國立雲林科技大學工業工程與管理所
Graduate school of Industrial Engineering & Management,
National YunlinUniversity of Science & Technology

A new approach to define sample size at attributes control chart in multistage processes: An application in engine piston manufacturing process

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作者： Ihsan Kayaa, *Orhan Engin*
報告學生：田馥華
指導老師：童超塵教授

Abstract

- The aim of the model is to determine the sample size for ACC.
- When GA solves the model, two main parameters are determined for every stage.
  - sample size, *n*
  - *acceptance number, c*

Contents

Keywords： Attribute control charts; Engine piston manufacturing; Multistage inspection problems; Genetic algorithms; Attribute control chart (ACC)

Introduction

- In attribute control charts, defining sample size is a problem.
- In this study, defining sampling size in attribute control charts is tried to be clarified under maximum acceptance probability and minimum cost constraints.
- GAs have a distinct advantage over the other artificial techniques, which is the possibility of obtaining good solutions even when radical alterations are performed on the statement of the problem.

Introduction

- And additionally, the number of constraints or the number of objective functions, do not affect the solution methodology or behavior of the algorithm completely.

Literature review

- Viharos and Monostori (1997), Celano and Fichera (1999) used GAs for control charts. Designing, cost minimization and economically design of control charts problems were solved by GAs.

- Wehrens et al. (1999), used GAs to define parameter of design experiment, and they defined best design parameter for quality.

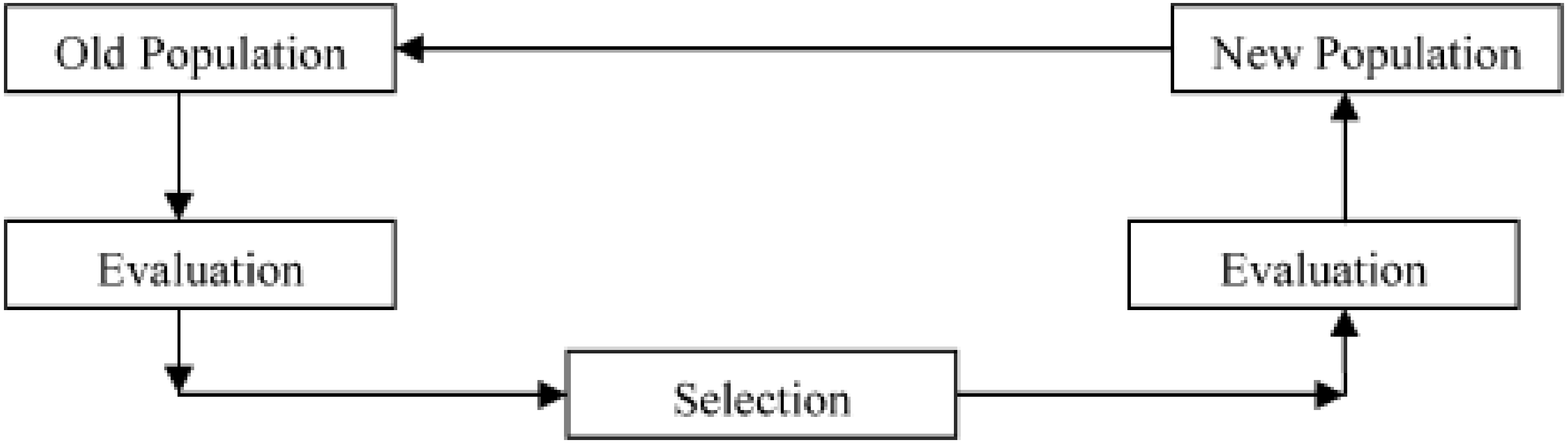
- Langner et al. (2002) formulated a multistage inspection problem and it was solved by using genetic algorithms.

Literature review

- Bakır and Altunkaynak (2004) improved a model for determining the shifts in the process mean and process variability help of x and R control charts. This model was solved with the help of GAs. GAs’ results are better then other techniques, which are in literature.

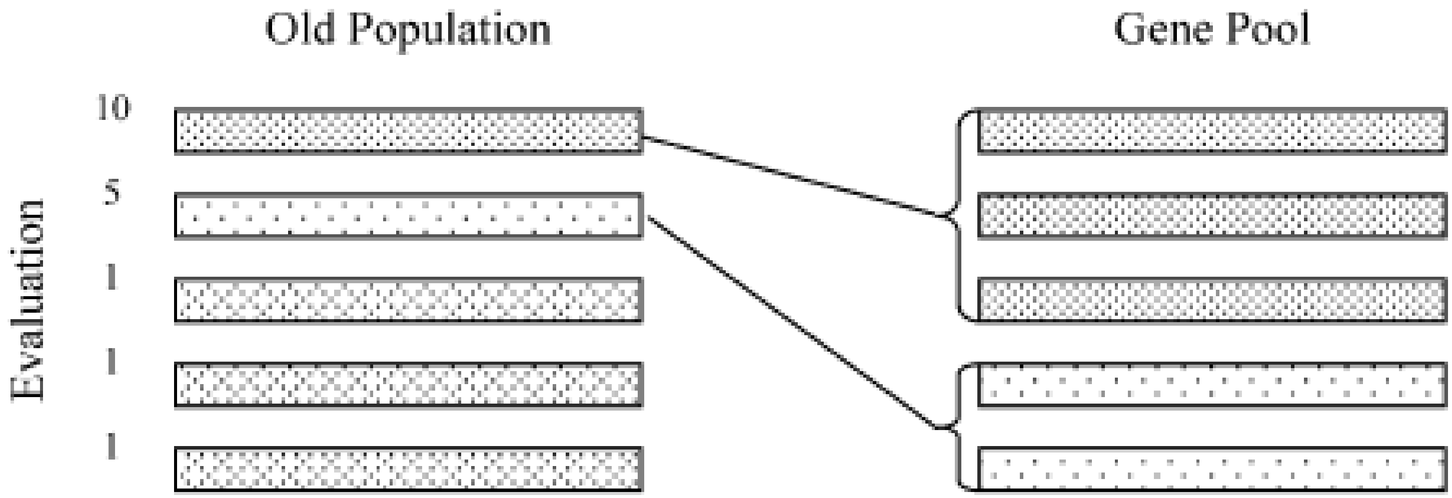
Genetic algoriyhms

❖ Since 1960s, there has been an increasing interest in the development of powerful algorithms to solve difficult optimization problems. This term is called evolutionary computation.

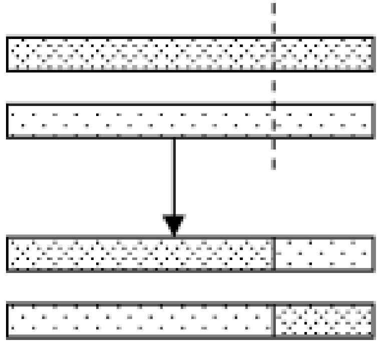


(a) Basic Genetic Algorithm Cycle

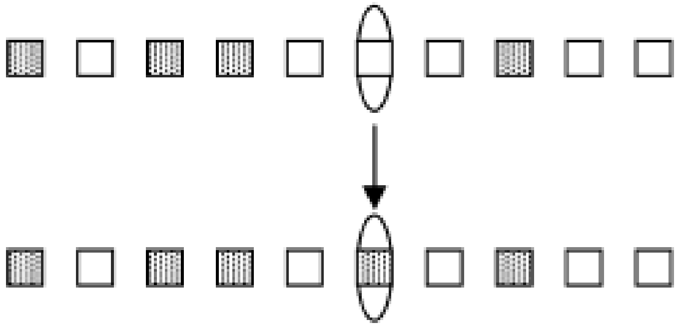
Genetic algoriyhms



(b) Evaluation and Contribution to the Gene Pool



(c) One-point Crossover



(d) Mutation

Genetic algoriyhms

- *Encoding*-Binary encoding
- *Selection*-Roulette wheel selection
- *Recombination*-the most important tool for Gas
  - *One-point crossover (OPX)*
  - *Position-based crossover (PBX)*
  - *Order crossover (OX)*
  - *Partial-mapped crossover (PMX)*
  - *Linear order crossover (LOX)*
- *Mutation operator*
  - *Inversion mutation*
  - *Neighbor exchange mutation*
  - *Reciprocal exchange mutation*
  - *Triplet mutation*
  - *Insertion mutation*

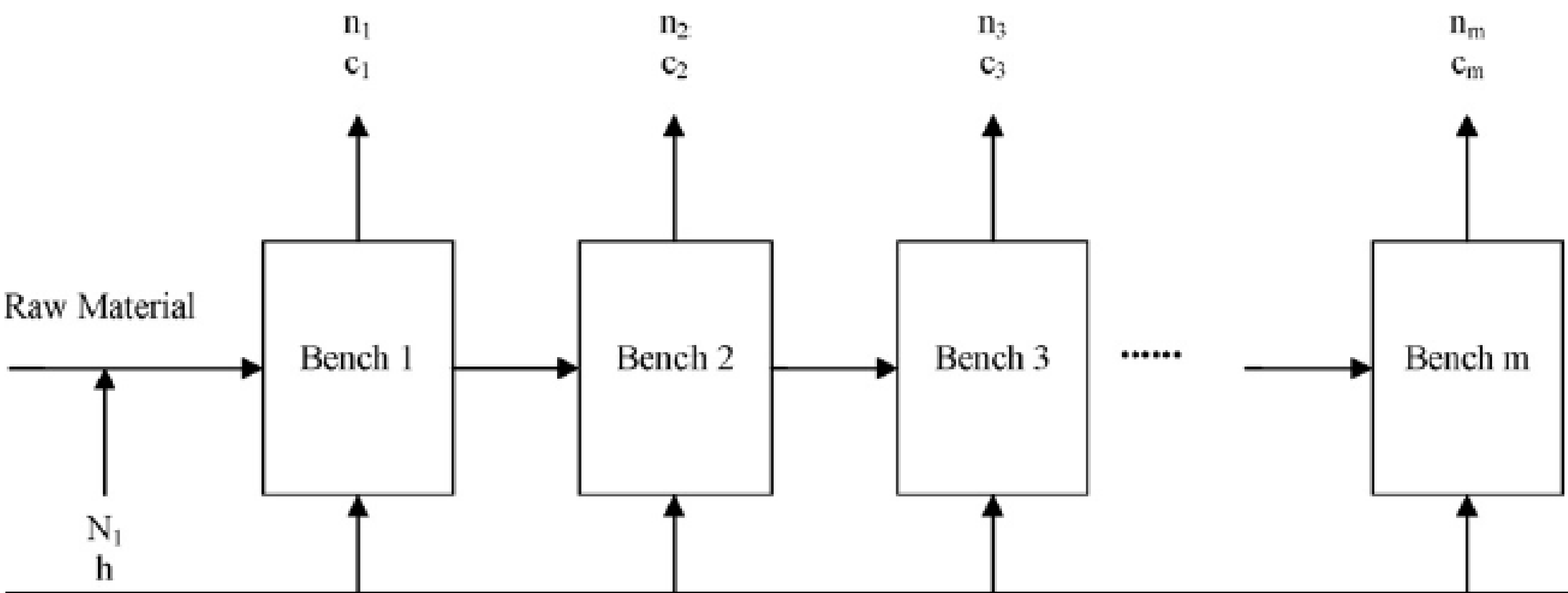
Description of the process

- In this paper, acceptance sampling approach is applied as a multistage process.

- Kolarik (1995), sample sizes in attributes control charts are typically much larger than sample sizes in variable control charts.

- Probably cost is very important but firstly, we should take enough sample size to fit our needs for control charts.

Description of the process



m ：*stage number*
ti ：*defective item rate for bench (stage)*
h ：*defective item rate for raw material*
Ni ：*lot size in stage i*
ni ：*sample size in stage i*
ci ：*acceptance number in stage I*
GKS*i* ： *defective number item for incoming to stage i*
TBPS*i* ：*defective number item which spoiled in bench in stage i*
TBKPS*i* ： *defective number item, which spoiled in bench but it* was defective

The proposed model

- GKS1 = *N1h1, i= 2, 3, . . . , m*
- TBPS*i* = *Niti, i= 1, 2, 3, . . . , m*
- TBKPS1 = *ht1N1*
- TBKPS1 = *Di−1t1 i = 2, 3, . . . , m*
- *Di = GKSi + TBPSi + TBKPSi*
- *Ni = Ni−1 − ki−1 i = 2, 3, . . . , m*
- *pi = Di/Ni*

$$P_{ai} = \sum_{x=0}^{c_i} \frac{\binom{D_i}{x}\binom{N_i - D_i}{n_i - x}}{\binom{N_i}{n_i}}$$

$$\text{and } P_{aT} = \prod_{i=1}^{m} P_{ai}$$

GKS*i* ： *defective number item for incoming to stage i*
Ni ：*lot size in stage i*
h ：*defective item rate for raw material*
TBPS*i* ：*defective number item which spoiled in bench in stage i*
ti ：*defective item rate for bench (stage)*
Di ：*total defective item number in stage i*
TBKPS*i* ： *defective number item, which spoiled in bench but it* was defective
ki ：*defective item number which found in stage i*
pi ：*proportion of defective item in stage i*
Pai ：*acceptance probability in stage i*
PaT ：*total acceptance probability for all stages*

The proposed model

$$\min C=\sum_{i=1}^{m} n_i m_i+\sum_{i=1}^{m} k_i \sum_{j=1}^{i} u_j+\sum_{i=1}^{m}(r_i p_i[(N_i-n_i)p_i \mathrm{C}k_i -r_i]p_{\mathrm{a}i})$$

Subject to:

$$P_{\mathrm{aT}} \geq P_{\mathrm{aT}}^{*}$$

$$n_i \geq c_i$$

$$n_i \geq k_i$$

$$c_i, k_i \leq D_i$$

ni ：*sample size in stage i*
m ：*stage number*
ki ：*defective item number which found in stage i*
ui ：*manufacturing cost item in stage i*
ri ：*rejection cost item in stage i*
pi ：*proportion of defective item in stage i*
Ni ：*lot size in stage i*
Cki ：*cost because of defect in stage i*
Pai ：*acceptance probability in stage i*
PaT ：*total acceptance probability for all stages*
ci ：*acceptance number in stage I*
Di ：*total defective item number in stage i*

Computational results

Table 2
Results of mutation and crossover operators

Crc

On

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Table 4
Results of mutation ratio

Table 5
Results of experiment

Parameter	Best value
Crossover parameter	Linear order crossover (LOX)
Crossover ratio	0.2
Mutation parameter	Neighbor exchange mutation (NEM)
Mutation rate	0.9

0.9	1132.07389	1139.966284
1.0	1132.07389	1148.548353

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An application in a piston manufacturing process

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
N_i	500	499	498	496	491	489
h (%)	0.1	0.0	0.0	0.04	1.01	1.43
t (%)	0.21	0.3	0.9	1.1	0.1	0.15
m_i	10	10	15	5	8	7
u_i	75	70	250	50	50	50
r_i	100	100	300	75	70	75
C_{ki}	85	70	300	70	70	90
GKS_i	0	1	1	2	5	7
n_i	4	5	7	7	4	5
c_i	1	1	3	3	2	1
P_{ai}	0.99999	1.00000	0.99999	0.99988	0.99118	0.999665
$Cost_i$	21.92	80.00	5,386.54	811.5987	2,381.29	2,620.878
Pat	0.90	0.90	0.90	0.90	0.90	0.90

$Cost_i$	677.1957249	2120	1567.927515	2159.497372	3776.506659
P_{aT}	0.85	0.85	0.85	0.85	0.85

An application in a piston manufacturing process

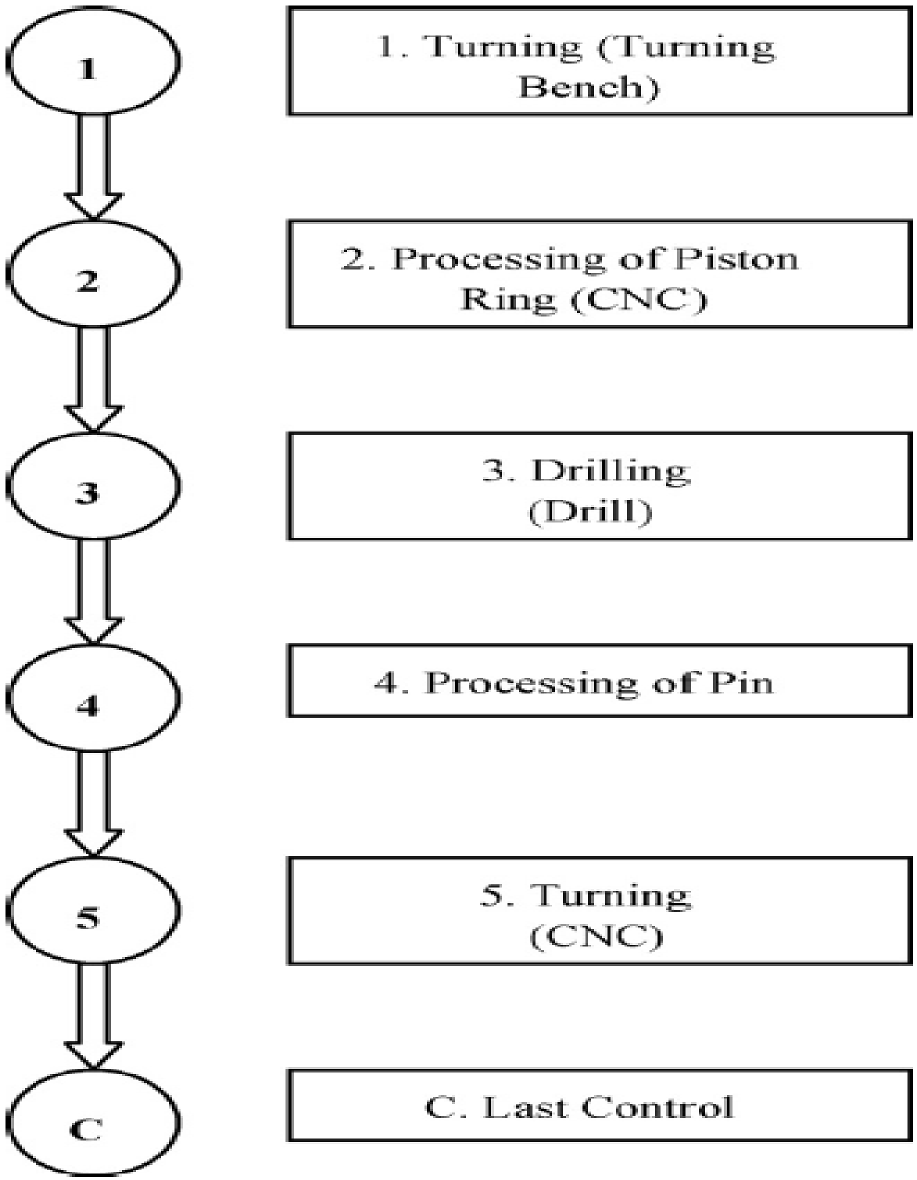

Fig. 5. Flow of piston production.

Conclusions

- GAs can be used to solve quality control problems.

- When these parameters are used, the performance of GAs, which are used to solve quality problems, will be increased.

- GAs can be used for defining sample sizes in attribute control charts very effectively.

- In future research, this approach can be improved for variable control charts, especially economical design. This approach is tested in piston production process; it will be tested in other production stages.

Thank You !