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Study on Improving the Fatigue of Mechanical Products Built on Quantum-Conveyed Lifetime Prototype and Sample Size

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ABSTRACT

To strengthen the structure of product functioned by machine, parametric Accelerated Life Testing (ALT) as arranged technique is offered to calculate the mechanical life repeatedly applied by torque, built on life–stress model and sample size. The established way allows an engineer to find out the product faults which have a notable effect in reliability. Finally, company can prevent product recalls from the open space where a market is. As an occasion, the ice-maker, holding the auger motor with bearing in a household refrigerator, was inspected.

Keywords: Mechanical System; Ice-Maker; Bearing; Parametric Alt; Fatigue; Design Imperfections

Introduction

The mechanical system moves power to hold an aim which needs forces & action of moving and attains mechanical advantages by properly implementing some mechanisms. By executing the refrigerating cycle, a household refrigerator gives cold air from evaporator (heat exchanger) to refrigerator & freezer compartment. As one of various functions, a refrigerator ice-maker harvests (cubed or crushed) ice and distributes it. It comprises an auger motor with bearing, helix upper dispenser, etc. Ice-maker should be devised to be operated under the conditions exerted by the end-user who actually utilizes it. If there are design inadequacies in the structural parts, ice-maker may not abruptly work in its life. As finding them by Parametric ALT, an engineer can devise in the optimal way [1,2].

It Consists

(1) an ALT procedure,

(2) load examination,

(3) an ALTs with numerous corrections, and

(4) a discernment if system comes to the goaled BX lifetime. As an occasion examination, the ice-maker, holding the auger motor with bearing, will be examined.

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Parametric Alt in Mechanical System

Dissolving a problem for Schrodinger's differential expression may be attained:

$$-\frac{h^2}{(8\pi^2 m)}\frac{(d^2\psi_n(x))}{(dx^2)} = E_n\psi_n; \psi_n(x) = \sqrt{\frac{2}{a}} sin\left(\frac{n\pi}{a}\right)x; E_n = \frac{n^2h^2}{8ma^2} n > 0 \quad (1)$$

Linear transport can be stated:

$$J = LX \quad (2)$$

As an occasion, solid-state diffusion for silicon, J, may be manifested

$$J = B\sinh(aS)\left(-\frac{E_a}{kT}\right) \quad (3)$$

As Equation (3) puts the reverse, the life-stress (LS) statement may be demonstrated:

$$TF = A[sinh(aS)]^{(-1)} exp\left(\frac{E_a}{kT}\right) \quad (4)$$

The $[sinh(aS)]^{-1}$ in Equation (4) has attributes:

1. $(S)^{-1}$ in the start has nearly straight-line effect,
2. $(S)^{-n}$ is established as a middle effect, and
3. $(e^{aS})^{-1}$ in the end is huge.

In the middle effect, an ALT is performed. As the stress originates from effort in power transmission, equation (4) may be redefined as:

$$TF = A(S)^{-n} exp\left(\frac{E_a}{kT}\right) = B(e)^{-\lambda} exp\left(\frac{E_a}{kT}\right) \quad (5)$$

To attain the acceleration factor (AF), expressed as the connection between the higher-level stress and typical stress, it may be replaced to integrate with this idea:

$$AF = \left(\frac{S_1}{S_0}\right)^n \left[\frac{E_a}{k} / k\left(\frac{1}{T_0} - \frac{1}{T_1}\right)\right] = \left(\frac{e_1}{e_0}\right)^{\lambda} \left[\frac{E_a}{k}\left(\frac{1}{T_0} - \frac{1}{T_1}\right)\right] \frac{E_a}{k}\left(\frac{1}{T_0} - \frac{1}{T_1}\right) \quad (6)$$

To attain the allowed time for parametric ALT, sample size formulation incorporated with Equation (6) might be defined as [2]:

$$n \geq (r+1)\cdot\frac{1}{x}\cdot\left(\frac{L_{BX}^*}{AF\cdot h_a}\right)^{\beta} + r \quad (7)$$

Case Investigation: Enhancing Life of The Ice-Maker Building in Auger Motor With Bearing in a Domestic Refrigerator

End-user sometime employs the refrigerator to distribute (crushed or cubed) ice. To satisfy these requests, a refrigerator ice-maker is devised. Dispensing ice in a refrigerator necessitates (1) ice harvests in an ice-maker, (2) the customer presses the bowl-shaped container to the ice lever, and (3) ice dispenses into it. The major components have helix support, blade dispenser, blade, helix upper dispenser, an auger motor with bearing, etc. (Figure 1).

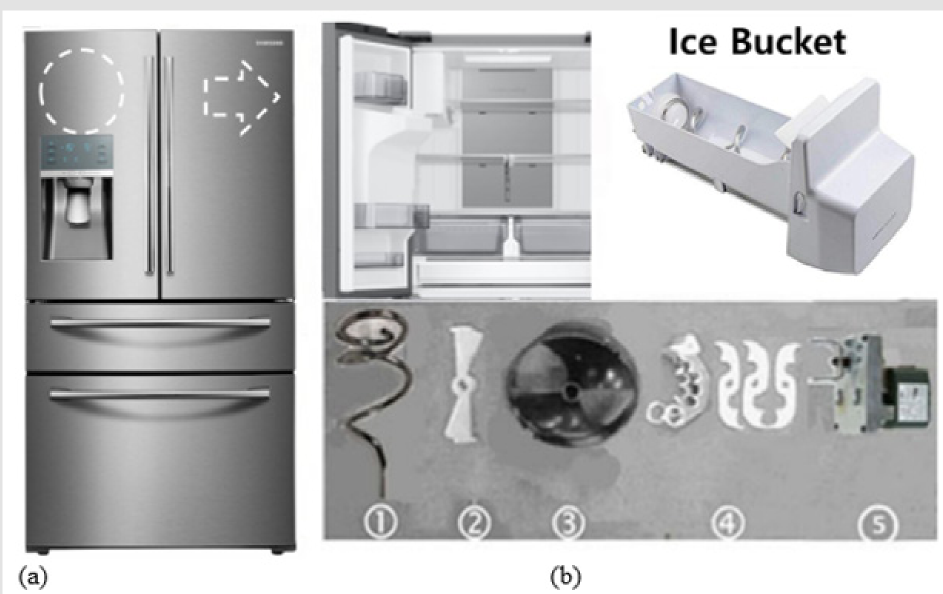

Figure 1: (a) Refrigerator and (b) Ice-maker system with helix support[1] , blade dispenser[2], helix upper dispenser[3], blade[4], and auger motor[5].

 DOI: 10.26717/BJSTR.2023.53.008461

From the market, as repetitively pressing/unloading lever is exerted, ice-makers, including auger motors with bearing, had been fracturing due to unidentified design defects, following by end-users to request the action of replacing it. To correctly function the ice-maker system for expected life, its design flaws might be discovered by chance and altered by parametric ALT (Figure 2). From the ice-maker modeling (Figure 3), the governing equation can be expressed as follows:

$$\begin{bmatrix} di_a / dt \\ d\omega / dt \end{bmatrix} = \begin{bmatrix} -R_a / L_a & 0 \\ mk_a & -B \end{bmatrix} \begin{bmatrix} i_a \\ \omega \end{bmatrix} + \begin{bmatrix} i / L_a \\ 0 \end{bmatrix} e_a + \begin{bmatrix} 1 \\ -1/J \end{bmatrix} T_L \quad (8)$$

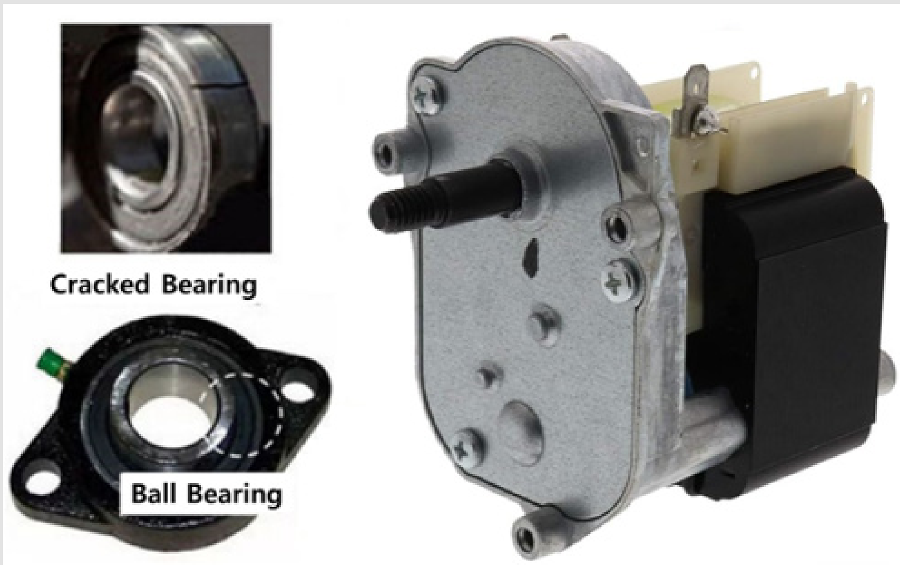

Figure 2: Failed auger motor in ice-maker.

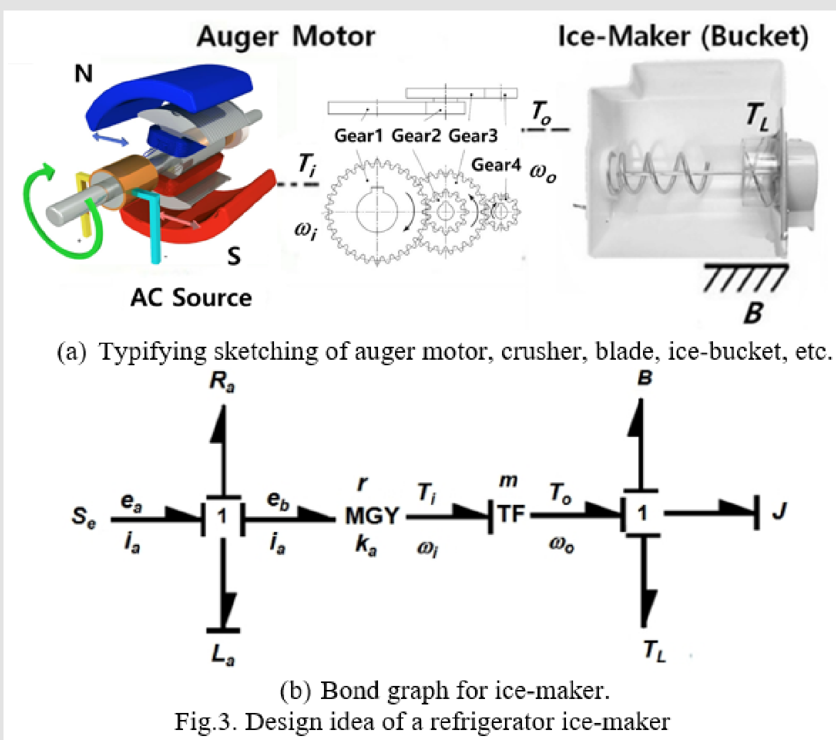

Figure 3: Design idea of a refrigerator ice-maker.

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When the stress relies on the applied torque, Equation (5) can be redefined:

$$TF = A(S)^{(-n)} = AT_L^{-\lambda} = A(F_c \times R)^{-\lambda} = B(F_c)^{-\lambda} \quad (9)$$

Therefore, established on Equation (6), the AF may be redefined:

$$AF = \left(\frac{S_1}{S_0}\right)^n = \left(\frac{T_1}{T_0}\right)^\lambda = \left(\frac{F_1 \times R}{F_0 \times R}\right)^\lambda = \left(\frac{F_1}{F_0}\right)^\lambda \quad (10)$$

For the ice-maker, the operating (or surroundings) conditions are 0–43 °C with 0.2–0.24 g's acceleration, and a humidity ranging from 0 to 95%. The working time of ice-maker per day were from three to eighteen. Established on the life for 10 years, the ice-maker was executed to 65,700 usage cycles. For the worst-occasion, the greatest torque exposed to the customer in dispensing ice, T_0, was 0.69 kN-cm. For ALT, the applied torque, T_1, increased to 1.47 kN-cm. With a cumulative factor, λ, of 2, AF in Equation (10) was 4.0. To attain the lifetime objective – B1 lifetime for 10 years, if the shape parameter, β, was presumed to have 2.0, the mission cycles for 10 samples designated in Equation (7) were 42,000 cycles. The troublesome design of ice-maker therefore may be found and modified.

Results and Conclusion

In 1st ALT, fractured bearing of the auger motor in ice-maker reproduced at 6,500 cycles and 6,500 cycles (Figure 4). As carefully examining the fractured bearings from the first ALT and the marketplace, failures were found in the outside ring. That is, the fractured outside part on the cross-section was an Intergranular (IG) crack due to repetitive torque under harsh surrounding circumstances(-20°C↓). As action plans, matter of the problematic bearing in the auger motor was altered from AISI 52100 Alloy Steel to the bearing with sintered and hardened steel. In 2nd ALT, the helix upper dispenser made of polycarbonates fractured in the disclosure area of the blade dispenser. To comprehend the root cause of the troublesome product, it was discovered that there was an imperfection in the structural part — the weld line between the helix upper dispenser and the blade dispenser—that was some micro-voids built in the plastic injection process. As an action plan, an enforced rib of the helix had made thicker after the injection process was modified. Thus, a finite element method (FEM), combined with the ALT outcome, was performed. As an outcome, the part stress by the FEM analysis was decreased from 45.0 kPa to 20.0 kPa (Figure 5). As the designs were changed, the ice-maker in a refrigerator will satisfactorily perform to fulfil the aimed lifetime – B1 lifetime for 10 years – because there were no issues until 60,000 cycles..

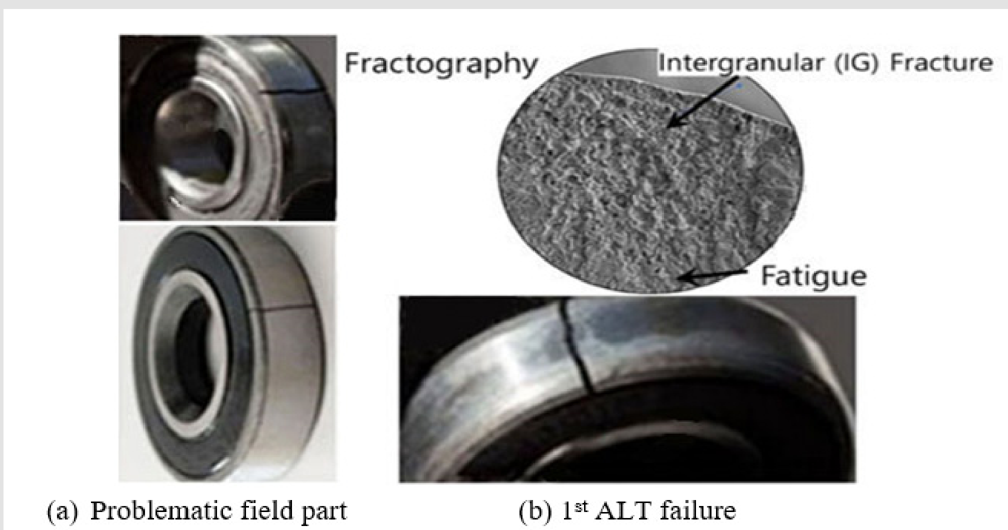

Figure 4: Problematic designs of dispenser in market and 1st ALT.

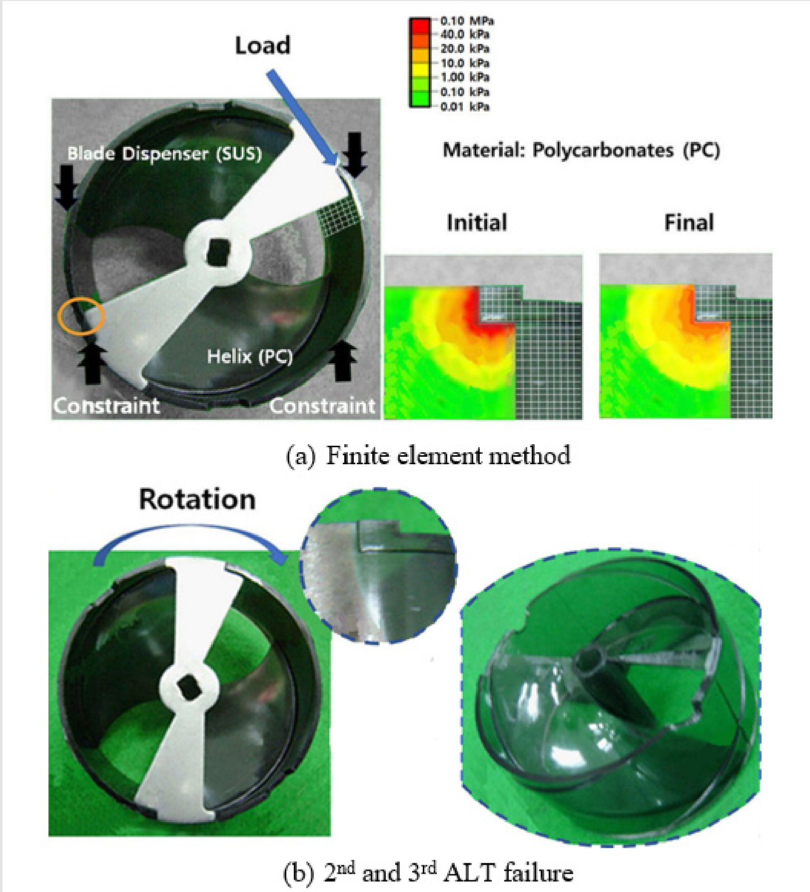

Figure 5: Problematic designs of dispenser in 2nd ALT.

References

1. Woo S, O Neal D, Pecht M (2023) Improving the lifetime of mechanical systems during transit established on quantum/transport life-stress prototype and sample size, Mechanical Systems and Signal Processing 193: 110222.
2. Woo S, Pecht M, O Neal D (2020) Reliability design and case study of the domestic compressor subjected to repetitive internal stresses, Reliability Engineering and System Safety 193: 106604.

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