# CHAPTER 4

# AGA BASED MULTI-PERIOD DTO OF EOL PRODUCTS

In this chapter, a novel meta-heuristic strategy is proposed based on an adaptive genetic algorithm (AGA) for acquiring high benefit from the End-of-life (EOL) reverse logistic operation. The objective of the proposed model is to decide the best blend of the quantity of every item sort to be reclaimed from the end user. The EOL items are then dismantled for the recovery of reusable materials and exchanged so as to meet a particular level of interest under an assortment of physical, monetary and natural imperatives. The surplus materials are reused, put away for utilization in resulting periods or legitimately arranged.

In the present dynamic world, the general public is relentlessly moving to a fast track of economic and industrial development. Innovative improvements, in the zones of both item and process advances, are occurring at a quick pace (B.S. Rathore, 2001). Shortening of thing life cycles, rapid advancement, innovations and part improvements are pointers to the fast-changing manufacturing situation. Fundamental and strengthening these globalization patterns are the quickly changing mechanical condition (M.Z. Muhammad et al. 2010).

Increasing global competition coupled with rapidly changing technology, and shortening of product life cycles, have made corporations vulnerable to failure more than any time in the past (A. Jalan and B.H. Kleiner, 1995). Organizations, which are able to continually build new strategic assets faster and cheaper than those of their competitors, will create long-term competitive advantages (A. Ajitabh, and K. Momaya, 2004). Advance the current headways and agile development in the field of data innovation has opened up the conduits and prompted to the globalization of economies and has brought about the worldwide rivalry between the associations ((H.H. Vanden-Kroonenberg, 1989), (D. Leonard-Barton, 1991)).

As the organizations confronted with element condition and the item and innovation life cycles are likewise getting abbreviated. The technologists left with short response time for saddling. The overwhelming ventures required for indigenizing the R&D exercises inside the association (C. Piggies' and M.V. Thirumurthy, 1996; A. Gungor and S.M. Gupta, 1999). Obsolete items are additionally regularly marked as end-of-life (EOL) items. There is devour of strategies to direct these things, for example, reprocess, reuse or transfer, to give some examples.

As overseeing returns involve a particular course of action and information following instruments, reverse logistics temporary workers have to acknowledge as the sought ones (E. Grenchus et al. 1997; V.D.R. Guide et al. 1997). The presence of different measuring sticks and the viewpoint of the leader tend to scale up the complexity of the determination (Bloemhof-Ruwaard et al. 1995).

Dismantling is the underlying methodology to recover parts and materials from EOL items for re-utilization and reprocess. One of the unique strategies to manage the resultant threat is to depend on the work of heuristic procedure to change the stochastic brand into a deterministic mode and after that set out to comprehend the deterministic danger (L. Moyer and S.M. Gupta, 1997). In result, the crucial point here is to streamline the quantity of the reclaimed item to be dismantled to upgrade the benefit of offering segments and materials, without in any capacity making harm the eco-framework.

A portion of the current research business related to the end of life reverse logistic recorded as takes after.

A metaheuristic strategy to reduce the operational cost of waste electrical and electronic items have proposed by Luu Quoc Dat et al. (2012). Strategy for the end of vehicle reverse logistics to solve the issue in outside supplier was suggested by Mahdi Mahmoudzadeh et al. (2013). A linear programming model for determining the reusable items from the reverse logistics was developed by Sónia R. Cardoso et al. (2013). A comprehensive model for the return product prediction was done by Harold Krikke et al. (2013). So far proposed the system in reverse logistics have predicted the end user product performance, however, the prediction accuracy is not satisfactory level. Thus the proposed system a metaheuristic approach is applied to determine the best combination of E-O-L product for D-T-O. The proposed model can enhance the profit and reduce the loss in reverse logistics.

## 4.1 Genetic Algorithm

Genetic algorithm (GA), at first conveyed to spotlight by John Holland in mid-seventies, has developed as a leader among a few strategies for machine learning and capacity improvement. By chance, an algorithm is an arrangement of following measures fundamental to be performed to finish an errand. The GA is a creative strategy enriched with particular precepts of genetics incorporated in it, of which "standard choice" and "assessment Theory" are the essential preparing principles in the execution of GA. Truth told GA mixes the versatile character of the intrinsic genetics and test is performed by the method for randomized information trade.

It is satisfying that there is a large group of test instruments, of which analytics reliant. Enumerative and arbitrary investigation strategies are discovered continually employed. The new methodologies, for example, Calculus-needy and enumerative strategies are equipped to introduce relatively radiant answers for test spaces of minor measurement and the large deviation from indicating a point in their zone. Truth told, much the same as all sensible advances, the viability has a tendency to be mediocre in conveying answer for complex issues, including large test space in perspective of their inadequacy to overshoot such neighborhood ideal focuses and touch base at the excellent general point. With an eye on overpowering the nearby, perfect centers fall back on the work of self-assertive test strategies.

It is correlated to note that such sort of randomized examination does not go under the ambit of directional tests. The relevant test performed arbitrarily, and the information accumulated from the analysis employed as a part of offering some assistance to the ensuing investigations. No big surprise, the remarkable Genetic algorithm gets itself stopped in the aggregation of same test strategies.

It is noteworthy to note that the impressive Genetic algorithm creeps past the whole imperatives relating to the conventional strategies said somewhere else, by viable utilizing the main building squares which are different from those of the conventional strategies, as point by point underneath:

- The style of GA working continues with a programming of the limitations settled and not exclusively on the requirements alone.
- The creative GA constructs its examination about a populace of focus as opposed to an emphasis on a single point taken after by the common strategies.
- The novel GA utilizes target work information, set up of the subject or other helper information.
- The unique GA tends to utilize probabilistic move controls by stochastic operands, disregarding deterministic creeds

At the outset, GA elegantly carries out the arbitrary choice of preliminary probe points from the overall probe space. Each and every point in the probe space represents one set of values for the constraints of the issue. Each constraint is programmed with a string of bits. The individual bit is termed as “gene”. The content of each and every gene is labeled as “allele”. The overall string of the related genes of all constraints written in a series is known as a “chromosome”. Therefore, there is a specific chromosome for each and every point in the probe space.

Populace speaks to a gathering of chromosomes. The number of chromosomes in populace speaks to the "populace measure", and the aggregate number of qualities in a string implies the "line length". The people are prepared and surveyed by the method for a few administrators of GA to create a new populace and the relative system proceeds till the all-inclusive ideal point accomplished. The two unmistakable fragments of the strategy are known as "era and assessment" individually.

While evaluating the GA, it outlines a wellness capacity and gauge the wellness for each and chromosome of a populace. This fitness represents a sign of the aptness of the values of the constraints characterized the relative chromosome, as a solution of the optimization dilemma in question. Furthermore, this illness employed as a predisposition for picking the guardians and creating a crisp populace from the present one (Mitsuo Gen and Runwei Cheng, 1997). The flowchart of the Genetic Algorithm (Denny Hermawanto, 2013) shown in the following Fig 4.1.

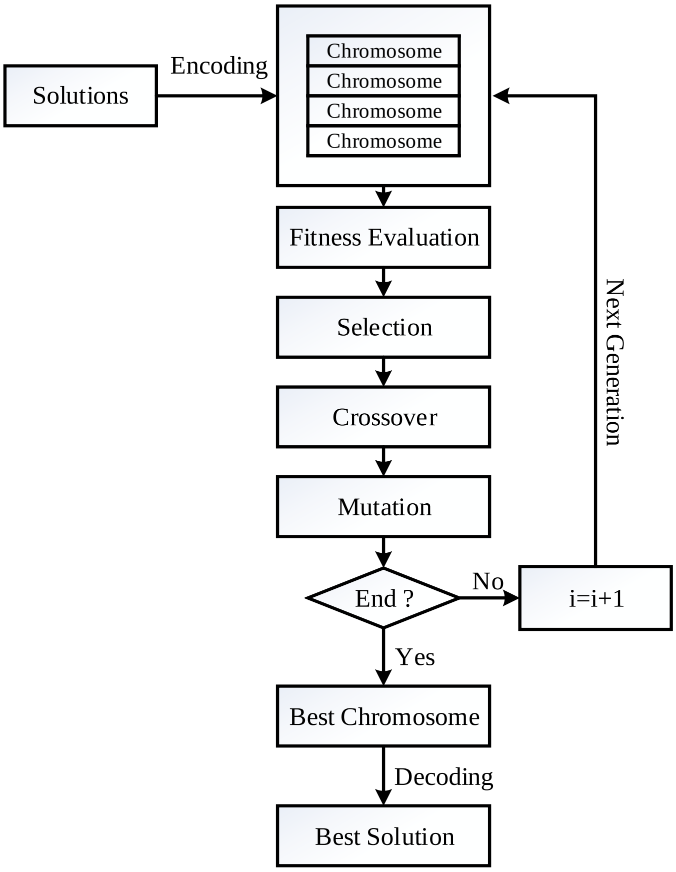


Figure 4.1. Genetic Algorithm Flowchart

## 4.2 Proposed Meta-Heuristic Approach for Multi-Period DTO

Dismantling to request (D-T-O) is a first procedure to make most extreme yield from the end of life (E-O-L) items. In this stage, the carved parts and materials are expelled methodically from the first E-O-L items. Besides the D-T-O is the hardest procedure while playing out the E-O-L reverse logistic (RL). Henceforth an appropriate grouping is necessary to get the most last pick up from E-O-L reverse logistics. The proposed E-O-L design with AGA based D-T-O engineering appears in Fig 4.2.

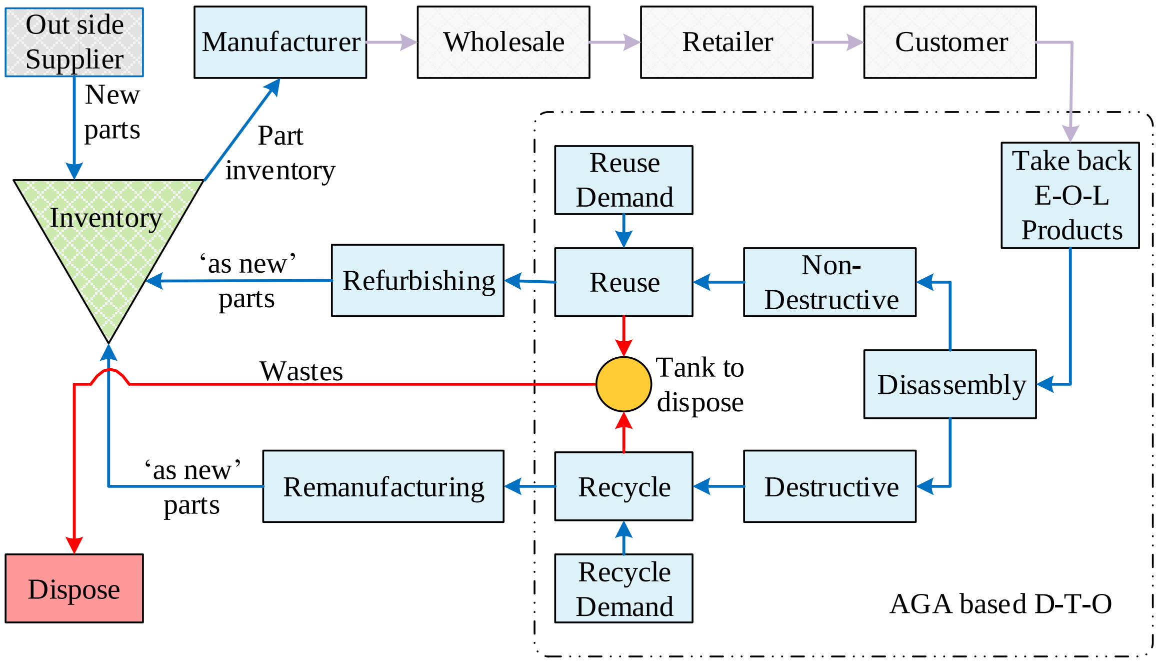


Figure 4.2. AGA based E-O-L Reverse Logistic Architecture

In this part, two major kinds of disassembly are applied such as destructive and non-destructive. The architecture of the proposed system shown in Fig 4.2. The above design shows the complete E-O-L reverse logistic flow, which is for the end user or collection point, then flows in manufacturing and back to the user via retailer as a new product. Initially, the collected E-O-L products are kept in a storage space or inventory or may be outside of the particular manufacturing plant. Then some of the required amounts of product are sent to reverse logistic operation. The objective of the proposed strategy is to reduce the total cost needed for the reverse logistics.

### *4.2.1 Formation of Objective Function*

Disassembly to order is an essential process in the E-O-L disassembly; the D-T-O process leads huge loss due to improper product selection. Hence it is essential to select the best suitable combination of E-O-L product for the purpose of D-T-O. Thus the principal objective of this chapter is to reduce the disassembly cost by choosing the most appropriate mix of E-O-L products.

The aggregate no of procurement components (PC), as well as the aggregate no of disposal component (DC), can recognize by utilizing the accompanying conditions (4.1) and (4.2) separately (P. Imtanavanich and S.M. Gupta, 2004).

$$PC_j = \max[RUD_j - \sum_i (EP_i \cdot NDY_j);0] \tag{4.1}$$

$$DC_j = \max[\sum_i (EP_i \cdot NDY_j) - RUD_j;0] \tag{4.2}$$

Where,

'$PC_j$' - Total number of Procured Components in unit;

'$DC_j$' - Total number of Disposed Component in unit;

'$RUD_j$' - $j^{th}$ type Reuse component demand in unit;

'$EP_i$' - $i^{th}$ type whole E-O-L products in unit;

'$NDY_j$' - Non-Destructive disassembly Yield in %;

The principle goal of this chapter is to limit the aggregate cost, which incorporates add up to reclaim value, add up to acquisition cost and total transfer. The capacity for the full price given in the beneath eqn. (4.3).

$$TC = \sum_i (EP_i \cdot bc_i) + \sum_j (pc_j \cdot PC_j) + \sum_j (dc_j \cdot DC_j) \tag{4.3}$$

Where,

'$bc_i$' - unit take-back cost for product i (Rs/unit)

'$pc_j$' - unit procurement cost for component type j (Rs/unit)

'$dc_j$' - unit disposing cost for component type j (Rs/unit)

$$EP_i, PC_j, DC_j \geq 0$$

The eqn. (4.1) is the aggregate cost required for E-O-L reverse logistics. At that point, the target of this work is to limit the total cost. Defining of the aggregate cost work turns into a perplexing undertaking when all is said in one case since it might contain various items and part. Subsequently, improvement favored for settling the errand. This chapter pick up the genetic algorithm (GA) development. The definite dialogue on the traditional GA is given in the area underneath.

### *4.2.2 Modelling of GA based Optimization for D-T-O*

One of the critical processes in reverse logistics is D-T-O, particularly in E-O-L reverse logistic. So as to decrease the multifaceted nature in D-T-O handle the delicate figuring process like streamlining entered in the reverse logistic process. The result got after the entrance of the advancement is better than anyone might have expected. With a specific end goal to meet the greatest level of enhancement and to acquire more benefit, this work utilizing the GA advancement in E-O-L reverse logistics. GA is one of the most popular strategy for the optimization. The described of the proposed strategy is examined as takes from ref. (A.J.D. Lambert, 2003). Step by step procedure involved in the proposed approach is as follows;

**4.2.2.1** *Initialization*

In this stage, the population is initialized to determine the optimal solution. This essential populace is thinking about as the fundamental chromosomes of the GA. The proposed strategy is thinking about three parameters for every chromosome. The three parameters employed are procurement cost, take back cost and disposal cost. The introduced capacity is given as takes after.

$$f(x) = \{pc, bc, dc\} \tag{4.4}$$

After this arbitrary introduction, a portion of the best mix arrangements chosen for further preparing.

**4.2.2.2** *Selection*

The choice of reasonable chromosomes depends on the wellness work. The welfare capacity is only the target size of the proposed strategy, which given in the eqn. (4.3). The parameters in each chromosome set is substituted in the target work and comparing total cost is acquired. In our proposed strategy our goal is to limit the aggregate value. Subsequently, the underlying chromosomes create minimal effort considered for the further handling. Along these lines from this stage a portion of the reasonable chromosomes, which will require minimal effort are chosen. At that point the chose chromosomes set for the enhancement by GA.

**4.2.2.3** *Crossover*

Crossover is the pre-update stage in GA, and the crossover provides new offerings. The new offerings generated by partial combining two parent chromosomes. Then in the next stage, the offerings are converted to the new solution.

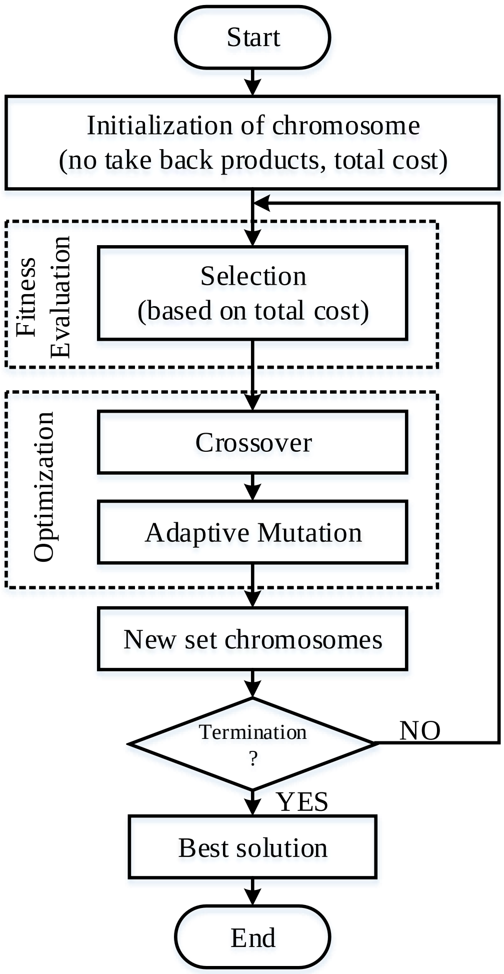


Figure 4.3. Flow chart for the proposed AGA based D-T-O

**4.2.2.4** *Adaptive Mutation*

Mutation is the heart function in GA, which helps to produce a new solution from the offerings obtained in the previous stage. To improve the performance in variation and adaptive mutation rate is used instead of random mutation. The function to calculate the adaptive mutation rate given in eqn. (4.5).

$$m_r = \sqrt{\frac{c}{2\pi}} * \frac{\exp(-c/(2(R-\mu)))}{(R-\mu)^{3/2}} \tag{4.5}$$

Where '$m_r$' is the mutation rate, 'R' is a random value [0, 1] which changes in every iteration and 'c' & '$\mu$' are mutation parameters considered as 2.

Toward the end of this adaptive mutation stage another arrangement of ideal arrangement is getting, and end criteria checked if it meets the end the procedure finished; the procedure repeated from the selection phase. The diagrammatic portrayal of the proposed system stream is given in Fig 4.3.

## 4.3 Result and Discussion

Offered the optimal D-T-O in E-O-L reverse logistics in light of GA is executed on the working platform of MATLAB 2014a, with the system configuration; Intel Core i5 processor, 8GB RAM and Windows 8.1 operating system. Give us a chance to expect a case for the trial check of our proposed strategy. The presumption must like this present reality issue yet in the low level. For this situation illustration, thinking about 100 E-O-L items, and every item contains nine segments. The product consider in this work is PC, and its parts are numbered from 1 to 9. The detail of parts and their comparing acquirement and transfer cost is given in Table 4.1.

**Table 4.1:** Component detail per product

| Item | Name of component | Material type | New product cost | Disassembly | |
|---|---|---|---|---|---|
| | | | | Cost ($) | Method |
| 1 | Outer cover | Aluminium (A) | 3 | 2 | Destructive (D) |
| 2 | Power supply | Copper (C) | 4 | 3 | Destructive (D) |
| 3 | System fan | Plastic (P) | 3 | 2 | Destructive (D) |
| 4 | RAM | Plastic (P) | 6 | 3 | Non-destructive (N) |
| 5 | DVD Drive | Aluminium (A) | 7 | 4 | Non-destructive (N) |
| 6 | Hard Disk slot | Plastic (P) | 2 | 2 | Destructive (D) |
| 7 | CPU | Plastic (P) | 6 | 2 | Non-destructive (N) |
| 8 | Heat sink | Aluminium (A) | 4 | 3 | Destructive (D) |
| 9 | Hard disk | Aluminium (A) | 6 | 2 | Non-destructive (N) |

The Table 4.1 presents the bill of material (BOM), which incorporates the segment detail alongside the dismantling. Those lost parts are numbered as '0'. The details of some of the elements are given in Table 4.2, and the total information employed for our usage is provided in the supplement segment:

**Table 4.2:** Example E-O-L product details

| Product No | Components details | Disassembly Method |
|---|---|---|
| 1 | 100000000 | D00000000 |
| 2 | 100000002 | D0000000D |
| 3 | 100000009 | D0000000N |
| 4 | 100000089 | D000000DN |
| 5 | 100000089 | D000000DN |
| 6 | 100000789 | D00000NDN |
| 7 | 100000789 | D00000NDN |
| 8 | 100006789 | D0000DNDN |
| 9 | 100056789 | D000NDNDN |
| .<br>. | .<br>. | .<br>. |
| 100 | 100456009 | D00NND00N |

The goal for this test usage is to fabricate twenty new items from the available hundred E-O-L items. In ideal case the total number of E-O-L parts as nine hundred for hundred items. Be that as it may, in down to earth situation it is impractical, due to the missing items. From the information, employed as a part of this section the most extreme no of accessible segments is four hundred sixty-three including both dangerous and non-ruinous. In this, the most intense available, non- destructive sectors are two hundred, and destructive parts are two hundred sixty-three. The total non- destructive elements can specifically utilize for the reuse with less measure of misfortune. A portion of the ruinous part in the wake of remanufacturing or reusing it can utilize for the reuse.

To make twenty new items, require hundred and eighty parts i.e. twenty numbers of every segment sort are required. Keeping in mind the end goal to fulfil our prerequisite have to take more extreme of fifty-five E-O-L items (estimated). Bearing in mind the end goal to choose the most reasonable blend, to diminish the aggregate cost the AGA employed. The execution of the proposed approach contrasted and the current methods like evolutionary programming (EP) and genetic algorithm (GA). The examination of different strategies for the E-O-L Items D-T-O given in Table 4.3.

**Table 4.3:** Comparison of various strategies

| Strategy | Take products | Cost (in $) | | |
|---|---|---|---|---|
| | | Disassembly | Procurement | Total |
| Proposed AGA | 47 | 30 | 25 | 525 |
| GA | 53 | 35 | 26 | 591 |
| EP | 55 | 38 | 26 | 614 |

From the Table 4.4, the total no of take back products by our proposed AGA strategy is 47 products, which are 6 numbers less than GA and 8 numbers less than EP. The total disassembly cost by proposed approach is 30 $, which is 5 and 8 dollars less than that of GA and EP respectively. The total procurement cost by proposed approach is 25$ which is one dollar less than both GA and EP. The total cost for the complete reverse logistic by proposed AGA method is only 525$ but for GA and EP is 591 and 614 respectively. The graphical representation for these comparisons is given in Fig 4.4 to 4.7.

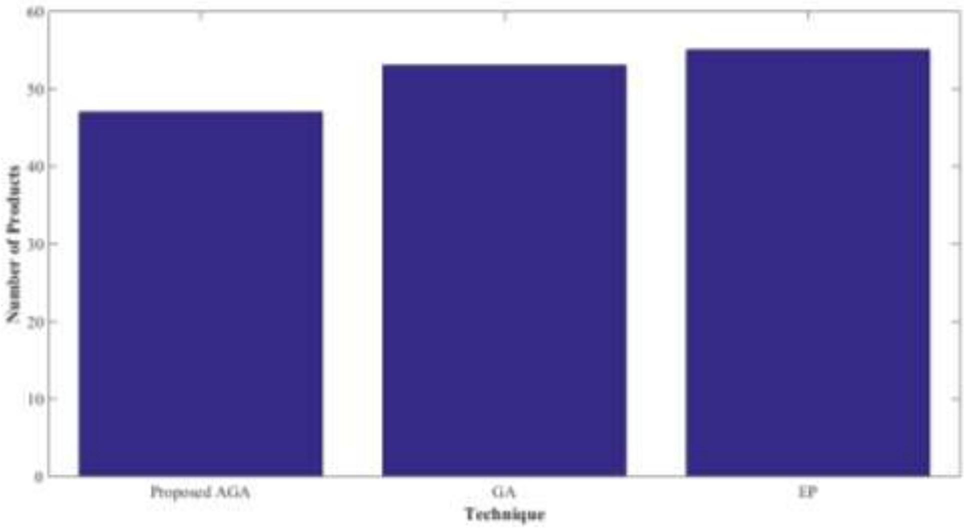


Figure 4.4. Take back products comparison

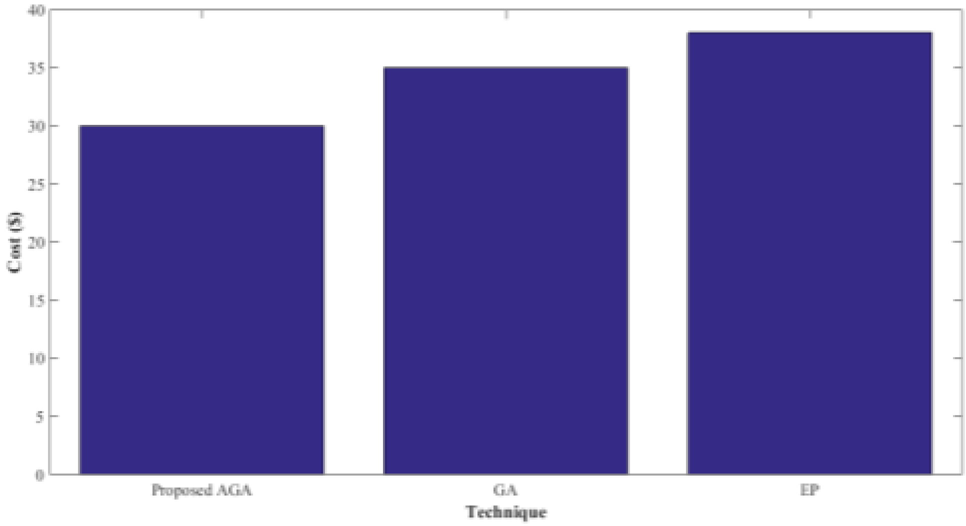


Figure 4.5. Disassembly Cost comparison

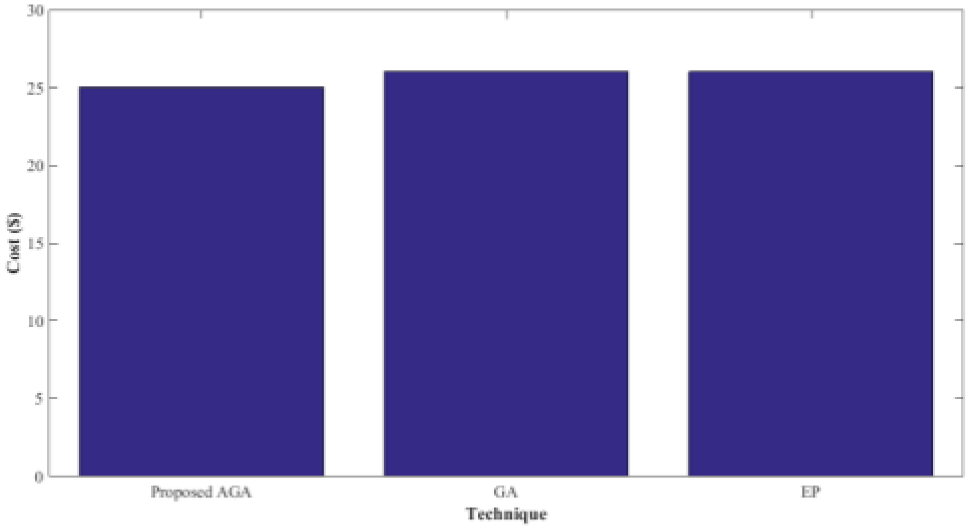


Figure 4.6. Procurement Cost comparison

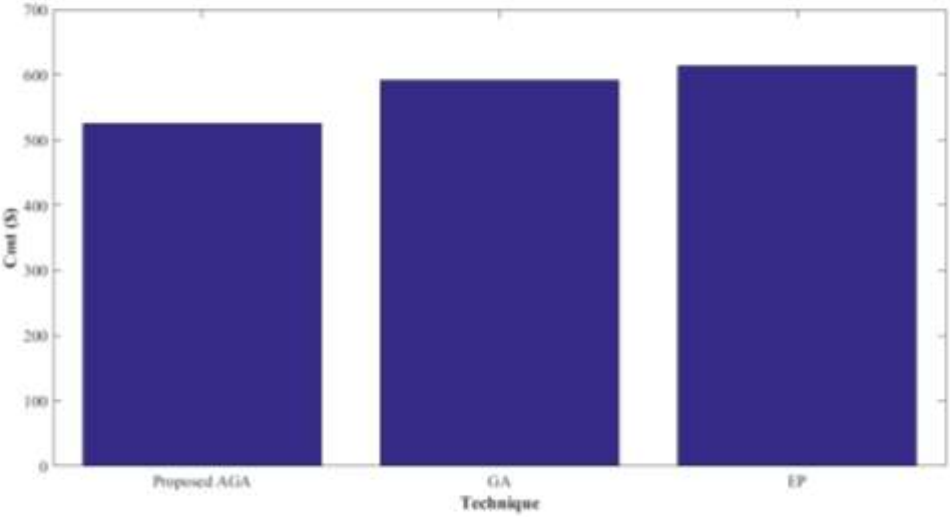


Figure 4.7. Total Cost comparison

In the Fig 4.4 to Fig 4.7, the examinations of reclaimed items, dismantling cost, procurement cost and aggregate cost are given. These figures unmistakably demonstrate that the cost required for the E-O-L Items D-T-O is nearly not as much as that of the GA and EP. The meeting of the proposed AGA method thought about for demonstrating the enhancement execution, and its graphic portrayal given in Fig 4.8.

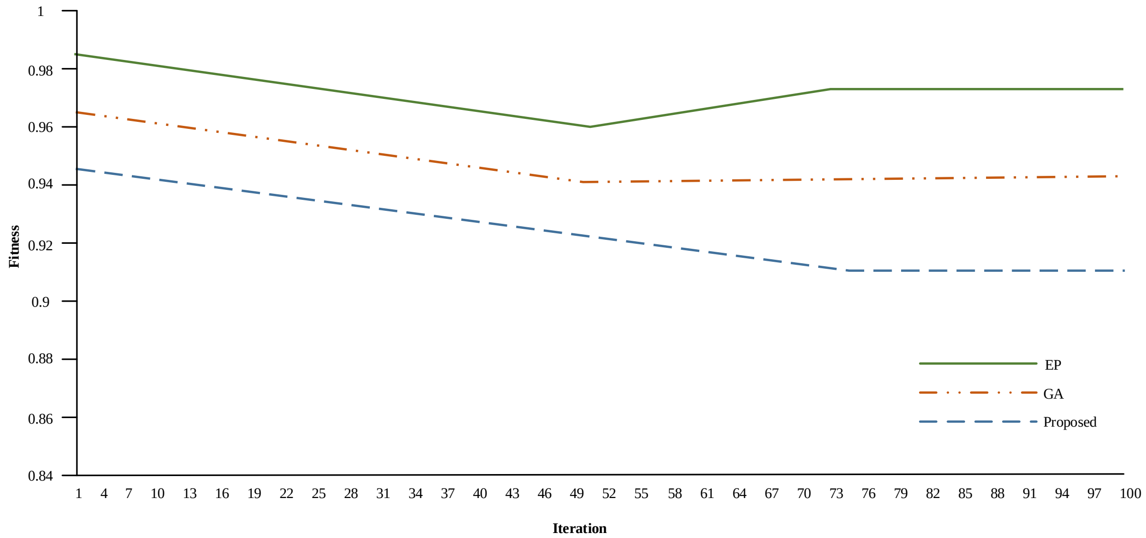


Figure 4.8. Convergence Comparison or Termination Graph

In Fig 4.8 the meeting graph is given. It obviously demonstrates that the proposed AGA based multi-objective meta-heuristic approach for the multi-period E-O-L Items D-T-O is superior to anything that of ordinary GA and EP based methodologies. So far the proposed approach for the multi-period E-O-L Items D-T-O in reverse logistic broke down by considering a case illustration and the execution is investigated by contrasting and the routine GA and EP based systems. The execution investigation demonstrated that the proposed AGA based approach had preferred execution in all viewpoints over the customary GA and EP based methodologies. In this way, these examinations recommend that the proposed approach improves as a possibility for the constant reverse logistic operations on E-O-L items.

Reverse logistics in manufacturing industries is an inspired research area of this thesis. In this chapter, an adaptive genetic algorithm based D-T-O of E-O-L products was proposed. The proposed strategy is planned to reduce the total cost required for the reverse logistics. The D-T-O process can extract valuable components from the E-O-L products, which can be directly used for the new product production. Thus the total cost required for the production of gadgets in a short time can reduce. The proposed AGA strategy provided better performance by comparing with the conventional metaheuristic algorithm like evolutionary programming.

The strategy used in this chapter provided an optimal number of E-O-L products for the D-T-O process. The proposed strategy helps to reduce the money spend for the disassembly of E-O-L products. But the proposed strategy fails to address the time management and usage of machine. Hence in the next chapter (chapter 5) a novel strategy is proposed based on ABC algorithm for the scheduling, which can manage time and machine usage.