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Warranty and discrete preventive maintenance

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Abstract

Preventive maintenance actions over the warranty period have an impact on the warranty servicing cost to the manufacturer and the cost to the buyer of fixing failures over the life of the product after the warranty expires. However, preventive maintenance costs money and is worthwhile only when these costs exceed the reduction in other costs. The paper deals with a model to determine when preventive maintenance actions (which rejuvenate the unit) carried out at discrete time instants over the warranty period are worthwhile. The cost of preventive maintenance is borne by the buyer.
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1. Introduction

All products are unreliable in the sense that they eventually fail. An item failure can occur early in its life due to manufacturing defects or late in its life due to degradation of the item. The degradation is dependent on age and usage. Most products are sold with a warranty that offers protection to buyers against early failures over the warranty period. The warranty period offered has been progressively getting longer. For example, the warranty period for cars was 3 months in the early thirties and this changed to one year in the sixties and currently it varies from three to five years. With extended warranties, an item is covered for a significant part of its useful life. This implies that failures due to degradation can occur within the warranty period. The degradation of item can be controlled by preventive maintenance and this reduces the likelihood of failures. This implies that preventive maintenance becomes important when warranty periods are long.

Offering warranty implies additional costs to the manufacturer. This is the cost of repairing item failures (through corrective maintenance) over the warranty period. Preventive maintenance during the warranty period can reduce this cost. Since the buyer pays nothing for repairs during the warranty period, there is no incentive for him/her to invest any effort into preventive maintenance. It is worthwhile for the manufacturer to carry out preventive maintenance only if the reduction in the warranty servicing cost is greater than the extra cost incurred with preventive maintenance.

However, from the buyer's perspective, investment in preventive maintenance during the warranty period and after the warranty has expired can have a significant impact on the maintenance cost after the warranty has expired which is borne by the buyer. As a result, buyer's preventive maintenance actions (during the warranty period and afterwards) need to be determined in the lifecycle context.

In this paper we develop a framework to study preventive maintenance for items sold with warranty from both buyer and manufacturer perspectives. Such a framework allows one to build alternate models to determine optimal preventive maintenance strategies. The outline of the paper is as follows. In Section 2, we give a brief overview of product warranty and maintenance so as to set the background for the main contribution of the paper. Following this, we develop a framework to study preventive maintenance for items sold with warranty in Section 3. In Section 4, we carry out a review of the literature dealing with warranty and maintenance against this framework. Section 5 deals with the new model formulation and its

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analysis. Finally, we conclude with some discussions of topics for future research.

2. Warranty and maintenance

2.1. Product warranty

A warranty is a contract between buyer and manufacturer that becomes effective on the sale of an item. The purpose of a warranty is basically to establish liability in the event of a premature failure of an item, where 'failure' is meant as the inability of the item to perform its intended function. The contract specifies the promised performance and if this is not met the means for the buyer to be compensated. The contract also specifies the buyer's responsibilities with regards to due care and operation of the purchased item.

There are many aspects of product warranty and these are covered in Blischke and Murthy (1996) [1]. Murthy and Djamaludin [2] reviewed the warranty literature over period 1990–2001. One aspect of particular interest to manufacturer is warranty cost-the cost associated with the servicing of claims occurring under warranty. This issue has received a lot of attention and further details can be found in Blischke and Murthy (1994) [3].

2.2. Maintenance

Maintenance can be defined as actions to (i) control the deterioration process leading to failure of a system and (ii) restore the system to its operational state through corrective actions after a failure. The former is called 'preventive' maintenance and the latter 'corrective' maintenance.

Corrective maintenance (CM) actions are unscheduled actions intended to restore a system from a failed state to a working state. This involves either repair or replacement of failed components. In contrast, preventive maintenance actions are scheduled actions carried out to either reduce the likelihood of a failure or prolong the life of the component.

In general, preventive maintenance is carried out at discrete time instants. In the case where they are done fairly frequently (the mean time between maintenance actions $\ll$ the life of the item), then they can be approximated as occurring continuously over time. This results in the modelling and analysis becoming simpler.

Several review papers on maintenance have appeared over the last 30 years. These include Pierskalla and Voelker (1976) [4], McCall (1965) [5], Sherif and Smith (1976) [6], Jardine and Buzzacot (1985) [7], Thomas (1986) [8], Gits (1992) [9], Pintelton and Gilders (1992) [10], Dekker (1996) [11] and Scarf (1997) [12], Valdez-Flores and Feldman (1989), [13]. Cho and Parlar (1991) [14] and Dekker et al (1997) [15] deal with the maintenance of multi-component systems. These contain references to the large number of papers and books dealing with maintenance.

3. Framework for the study of warranty and maintenance

For the manufacturer the time interval of interest is the warranty period. In the case of non-renewing warranty, the warranty period is fixed. In the case of renewing warranty, the warranty period is a random variable. The variable of interest is the warranty cost incurred by the manufacturer over the warranty period.

For the buyer, the time interval of interest is the period from the instant an item is purchased to the instant when it is disposed or replaced. This includes the warranty period and the post-warranty period. The cost of rectification over the warranty period depends on the type of warranty. It can vary from no cost (in the case of free replacement warranty) to cost sharing (in the case of pro rata warranty). The cost of rectification during the post-warranty period is borne completely by the buyer. The variable of interest to the buyer is the cost of maintaining an item over its useful life.

Preventive maintenance actions are carried out either to reduce the likelihood of a failure and/or to prolong the life of an item. Preventive maintenance can be perfect (restoring the item to 'good-as-new') or imperfect (restoring the item to a condition that is between as 'good-as new' and as 'bad-as-old'). Corrective maintenance can be either minimal (repairing to back-as-old), imperfect or perfect. See Lindqvist [16] for more on modelling of repairable systems.

Preventive maintenance over the warranty period has an impact on the warranty servicing cost. It is worthwhile for the manufacturer to carry out this maintenance only if the reduction in the warranty cost exceeds the cost of preventive maintenance. From the buyer's perspective, a myopic buyer might decide not to invest in any preventive maintenance over the warranty period since the manufacturer rectifies all failures over the warranty period at no cost to the buyer. Investing in maintenance is viewed as an unnecessary cost and hard to justify. However, from a life cycle perspective the total life cycle cost to the buyer is influenced by maintenance actions during the warranty period and the post warranty period. This implies that the buyer needs to evaluate the cost under different scenarios for preventive maintenance actions. This raises several interesting questions and include the following:

1. Should preventive maintenance be used during the warranty period?
2. If so, what should be the optimal maintenance effort? Should the buyer or the manufacturer pay for this or should it be shared?
3. What level of maintenance should the buyer use during the post warranty period?

A proper evaluation of alternate options requires realistic models and analytical tools.

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