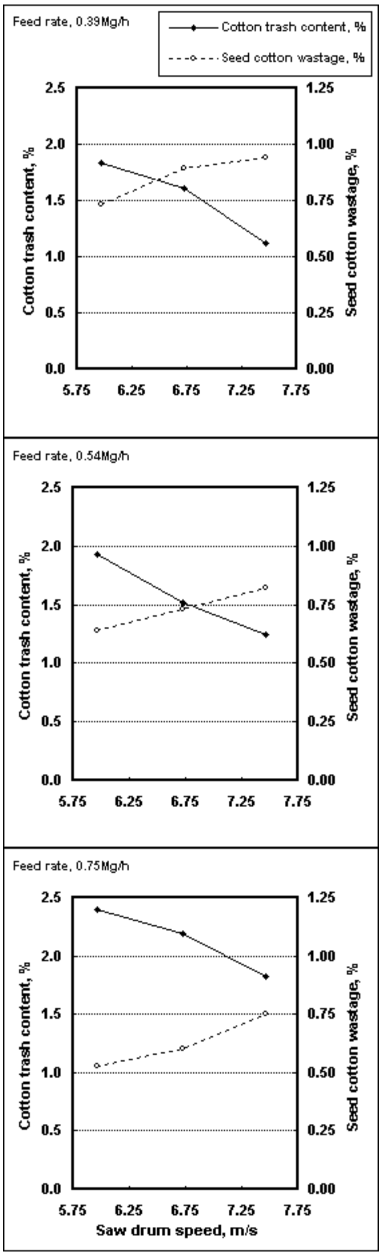


Fig. 3: Relationship between saw drum speed and both of trash content and cotton wastage at different feed rates and moisture content of about 5.16%d.b. before modification.

Fig. 4: Relationship between saw drum speed and both of trash content and cotton wastage at different feed rates and drying air temperature of 338.15K after modification.

As a conclusion, from Figs. 3 and 4, seed cotton wastage was reduced by 14 and 32.58% for the prototype before and after modification respectively. As well as, cotton trash content was reduced by 8.87 and 35.75% for the prototype before and after modification in successive.

Prototype productivity:

Fig 5 illustrates the relationship between feed rate and productivity of prototype at saw drum speed of 6.73m/s, cotton moisture content of 5.16%d.b. and drying air temperature of 338.15K. Generally, the prototype productivity was directly proportional to feed rate. At constant saw drum speed of 6.73m/s before modification, the prototype productivity was increased from 0.269 to 0.517Mg/h (+92.19%) by increasing feed rate from 0.30 to 0.60Mg/h. While after modification, it was increased from 0.317 to 0.663Mg/h (+109.15%) by increasing feed rate from 0.39 to 0.75Mg/h. Moreover, the values of prototype productivity after modification were higher than that before modification at all investigated feed rates. It can be concluded that the prototype productivity was raised by 92.19 and 109.15% before and after modification respectively by changing feed rate within the applied range. Also, by increasing feed rate from 0.60 to 0.75Mg/h, the prototype productivity was raised from 0.517 to 0.663Mg/h (+28.24%).

Prototype Cleaning Efficiency:

The relationship between feed rate and cleaning efficiency of prototype at saw drum speed of 6.73m/s, cotton moisture content of 5.16%d.b. and drying air temperature of 338.15K is depicted in Fig. 6. In general, prototype cleaning efficiency was inversely proportional to feed rate. At constant saw drum speed of 6.73m/s before modification, the prototype cleaning efficiency was decreased from 78.1 to 74.0% (-5.25%) by increasing feed rate from 0.30 to 0.60Mg/h. While after modification, it was reduced from 93.5 to 89.7% (-4.06%) by increasing feed rate from 0.39 to 0.75Mg/h. In addition, at all the investigated feed rates, the prototype had higher values of cleaning efficiency after modification than that before. Briefly, the prototype cleaning efficiency was reduced by 5.25 and 4.06% before and after modification successively by changing feed rate within the investigated range. Moreover, it was increased from 74.0 to 89.7% (+21.22%) by raising feed rate from 0.60 to 0.75Mg/h.

Prototype Energy Requirements:

Fig. 7 shows the effect of feed rate on unit energy at saw drum speed of 6.73m/s, cotton moisture content of 5.16%d.b. and drying air temperature of 338.15K. Unit energy values were decreased by increasing feed rate for the prototye before and after modification. At constant saw drum speed of 6.73m/s before modification, the unit energy of prototype was decreased from 38.81 to 22.28kW.h/Mg (-42.59%) by increasing feed rate from 0.30 to 0.60Mg/h. But after modification, it was minimized from 45.07 to 23.88kW.h/Mg (-47.02%) by increasing feed rate from 0.39 to 0.75Mg/h. The unit energy values were higher for the modified prototype than that before. In short, the prototype unit energy was minimized by 42.59 and 47.02% before and after modification respectively by changing feed rate within the investigated range. Moreover, it was raised from 22.28 to 23.88kW.h/Mg (+7.18%) by increasing feed rate from 0.60 to 0.75Mg/h.

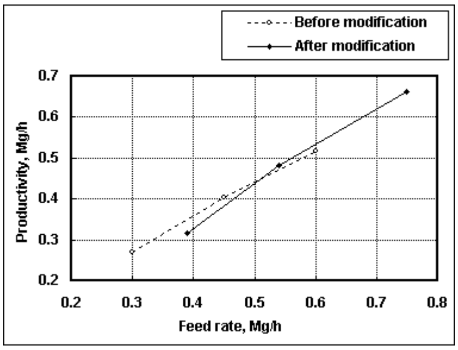


Fig. 5: Relationship between feed rate and extractor productivity at saw drum speed of 6.73m/s, moisture content of about 5.16%d.b. and drying air temperature of 338.15K.

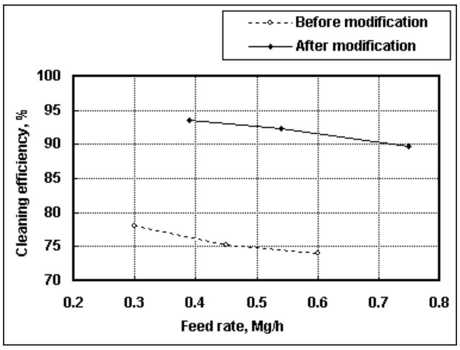


Fig. 6: Relationship between feed rate and extractor cleaning efficiency at saw drum speed of 6.73m/s, moisture content of about 5.16%d.b. and drying air temperature of 338.15K.

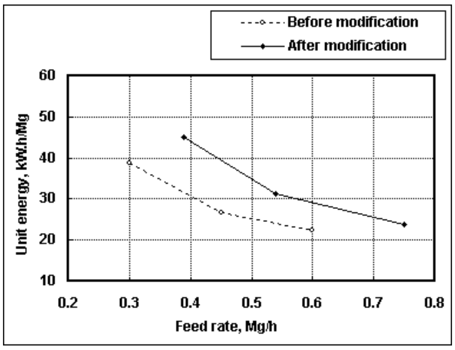


Fig. 7: Relationship between feed rate and extractor unit energy at saw drum speed of 6.73m/s, moisture content of about 5.16%d.b. and drying air temperature of 338.15K.

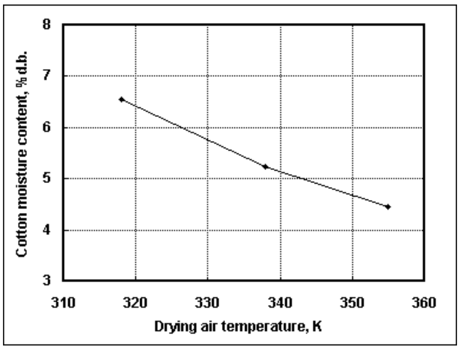


Fig. 8: Relationship between drying air temperature and cotton moisture content at feed rate of 0.54Mg/h and saw drum speed of 6.73m/s after modification.

Drying Air Temperature:

Fig. 8 depicts the relationship between drying air temperature and cotton moisture content after modification at feed rate of 0.54Mg/h and saw drum speed of 6.73m/s. In general, cotton moisture content was inversely proportional to the drying air temperature. The moisture content of seed cotton was reduced from 6.54 to 4.46%d.b. (-31.80%) by increasing drying air temperature from 318.15 to 355.15K (+11.63%). This means that the designed drying air temperatures play an important role in reducing the cotton moisture content, and consequently enhance cleaning efficiency and finally the cleaning process will be intensified. Table 1 indicates the standard deviation values of cotton moisture content entering the prototype before modification and the exiting ones after modification. Values of cotton moisture content exiting the modified prototype under the effect of drying air temperature were very close to those entering it before its modification. As the standard deviation was decreased from 0.1626 to 0.0424%d.b. (-73.92%), the average moisture content was reduced from 6.425 to 4.430%d.b. (-31.05%). It can be concluded that drying seed cotton immediately before its cleaning and extracting improves the cleaning efficiency and minimizes energy requirements. Therefore, there was no need to dry seed cotton separately after its picking up as the modified prototype has saved this supplemental process, and hence the unit cost can be minimized.

Table 1: Standard deviation values of cotton moisture content entering the prototype before modification and the exiting ones after modification.

Initial moisture content of cotton entering the prototype before modification, %d.b.	Final moisture content of cotton exiting the prototype after modification, %d.b. (drying air temperature, K)	Mean, % d.b.	Standard deviation of the initial and final moisture content, %d.b.
6.31	6.54 (318.15)	6.43	0.1626
5.16	5.23 (338.15)	5.20	0.0495
4.40	4.46 (355.15)	4.43	0.0424

Total Cost Requirements:

A detailed estimation of the prototype cost before and after its modification is given in Table 2. The overall cost requirements for the prototype before and after modification are listed in Table 3. For the modified extractor, their values were slightly smaller (-0.66%) than that before modification. The lowest values of total cost were of 25.86 and 25.69LE/h for the prototype before and after modification respectively. This may be as the fixed and operating cost parameters are nearly alike. However, the total cost was of 25.86LE/h before modification at feed rate of 0.45Mg/h, saw drum speed of 6.73m/s and cotton moisture content of 5.16%d.b. Whereas, after modification its value was of 25.69LE/h at feed rate of 0.54Mg/h, saw drum speed of 6.73m/s and drying air temperature of 338.15K. This means that the prototype had its lowest cost only under the optimum operating conditions.

Criterion Function Cost:

Table 3 indicates the values of criterion function cost for the prototype before and after modification. Criterion function cost includes both of machinery operating cost (unit cost) and cost due to seed cotton losses (losses cost). However, the criterion function cost was essentially determined to specify the most economic prototype. Its value was smaller for the modified prototype by 16.77% than that before modification as seed cotton losses were minimized after modification. Moreover, the lowest values of criterion function cost were obtained at the optimum operating conditions. Its value was of 64.17LE/Mg before modification at feed rate of 0.45Mg/h, saw drum speed of 6.73m/s and cotton moisture content of 5.16%d.b. Meanwhile, after modification its value was of 53.41LE/Mg at feed rate of 0.54Mg/h, saw drum speed of 6.73m/s and drying air temperature of 338.15K.

Table 2: Estimation of the prototype cost.

Item	Tractor	Prototype before modification	Prototype after modification
No. of years (used before)	9	1	1
Remaining value, LE	4632.3	5780	6936
Fixed cost, LE/year: a) Depreciation b) Interest on investment, housing, taxes and insurance	- 694.81 639.25	- 1120 797.6	- 1224 957.17
Total fixed cost, LE/year	1334	1917.6	2181.17
Operating hours per year	1000	700	700
Operating cost, LE/year: a) Repairs and maintenance b) Fuel + lubrication c) Electric current d) Labor	- 1000 7500 - 2100	- 400 100 - 3750	- 480 135 475 2775
Total operating cost, LE/year	10600	4250	3865
Total cost, LE/year	11934	6167.6	6046.17
Prototype cost before modification, LE/h	(11934 + 6167.6)/700 = 25.86		
Prototype cost after modification, LE/h	(11934 +6046.17)/700 = 25.69		

Table 3: The economical cost for producing one megagram seed cotton at the optimum operating conditions.

Prototype	Feed rate, Mg/h	Saw drum speed, m/s	MC, %d.b.	Drying Air temperature, K	Productivity, Mg/h	Total cost requirements, LE/h	Criterion cost, LE/Mg
Before modification	0.45	6.73	5.16	-	0.403	25.86	64.17
After modification	0.54	6.73	-	338.15	0.481	25.69	53.41

Quality Characteristics Of Seed Cotton:

The quality characteristics of the extracted seed cotton for the prototype before and after modification are listed in Table 4. It was obvious that the span fiber length, fiber length uniformity ratio and fiber strength are directly proportional to both of feed rate and cotton moisture content and inversely proportional to both of saw drum speed and drying air temperature. Conversely, the color reflectance and yellowness are directly proportional to both of saw drum speed and drying air temperature and inversely proportional to both of feed rate and cotton moisture content.

T4

At the optimum operating conditions of 6.73m/s saw drum speed, 5.16%d.b. cotton moisture content and 0.45Mg/h feed rate before modification and 338.15K drying air temperature and 0.54Mg/h feed rate after modification, both of fiber length uniformity ratio and color reflectance were increased by 1.53 and 2.63% for the modified prototype than that before modification respectively. Contrariwise, both of fiber strength and color yellowness were decreased by 2.14 and 6.90% for the modified prototype than that before modification respectively. The maximum values of 2.5 & 50% span fiber length, fiber length uniformity ratio and fiber strength were of 31.9mm, 15.2mm, 47.6% and 28.9g/tex respectively for the prototype before modification at feed rate of 0.60Mg/h, cotton moisture content of 6.31%d.b. and saw drum speed of 5.97m/s. While, they were of 32.6mm, 15.6mm, 48.4% and 28.3g/tex respectively for the modified prototype at feed rate of 0.75Mg/h, drying air temperature of 318.15K and saw drum speed of 5.97m/s. On the other hand, the lowest values of color reflectance were of 70.2 and 71.9% for the prototype before and after modification respectively at feed rate of 0.60 and 0.75Mg/h and moisture content of 6.31%d.b. and drying air temperature of 318.15K in successive. Meanwhile, the lowest values of color yellowness were of 8.1 and 7.2units for the prototype before and after modification respectively at feed rate of 0.60 and 0.75Mg/h and moisture content of 4.40%d.b. and drying air temperature of 355.15K successively. In short, the cotton fiber technology characteristics were highly improved and strongly influenced by the investigated variables for the modified prototype than that before modification. A multiple linear regression equation was developed. It had the following formula:

$E = a_o + b_1M + b_2F + b_3S$ ………………………………….…………..………. (12)

Where;

E is the efficiency indicator of prototype, %;
M is the cotton moisture content (%d.b.) or drying air temperature (K);
F is the feed rate, Mg/h;
S is the saw drum speed, m/s;
a_o is the Y-intercept and
b1,b2 and b3 is the regression coefficients.

Values of the predicted regression coefficients and its determination coefficients (R^2) are listed in Table 5.

Table 5: Multiple linear regression equation, describing the cleaning process of seed cotton extractor.

Indicator	Before modification					After modification				
	a_o	Regression coefficients			R^2	a_o	Regression coefficients			R^2
		B_1	b_2	b_3			b_1	b_2	b_3	
Productivity, Mg/h	+0.0352	+0.0149	+0.8159	-0.0126	0.9945	+0.3074	-0.0008	+0.9917	-0.0155	0.9967
Cleaning efficiency, %	+77.6642	-1.9552	-13.7037	+2.2433	0.9338	+41.6782	+0.1205	-10.8410	+2.3100	0.9624
Specific energy, kW.h/Mg	+34.8650	+0.9159	-54.2963	+2.0514	0.9308	+66.3770	-0.0540	-56.8304	+2.4849	0.9216
Total cost, LE/h	+5.7877	+1.1274	+12.9852	+1.1311	0.9553	+36.1907	-0.0766	+9.2015	+1.5604	0.9634
Criterion cost, LE/Mg	+81.2030	+0.2537	-111.7593	+5.1780	0.9533	+98.7946	-0.0626	-99.2523	+5.3041	0.9235

Conclusion

The specific conclusions can be pointed as follows:

1) The optimum operating conditions of the prototype were specified as follows: feed rate of 0.45 and 0.54mg/h before and after modification

respectively, cotton moisture of 5.16%d.b. before modification and drying air temperature of 338.15K after modification and saw drum speed of 6.73m/s. Moreover, performance of the modified prototype was better than that before at all operating conditions.

2) The prototype productivity was increased from 0.403 to 0.481Mg/h and its cleaning efficiency was raised from 75.2 to 92.4% after modification. The total cost for producing one megagram seed cotton was reduced from 64.17 to 53.41LE and total losses were minimized from1.43 to 0.73% after modification. While the specific consumed energy was increased from 26.76 to 31.37kW.h/Mg because of adding drying unit to the modified prototype.
3) The cotton fiber technology characteristics were better for the modified prototype. Values of 2.5 and 50% span fiber length, fiber length uniformity and color reflectance were higher for the modified prototype. While both of fiber strength and color yellowness were slightly smaller for the modified prototype than that before modification.

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تعديل ووصف أداء نموذج أولى جديد لتنظيف القطن الزهر

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يعد محصول القطن من المحاصيل الإستراتيجية الهامة بالإضافة إلى أنه يعتبر من أهم المحاصيل التصديرية في مصر نظراً لجودته و تفوقه على جميع الأقطان العالمية في صفاته الغزلية. ولكن بنظرة إلى المساحات المزروعة بالقطن داخل مصر خلال العشرون عاماً الأخيرة وجد أنها في تناقص مستمر ، فقد تناقصت من حوالي مليون إلى نصف مليون فدان فقط خلال هذه الفترة (إحصائيات وزارة الزراعة المصرية، 2006). ومن أهم الأسباب في ذلك هو ارتفاع تكاليف إنتاجية المحصول وبالأخص عملية الجني اليدوي، لما تحتاجه من عمالة كثيرة. ولتقليل هذه التكاليف فإنه ينصح باستخدام الجني الآلي، ولكن يعاب على هذه الطريقة ارتفاع نسبة الشوائب في القطن الزهر الناتج. نظرا لوجود قصور في آلات جني القطن المستوردة مع أصناف القطن المصرية من حيث تماثل أوضاع لوز القطن على النبات. لذلك استهدف هذا البحث إجراء تعديل على نموذج أولى مصنع محلياً لتنظيف القطن الزهر بعد جنيه آلياً (اليماني، 2007) وذلك بإضافة وحدة تجفيف وزيادة عدد الدرافيل المنشارية للنموذج الأولى بهدف زيادة كفاءة التنظيف والإنتاجية وتقليل الفاقد الكلى. وقد تم دراسة العوامل المؤثرة على أداء الآلة لتحديد أنسب ظروف تشغيل لها قبل وبعد التعديل وهى كالآتي:

متغير الدراسة	الآلة قبل التعديل	الآلة بعد التعديل
المحتوي الرطوبى، % على أساس جاف	6,31 ، 5,16 ، 4,40	13
درجات حرارة هواء التجفيف، كلفن	-	318,15 ، 338,15 ، 355,15
سرعة الدرافيل المنشارية، م/ث	5,97 ، 6,73 ، 7,47	5,97 ، 6,73 ، 7,47
معدلات التلقيم، ميجاجرام/ساعة	0,30 ، 0,45 ، 0,60	0,39 ، 0,54 ، 0,75

وقد أظهرت النتائج المتحصل عليها ما يلي:

لوحظ أن أداء الآلة المعدلة أفضل عند ظروف التشغيل المثلى لها قبل وبعد التعديل (معدل تلقيم 0,45 و0,54ميجاجرام قبل وبعد التعديل على الترتيب، وسرعة الدرافيل المنشارية قبل وبعد التعديل 6,73متر/ث ، ومحتوى رطوبى قبل التعديل 5,16% على أساس جاف، ودرجة حرارة هواء التجفيف بعد التعديل 338,15كلفن). حيث ارتفعت كفاءة التنظيف لمخلوط القطن الزهر من 75,2 إلى 92,4% وزادت الإنتاجية من 0,403 إلى 0,481ميجاجرام/ساعة، وانخفض الفاقد من 1,43 إلى 0,73% كما انخفضت تكلفة إنتاج واحد ميجا جرام من القطن الزهر من 64,17 إلى 53,41 جنيهاً مصرياً ، بينما ارتفعت قيمة وحدة الطاقة المستهلكة من 26,76 إلى 31,37 كيلووات ساعة/ميجا جرام نظراً لإضافة وحدة التجفيف للآلة. تفوقت الصفات التكنولوجية للقطن الناتج من الآلة المعدلة في طول التيلة عند نسبة توزيع 2,5% و50% وكذا درجة الانتظام ودرجة انعكاس اللون، بينما انخفضت في كلاً من درجة المتانة والاصفرار.

Table 4: Quality characteristics of the extracted seed cotton before and after modification of prototype.

Pro-totype	M.C., %d.b.	Drying air temp., K	Feed rate, Mg/h	*2.5% span fiber length, mm*			*50% span fiber length, mm*			*Fiber length uniformity ratio, %*			*Fiber strength, g/tex*			*Color reflectance (Rd), %*			*Color yellowness (+b), unit*		
				5.97 m/s	*6.73 m/s*	*7.47 m/s*	*5.97 m/s*	*6.73 m/s*	*7.47 m/s*	*5.97 m/s*	*6.73 m/s*	*7.47 m/s*	*5.97 m/s*	*6.73 m/s*	*7.47 m/s*	*5.97 m/s*	*6.73 m/s*	*7.47 m/s*	*5.97 m/s*	*6.73 m/s*	*7.47 m/s*
Before modification	6.31	-	0.30	31.3	31.1	30.8	14.6	14.3	14.0	46.6	45.9	45.4	28.3	28.1	27.7	71.3	71.6	72.0	9.0	9.4	9.7
			0.45	31.6	31.4	31.2	14.8	14.5	14.3	46.8	46.2	45.8	28.6	28.3	28.0	70.6	70.9	71.5	8.7	9.1	9.4
			0.60	31.9	31.7	31.5	15.2	14.9	14.6	47.6	47.0	46.3	28.9	28.7	28.4	70.2	70.7	71.2	8.4	8.6	9.2
	5.16	-	0.30	31.1	30.8	30.5	14.4	14.0	13.8	46.3	45.5	45.2	28.1	27.9	27.5	72.1	72.5	72.8	8.8	9.1	9.5
			0.45	31.4	31.2	30.9	14.6	14.3	14.1	46.5	45.8	45.6	28.4	28.1	27.9	71.7	72.2	72.6	8.5	8.7	9.1
			0.60	31.6	31.5	31.3	15.0	14.8	14.4	47.4	46.9	46.0	28.6	27.9	27.6	71.4	71.9	72.3	8.3	8.5	8.9
	4.40	-	0.30	30.9	30.6	30.3	14.2	13.9	13.6	45.9	45.4	44.9	27.5	27.3	27.0	73.2	73.6	73.9	8.5	8.8	9.3
			0.45	31.2	30.8	30.7	14.4	14.1	13.9	46.1	45.7	45.3	27.8	27.5	27.4	72.7	73.1	73.5	8.2	8.4	9.0
			0.60	31.3	31.1	30.9	14.7	14.5	14.2	47.3	46.6	45.6	28.1	27.8	27.5	72.3	72.6	73.0	8.1	8.3	8.7
After modification	-	318.15	0.39	31.9	31.6	31.3	14.9	14.7	14.5	47.1	46.9	46.6	27.6	27.3	27.1	73.1	73.8	74.2	8.4	8.8	9.2
			0.54	32.3	31.9	31.6	15.2	15.0	14.7	47.6	47.3	46.7	27.9	27.7	27.4	72.3	73.2	73.7	8.1	8.5	8.9
			0.75	32.6	32.4	31.8	15.6	15.4	15.8	48.4	48.2	48.1	28.3	28.0	27.8	71.9	72.5	73.1	7.9	8.2	8.6
	-	338.15	0.39	31.4	31.2	31.1	14.6	14.5	14.4	46.5	46.4	46.3	27.3	27.0	26.7	74.3	74.9	75.3	8.2	8.5	8.9
			0.54	32.2	32.0	31.3	15.0	14.9	14.8	46.6	46.5	46.4	27.7	27.5	27.2	73.6	74.1	74.7	7.8	8.1	8.5
			0.75	32.5	32.3	31.6	15.3	15.1	15.0	47.0	46.7	46.6	28.0	27.8	27.4	73.0	73.5	73.9	7.6	7.9	8.4
	-	355.15	0.39	31.2	31.1	30.8	14.4	14.2	14.0	46.1	45.6	45.4	27.2	26.8	26.5	75.1	75.5	76.1	7.9	8.2	8.5
			0.54	32.0	31.7	31.2	14.8	14.7	14.6	46.3	46.1	46.0	27.5	27.2	26.9	74.4	74.9	75.3	7.5	7.8	8.1
			0.75	32.4	32.1	31.5	15.1	15.0	14.9	46.6	46.4	46.3	27.8	27.5	27.1	73.9	74.5	74.9	7.2	7.5	7.7