IMPROVEMENT OF A CONDITION-ASSESSMENT AND DECISION-MAKING METHOD FOR ENHANCING THE OPERATIONAL RELIABILITY OF ELECTRIC VEHICLE REDUCTION-GEAR TRANSMISSIONS

Nigina Rustamovna Nusratova
Engineer, ADM Jizzakh JSC, Jizzakh, Uzbekistan
Khikmat Kakharovich Ishmuratov
PhD, Professor, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

Abstract. This paper proposes a stepwise method for forming maintenance decisions based on the technical condition of an electric vehicle reduction-gear transmission. The approach is based on processing diagnostic data, assessing the current condition, comparing it with warning and critical thresholds, and selecting an appropriate maintenance action. The proposed algorithm is presented not as a result of experimentally proven effectiveness, but as a methodological framework for determining thresholds and decision rules in subsequent test-bench studies.

Keywords: electric vehicle, reduction gearbox, gear transmission, operational reliability, condition-based maintenance, condition assessment, diagnostics, decision threshold.

A fixed-interval maintenance strategy for an electric vehicle reduction gearbox does not always reflect the actual technical condition of the gear transmission. Under Condition-Based Maintenance (CBM), maintenance timing is determined not solely by calendar time or accumulated operating time, but by the approach of monitored condition indicators to established criteria [1, 2]. Experimental studies have also demonstrated the practical value of vibration monitoring for the early detection of gear damage, including pitting [3].

In this study, the maintenance decision is divided into three condition states: normal - continued operation; warning - additional diagnostics and maintenance planning; and critical - technical intervention. Numerical threshold values are deliberately not prescribed in advance; for a specific gearbox type, they should be identified from test-bench experiments and operational observations. Recent gearbox CBM research likewise uses multilevel Alert-Warning-Critical thresholds derived from degradation data [2].

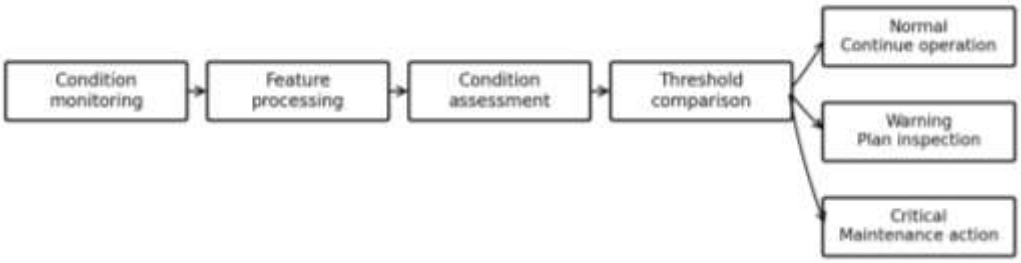

Figure 1. Proposed algorithm for condition-based maintenance decision making

The decision rule can be expressed in the general form: $D(t) < D_1$ - *normal;* $D_1 \leq D(t) < D_2$ - *warning;* $D(t) \geq D_2$ - *critical.* Here, D(t) is a condition-degradation indicator formed from diagnostic features, while D_1 and D_2 are the warning and critical thresholds, respectively. This expression is not a ready-made empirical model; D(t), D_1, and D_2 require experimental identification.

Table 1

Methodological structure of condition-based maintenance decisions

Condition state	Decision criterion	Recommended action
Normal	$D(t) < D_1$	Continue operation and scheduled monitoring
Warning	$D_1 \leq D(t) < D_2$	Additional diagnostics and maintenance planning
Critical	$D(t) \geq D_2$	Technical intervention followed by reassessment

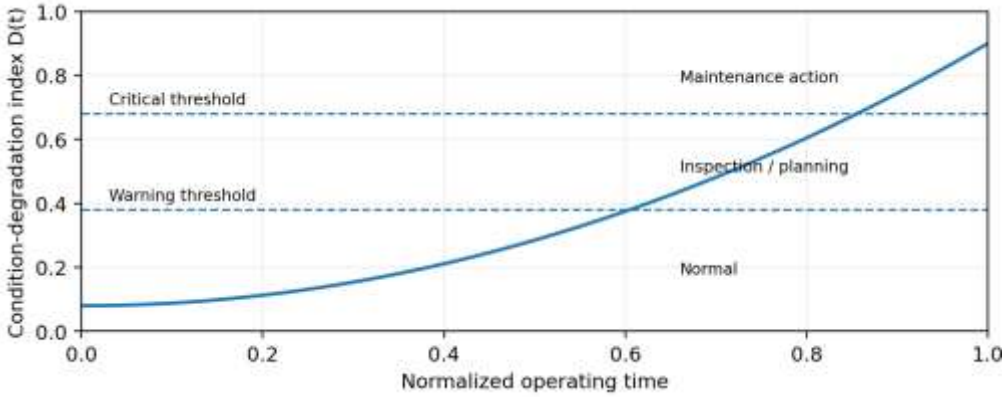

Figure 2. Conceptual model of D(t) degradation-indicator thresholds for assessing the technical condition of an electric vehicle reduction-gear transmission.

The principal feature of the proposed structure is that a diagnostic result is converted into a specific operational decision rather than being treated only as an indication of a fault. At the same time, the thresholds should not be regarded as universal constants: their justification depends on gearbox design, operating conditions, and accumulated monitoring history [1, 4]. At a subsequent stage of the PhD research, experimental data can be used to identify the decision thresholds and verify the repeatability of the method.

Conclusion. A methodological algorithm based on the sequence *"monitoring → condition assessment → threshold comparison → maintenance decision → reassessment"* is proposed for condition-based maintenance of an electric vehicle reduction-gear transmission. Decision rules for normal, warning, and critical condition states are formulated. Numerical values of D(t), D_1, and D_2 are not presented as experimental results; they are intended to be determined in subsequent test-bench studies.

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