INVESTIGATION OF MACHINE EFFICIENCIES IN CASE OF MACHINES CONTINUE TO RUN WITHOUT OPERATOR SUPERVISION BY REASON OF LUNCH TIME BREAK: AN APPLICATION IN THE TEXTILE INDUSTRY

YEMEK PAYDOSUNDA MAKİNALARIN İŞÇİ GÖZETİMSİZ ÇALIŞTIRILMASI DURUMUNDA MAKİNA RANDIMANLARININ SORGULANMASI: TEKSTİL ENDÜSTRİSİNDE BİR UYGULAMA

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ABSTRACT

In the textile spinning industry the operators are assigned generally multi machines. In two or three shifts working applications the operators deserve free time of 30 min for their lunch and rest needs. During this time, machines are mostly allowed to run without supervision of operator expecting the minimum loss at the efficiencies of machines. This application seems beneficial in some cases indeed. However, this application can be useless, costly and even risky in some cases too. This work aims by using simulation methodology to expose the borders of the feasible and unfeasible areas of this application. For this aim, the efficiency of spindles or machines are estimated and compared for both strategies of a) to allow the machines to running by themselves without supervision of operator and b) to shut down the all machines completely during lunch time. The parameters used in the investigation are a) the yarn (end) breaking rates which are related basically quality of material, setting and maintenance of machines, conditions of environment like humidity and temperature and b) the number of machines or spindles assigned operators. The findings obtained show that for the small yarn breaking rates and small the number of spindles, to allow the machines continuing to run without operators can be useful despite some risks. However, in case of high yarn breaking rates and high number of machines, to allow the machines to running themselves is useless and even ineffective.

Keywords: Machine efficiency, Estimation of machine efficiency by simulation, working in lunch time, Management policies in spinning mill, Ways of increasing mill efficiency

ÖZET

Tekstil iplik endüstrisinde işçilere genellikle birden fazla makina tahsis edilir. İki veya üç posta çalışma uygulamasının olduğu fabrikalarda işçilere yemek ve dinlenme ihtiyaçları için verilen 30 dakikalık süre zarfında randımanda olabilecek muhtemel kaybın minimum olması için çoğunlukla makinaların işçi gözetimsiz kendi başlarına çalışmalarına müsaade edilir. Bu uygulama çoğu kere yararlı olabilmekle beraber bazı durumlarda faydasız, maliyetli ve hatta riskli olabilmektedir. Bu çalışmada simülasyon metedolijisi kullanılarak söz konusu uygulamanın hangi durumlarda ve ne miktarlarda faydalı veya faydasız olduğunun belirlenmesi amaçlamaktadır. Bu amaçla, yemek paydosunda makinaların kapatılmayıp kendi kendine çalışmasına müsaade edilmesi ve kapatılması durumlarında makina randımanlarının hesaplanması ve karşılaştırılması yapılmaktadır. Bu araştırmada iki temel parametre göz önünde bulundurulmaktadır. Bunlardan bir tanesi iplik kopuş oranı olup genellikle kullanılan malzemenin kalitesi, makina ayarı ve bakımı ve ortam şartları (nem ve sıcaklık) ilgilidir. Diğeri de işçiye tahsis edilen iğ veya makina sayısıdır. Elde edilen bulgular bu uygulamanın küçük kopuş oranları ve makina sayıları için yararlı, yüksek kopuş oranı ve makina sayıları için faydasız hatta zararlı olduğunu göstermektedir.

Anahtar Kelimeler: Makine randımanı, Makine randımanının simülasyon yöntemi ile belirlenmesi, Yemek paydosunda çalışma, İplik fabrikalarında yönetim politikaları, Fabrikalarda randıman artırmanın yolları.

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1. INTRODUCTION

The spinning system is an important segment in the textile industries, which consists of a set of processes to convert raw cotton into yarn. This spinning process can run continuously only when there are no breaks in the output of yarn produced from every spindle. However, the yarn does break due to several reasons like ambient conditions in the spinning facility, such as humidity, quality of cotton and spindle speed, etc., and other factors such as piecing (joining) of the broken yarn, using a pre-determined yarn length, by a operator called 'sider'. Breaks in yarn spinning cause a decrease in productivity. (1)

The word of "productivity" is used above in the meaning of "efficiency". To increase the machine efficiency to produce a yarn with lower cost, which possibly brings more profit and lower prices, it is should be able to estimate, analyze and predict all the machines efficiencies for all the possible manufacturing and managing strategies to be considered by mill managers.

However, in the case of multi machine assignments these estimations and predictions is not easy in some industries as it is in spinning and weaving industries due to machine interference issue. Machine interference can be described simply as: ``Consider a mill consisting of n machines and r workers. Each machine operates for a period until it breaks down or otherwise requires attention, at which point it is sent to the service facility. A worker there spends a period servicing the machine and then returns it to operation. If there are more machines than workers, n > r, it will occasionally happen that all workers are already busy when another machine needs service. Thus this system is a simple example of what is referred to as a machine interference problem (2)

2. CONCEPT OF SPINDLE AND SPINNING MACHINE EFFICIENCY AND FACTORS AFFECTED THAT

2.1. Definition and description of efficiency of a machine

Various efficiency definitions may be faced in different scientific and industrial areas such as energy, thermodynamics, mechanics, agriculture, industry, etc. However, in the field of industrial production, machine efficiency is described as a measure of the utilization degree of a machine from the point of production. For example, in textile industry, machine efficiency is defined as a ratio of the actual production of a machine to the theoretical production of this machine for a certain time. This expression is expressed also as a ratio of total running time of the machine to a certain time considered as illustrated in Fig. 1 [3].
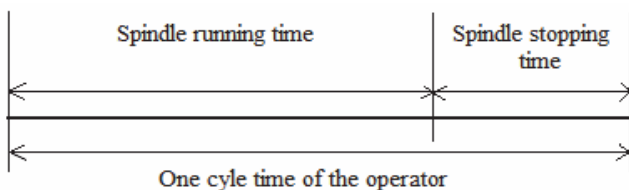
Figure 1. The illustration of the machine efficiency concept in the case of single machine assigned per operator.

Actual production of a machine for a certain period is also described as the production provided in spite of all the production loss due to all kinds of machine stoppages arisen in this considered period. However, the theoretical production of a machine in this period is described as the production without any loss due to stoppages. Thus, it is supposed that the machine considered runs continuously in this period. However, this is not possible in practice. Because in the textile spinning industry machines stop inevitably due to yarn breaks, roving chancing, mechanical, and electrical breakdowns and other failures such as resting time for lunch.

In the spinning industry every spindles of a machine can be considered as a small machine. Therefore, if every identical spindle on a machine are spinning same type of yarn from point of such as count, twist, material, color and are working under same technical and environmental conditions from point of such as speed, maintenance condition, operator care, humidity, temperature, light and etc then all spindles and machine will have same expected efficiency which will be considered as the spinning machine efficiency.

2.2. Factors affected spinning machine efficiency

The mill efficiency is affected by a lot of factors which are can be categorized mainly:

The factors related to operator responsibilities which are:

a) the yarn ends breaks mending time (directly)

b) the walking time (directly)

c) the number of spindles to be assigned per operator and service discipline which are determined by managers (indirectly)

d) the yarn ends break frequency which are affected by yarn material type, count, twist, spinning machine setting, and etc. (indirectly).

The factors unrelated to operator responsibilities which are:

a) the based on article such as yarn count and twist changing and setting up period,

b) the based on machine characteristics such as machine type, speed, effectiveness of routine and periodical machine maintenance, the number and qualification of maintenance worker, etc.

c) Environmental conditions such as spinning room climate (humidity, temperature), lightening, cleaning, etc.

d) Based on management responsibilities such as planning, organization, coordination, motivation and control of spinning process and workforce activity.

Total machine stoppages is mainly consist of yarn breaks stoppages and the others stoppage such as type of yarn changing, material absence, mechanical and electrical breakdowns, maintenance and etc. In determination of actual machines efficiencies it is needed also lost time due to the stoppages excluding yarn breaks stoppages mentioned above. This duration of stoppages can be determined by utilizing historical or past data. Generally, duration loss of these stoppages can change between five and fifteen percent of total stoppage depending on spinning mill. Therefore, in this study, we take into account only losses of yarn breaks in the estimation of machine efficiency because the results obtained will not be affected from this simplicity.

3. MATERIAL AND METHOD

In this work, we use simulation methodology to expose the benefit or cost of such a management application mentioned above which are faced in spinning mills generally. The simulation program used in this work has been written by the author. The algorithm of this program which considers periodical operator servicing system is given in Appendix1 and (2). On the other hand, the algorithm of the simulation program, which consider random operator servicing system, is given in (3). The parameters used in the program for the estimation of machines efficiencies are 1) the average end-breaks frequency λ, 2) the yarn breaks mending times TM 3) the average fixed walking time TW, and 4) the number of spindles assigned per operator. In this work the assumptions used are as below.

1) Yarn breaks fallows Poisson distribution with lambda λ parameter (number of break/one-spindle-one hour). In other words, the occurrence time of yarn breaks is described by exponential distribution which its mean will be shown with $1/\lambda$.

2) The operator average walking time TW and the operator average yarn breaks mending time are determined by the time study including the share of time of fatigue and personally needed by the operator.

3) It is supposed that the operator average walking time is 0.6 m/second as accepted in (1) ,which is correspondence TW = 0.000125 h to walk distance between two spindles of 75 mm, including the share of fatigue and personally needs

4) It is accepted that the operator's breaks mending time are distributed uniformly and determined as TM_1= 0,00139 h and TM_2= 0,00167 h included the share of fatigue and personally needs

5) The probability of a repair being successful is 100 %.

6) In the model considered, the mill is working three shifts and each of these shifts is 8 h. Every shift is consistent of 7.5 h working time and 0.5 h lunch time.

7) Operator servicing system is periodical.

In this paper we investigate the machine efficiencies obtained in application of;

Strategy 1) the machines assigned are running 7.5 h of time period under supervision of principle operator and then 0.5 h of time period in lunch time under supervision of stand by operator.

Strategy 2) the machines assigned are running 7.5 h of time period under supervision of operator and after 7.5 h of time period the machines are running by themselves without supervision of operator 0.5 h of time in lunch time.

Strategy 3) the machines are running 7.5 h of time period under supervision of operator and then the machines are shut down 0.5 h of time period in lunch time.

The machine efficiencies estimated for three strategies explained above are shown with R1, R2, and R3 respectively. In these estimations, different number of spindles and different lambda values are considered as shown in Figures 2,3,4,5. R1 and R2 values are obtained by simulation as illustrated in Appendix2 and in Appendix3. R3, however, is calculated by R3=R1 x (7,5/8) = 0,9375 x R1 formula or equation.

4. RESULTS AND DISCUSSION

1. As seen from Figure 2, 3, 4, 5 the machine efficiency R1 is higher than R2 and R3 for all lambda and for all number of spindles considered in any case as expected. However, this application requires additional operator and therefore additional cost.

2. Figure 2 indicates that in case of three machines assignment, the machine efficiency R2 values seem nearly same with R1 values for 0.03 and 0.1 lambda interval. However, after 0.1 lambda value R2 values decrease with respect to R1 values keeping its superiority against R3 values. In spite of this superiority against to the strategy 3 may not be preferable for some high lambda values due to some risks to be indicating bellow.

3. It is seen from Figure 3, 4, 5 the strategy 2 can be profitable even 4, 5, 6 machines assignment as long as it is worked small lambda values. For example, in case of three machine assignment to apply strategy 2 may be profitable until 0.2 lambda value perhaps for more than it. On the other hand, in case of six machine assignment to apply same strategy may be economical until 0.10-11 lambda values provided that some risks are considered. However, it is seen from Figure 5-6 as if this application can be useless and costly for 0.10-0.20 high lambda values.
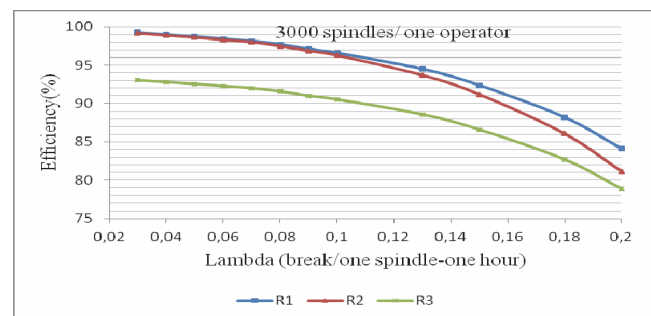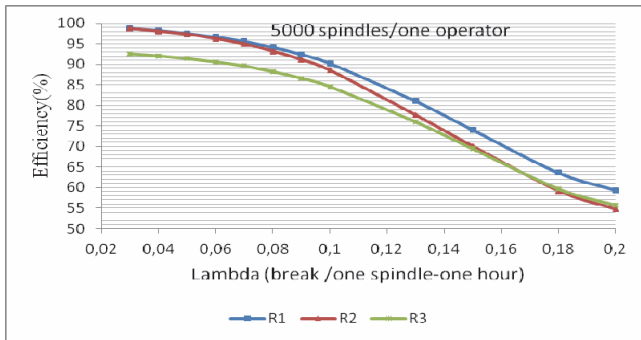

Figure 2. R1, R2 and R3 machine efficiency values for different lambda values in case of 3000 spindles (3 machines) assigned one operator (walking time TW = 0.000125 h, mending times TM_1= 0,00139 h and TM_2= 0,00167 h)
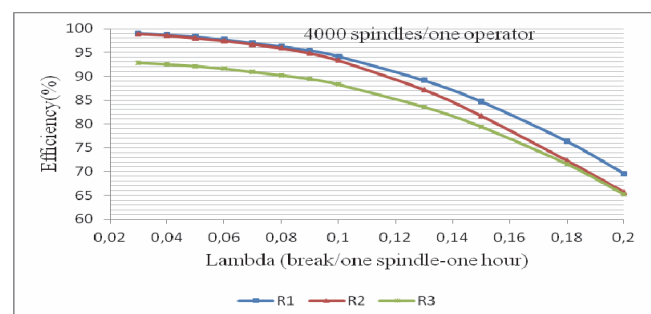
Figure 3. R1, R2 and R3 machine efficiency values for different lambda values in case of 4000 spindles (4 machines) assigned one operator (walking time TW = 0.000125 h, mending times TM_1= 0,00139 h and TM_2= 0,00167 h)

Risk is term that can be defined as the possibility of suffering harm from hazard and hazard is a source of risk that refers to actions that can cause harm. Technical assessment of nature and magnitude of risk as called risk assessment. Risk analysis is new tools and techniques of industrial sectors these days although this concept has many hundreds of year's history. Risk analysis refers to managerial tools that provide technical and vital information

in which management take sound actions for treating the risks. There are many goals and objectives of risk analysis within organization. The main goal is to strike and economic balance between the impacts of the risks on the enterprise and cost of implementing prevention and protective countermeasure (4). One of these risks to be mentioned here, may be, for example, roving of to be wound on the roller mills due to insufficient humidity, temperature, lack of pneumofil suction, lack of antistatic in row material, etc. In these cases, the costly and dangerous important results, such as breaking of roller or bearing and fire due to accumulation and compression,
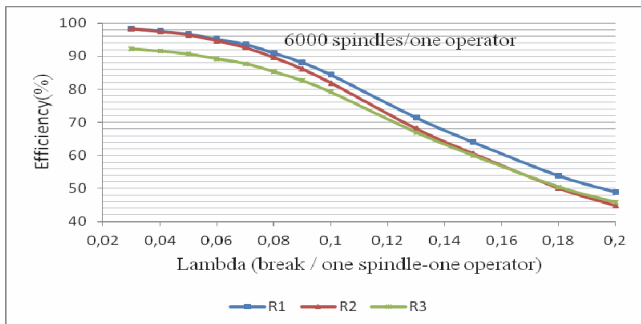

Figure 4. R1, R2 and R3 machine efficiency values for different lambda values in case of 5000 spindles (5 machines) assigned one operator (walking time TW = 0.000125 h, mending times TM_1= 0,00139 h and TM_2= 0,00167 h)

Figure 5. R1, R2 and R3 machine efficiency values for different lambda values in case of 6000 spindles (6 machines) assigned one operator (walking time TW = 0.000125 h, mending times TM_1= 0,00139 h and TM_2= 0,00167 h)
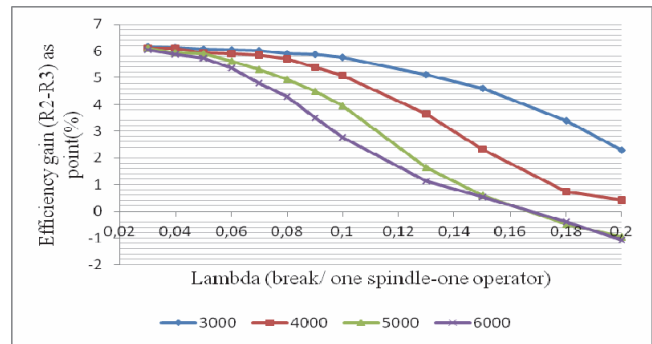
Figure 6. The advantage and disadvantage of the operating of machines without the operator supervision versus shut down machines in the lunch time.

5. CONCLUSION

As can be seen from the related figures, to allow the running machines going on operating without supervision of operator in lunch time of 30 minutes can be profitable particularly in case of small lambda values, which mostly related to type of material used(carded cotton, combed cotton, polyester, wool, etc), quality of material used in the yarn (the average length of fibers and their distribution, fines, strengths, etc), the characteristics of yarn (twist and count), machine settings (like adjustment of drafting cylinders and others), the condition of ring travelers and condition of environment (humidity and temperatures). However, this application may be economical even for medium lambda values in case of high number of spindles assigned operator providing that it will be able to compensate the cost of some risks due to without supervision of operator.

ACKNOWLEDGEMENTS

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ALGORITHM

Step 1. Determine given and to be determined parameters:
   A) Given main parameters
      a) Number of machines to be assigned per operator N
      b) Operator walking time (between two machines) TW
      c) One stoppage mended time TM
      d) Rate of stoppage λ
   B) Given auxiliary parameter
      a) Number of operator cycles Z
   C) To be determined parameters:
      a) Average efficiency of machines for Z th cycle.
      b) Weighted average efficiency of machines up to end of Z th cycle.
      c)Cycle time or total spent time (for walking and mending) by operator for Z th   cycle.
      d) Average stoppage time of one machine for Z th cycle.
      e) Total number of machines stoppages for Z th cycle.
      f) Total number of machines stoppages mended by operator for Z th cycle.
      g) Number of running machines at the end of Z th cycle.
      h) And averages of these seven parameters for Z cycles.
Step 2. Decide to the state of all the machines at the beginning of first cycle considering whether all machines are running or all machines are stopping. For this aim set up a variable named STATE
   a)   If all machines are accepted as stopping then do equal variable of "STATE (m)" to 1 (m = 1 to N) and go to Step 4
   b)   If all machines are accepted as running then do equal variable of "STATE (m)" to 2 (m = 1 to N)
Step 3. Define a variable for Running Times of every machine named RUNTIME (m) (m =1 to N). To calculate running times of every machine constitute Random Number of Exponential Distribution. For this aim, make up a Random Number "r" (0<r<1) for every machine and use the formula shown bellow.

$$\text{RUNTIME (m)} = -(1/\lambda) \times \ln(r) \qquad (m = 1 \text{ to } N) \qquad 0< \text{RUNTIME (m)} < 1$$

Step 4. Define a variable for Total Stopping Time for every machine named TOSTTM (m) and make this variable of all machines equal to zero at the beginning of first cycle.   TOSTTM (m) = 0   (m=1 to N)
Step 5.
   a) Define a variable for Number of Stoppage Mended by operator, for example, named
      NUSTMN.
   b) Make this variable equal to 0 at the beginning of first cycle (NUSTMN=0)
   c) Define a variable for Total Number of Stoppage (mended plus not mended) TNUST
   d) Make this variable equal to 0 at the beginning of first cycle (TNUST=0)
Step 6. Start operation cycle. Operator is moving towards from m=1th machine to next machine, that is, m=2nd machine with walking time TW (1th machine is accepting as running at the beginning of first cycle as expressed before)
   A) If 2 nd machine is stopping, that is, if STATE (2) =1 then,
    A.1) Mend this machine with mending time TM and show this machine is running, that is,
       make STATE (2) = 2
    A.2) Recalculate the running time of this 2 nd machine according to procedure
        explained in Step 3
    A.3) Add walking time TW and mending time TM to Total Stopping Time TOSTTM of
       every stopping machines between 1 th and N th,
    A.4) Reduce walking time TW and mending time TM from running times
        RUNTIME (m) of all running machines.
    A.4.1) If after reducing operation running times RUNTIME (m) of these running
        machines have approached to zero enough (For example < E = 0.00000001 hour)
        then accept these machines have just stopped and make state of these machines
        STATE (m) =1
    A.4.2) If just stopped machines were passed by operator then add one number of
        stoppage to Total Number of Stoppage TNUST only.
   B) If 2 nd machine is running, that is, if STATE (2)=2 then,
      B.1) Add walking time TW only to Total Stopping Time TOSTTM of every stopping
        machines between 1 th and N th,
      B.2) Reduce walking time TW only from running times RUNTIME (m) of all running
        machines.
      B.3) If after reducing operation running times RUNTIME (m) of these running
        machines
        have approached to zero enough (For example < E = 0.00000001 hour) then accept
        these machines have just stopped and make state of these machines STATE (m)=1
      B.4) If just stopped machines were passed by operator then add one number of stoppage
        to Total Number of Stoppage TNUST only.
Step 7. Return Step 5 and continue to these processes (without to redefine variables and their names) until N machines are controlled by operator, that is, until one cycle is completed by operator.
Step 8).

a) Calculate Cycle Total Stopping Times of all machines CTOSTTM accumulating Total Stopping Times of all Machines TOSTTM (m).

$$CTOSTTM = \sum_{m=1}^{N} TOSTTM(m)$$

b) Calculate Cycle Average Stopping Time of one Machine CATOSTTM dividing Cycle Total Stopping Times of all machines CTOSTTM to total number of machines N

    CATOSTTM = CTOSTTM / N

c) Define as Cycle Number of Stoppage Mended CNUSTMN considering added last Stoppage Mended to Number of Stoppage Mended NUSTMN

d) Define as Cycle Total Number of Stoppage CTNUST considering added last Stoppage to Number of Stoppage TNUST

e) Determine Cycle Time of Operator CTO, in other words, the time spent by operator by walking and by stoppage mending from 1 th machine to N th machine for calculation use bellow formula.

$$CTO = N \times TW + CNUSTMN \times TM$$

f) Determine number of running machines just at the end of Z th cycle NUMRAN. To make this accumulate all number of machines which their STATE(m)=2 at the end of cycle.

g) Calculate average machine Efficiency E for Z th cycle considered (it is valid for all identical machines)

    E = (CTO – CATOSTTM) / CTO

h) Calculate weighted average machine Efficiency EW for total Z cycles considered (it is valid for all identical machines)

$$EW = \sum_{i=1}^{Z} (CTO \times E) / \sum_{i=1}^{Z} (CTO)$$

Step 9. Return Step 4 and repeat these processes (without to redefine variables and their names) until Z th cycle is completed by operator, which is determined at the beginning

Step 10. Write output parameters shown bellow for every Z cycles:

a) Cycle Time of Operator CTO (with new notation TC)
b) Average Stopping Time of one Machine CATOSTTM (with new notation TS)
c) Cycle Total Number of Stoppage CTNUST (with new notation NS)
d) Cycle Number of Stoppage Mended CNUSTMN (with new notation NM)
e) Number of running machines just at the end of Z th cycle NUMRAN (with new notation NR)
f) Average Machine Efficiency for Z th cycle considered E
g) Weighted average machine Efficiency for total Z cycles considered EW

APPENDIX 2

Cycle by cycle the machine efficiency values obtained by means of the simulation program. In this program we accept a) at the beginning of operator working all spindles are working b) operator servicing system is periodical, c) number of spindle assigned one operator is 4000, d) distribution of breakings comply Poisson distribution and rate of breaking for per hour λ= 0.1, in other words, rate of breaking for 1000 spindle hour is 100, e) distance between two spindles is 75 mm f) operator walking time between two spindles is 0,6 m/sec or 0.000125 h as fixed, g) operator mending time of one breaking comply uniform distribution and both maximum and minimum mending time are 0,00167 h and 0,00139 h respectively, i) all spindles are identical, j) there is no any time that machines run without operator supervision.

Cycle Number	Number of broken mended in that cycle (hours)	Time spent by operator to complete that cycle (hours)	Average stop time for one spindle in that cycle	Number of total broken in that cycle	Time (duration) without operator supervision in that cycle (hours)	Machine efficiency for that cycle %	Cumulative machine efficiency up to that cycle (considering Cycles times) %
1	135	0.708	0.019	316	0.00	97.42	97.42
2	390	1.097	0.059	645	0.00	94.74	95.79
3	504	1.277	0.083	780	0.00	93.45	94.82
4	533	1.316	0.088	812	0.00	93.10	94.32
5	552	1.346	0.095	836	0.00	92.65	93.92
6	572	1.377	0.102	861	0.00	92.44	93.63
7	530	1.310	0.087	770	0.00	93.52	93.62
8	455	1.194	0.068	671	0.00	94.26	93.70
9	411	1.128	0.060	642	0.00	94.61	93.79
10	426	1.154	0.064	641	0.00	94.56	93.87
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90	460	1.207	0.074	703	0.00	94.01	94.12
91	463	1.209	0.073	690	0.00	93.93	94.12
92	447	1.185	0.069	682	0.00	94.31	94.12
93	436	1.166	0.065	655	0.00	94.34	94.13
94	464	1.213	0.070	713	0.00	94.44	94.13
95	449	1.187	0.070	694	0.00	94.24	94.13
96	457	1.199	0.071	687	0.00	94.33	94.13
97	448	1.186	0.072	689	0.00	93.80	94.13
98	458	1.202	0.071	714	0.00	94.28	94.13
99	494	1.255	0.074	705	0.00	94.07	94.13
100	416	1.139	0.060	636	0.00	94.79	94.14
Average	450.8	1.191	0.072	697.40	0.00	94.08	94.14

APPENDIX 3

Cycle by cycle the machine efficiency values obtained by means of the simulation program. In this program we accept a) at the beginning of operator working all spindles are working b) operator servicing system is periodical, c) number of spindle assigned one operator is 4000, d) distribution of breakings comply Poisson distribution and rate of breaking for per hour λ= 0.1, in other words, rate of breaking for 1000 spindle hour is 100, e) distance between two spindles is 75 mm f) operator walking time between two spindles is 0,6 m/sec or 0.000125 h as fixed, g) operator mending time of one breaking comply uniform distribution and both maximum and minimum mending time are 0,00167 h and 0,00139 h respectively, i) all spindles are identical, j) there is 0.5 h lunch and resting time after every 7.5 h operator working time period as indicated below, g) after lunch break time the operator returns to the same spindle that had left it to lunch.

Cycle Number	Number of broken mended in that cycle	Time spent by operator to complete that cycle (hours)	Average stop time for one spindle in that cycle (hours)	Number of total broken in that cycle	Time (duration) without operator supervision in that cycle (hours)	Machine efficiency for that cycle %	Cumulative machine efficiency up to that cycle (considering cycles times) %
1	135	0.708	0.019	316	0.00	97.42	97.42
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4	533	1.316	0.088	812	0.00	93.10	94.32
5	552	1.346	0.095	836	0.00	92.65	93.92
6	572	1.377	0.102	861	0.00	92.44	93.63
7	683	1.546	0.186	1002	**0.50**	91.13	93.19
8	565	1.368	0.091	805	0.00	92.23	93.19
9	466	1.214	0.071	665	0.00	94.28	93.31
10	413	1.135	0.059	631	0.00	94.75	93.44
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----	----	----	----	----	----	----	----
90	478	1.236	0.073	709	0.00	94.17	93.21
91	453	1.193	0.071	691	0.00	94.20	93.22
92	442	1.178	0.070	682	0.00	94.07	93.23
93	473	1.228	0.115	864	**0.50**	93.41	93.23
94	663	1.518	0.134	979	0.00	91.12	93.21
95	581	1.391	0.101	855	0.00	92.34	93.20
96	532	1.317	0.086	775	0.00	93.74	93.20
97	447	1.185	0.068	676	0.00	94.31	93.21
98	439	1.171	0.066	665	0.00	94.12	93.22
99	501	1.269	0.139	878	**0.50**	92.30	93.21
100	635	1.473	0.115	923	0.00	92.64	93.21
Average	516.3	1.292	0.095	782.23	0.085	93.26	93.21