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Title: Reliability modeling based on Maximum Entropy and non-central moments as an alternative for RCM schemes or replaceable systems

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Introduction and settlement of the problem.

En el marco de trabajo del mantenimiento centrado en confiabilidad (RCM) es usual contar con dificultades relativas a la frecuencia de falla de componentes vitales utilizados en la industria.

$$f(x) = \frac{\beta}{\eta}\left(\frac{x}{\eta}\right)^{\beta-1} e^{-\left(\frac{x}{\eta}\right)^{\beta}} ; x \in [0, \infty]$$

$$\hat{\eta} = \left(\frac{1}{r}\sum_{i=1}^{n} t_i^{\beta}\right)^{1/\beta}$$

$$R(T) = 1 - F(x \leq T)$$

Al mismo tiempo, los planes de mantenimiento representan una inversión en activos fijos, entrenamiento de personal y suministro de repuestos que supera en ocasiones lo que las medianas empresas pueden costear al corto plazo.

Methodology

Densidad de probabilidad generalizada.

$$S(P,P') = -\int f(t)\ln[f(t)]dt$$

$$\int f(t)dt = 1$$

$$\int t^k f(t)dt = \mu_k$$

Definición: *Principio de máxima entropía*:

«La entropía estadística de un sistema aleatorio alcanza el máximo compatible con las restricciones impuestas»

$$F(f,f',t) = -f(t)\ln[f(t)] - \sum_{i=1}^{n}\lambda_k t^k f(t)$$

$$\frac{d}{dx}\frac{\partial F}{\partial y'} - \frac{\partial F}{\partial x} = 0$$

$$f(t) = Ae^{-\varphi(t)}$$

Multiplicadores de Lagrange.

$$\int_{-\infty}^{\infty}\frac{d}{dt}f dt = 0$$

$$\int_{-\infty}^{\infty}t^n\frac{d}{dx}f dt = \lambda_k k\sum_{k=1}^{N}\int_{-\infty}^{\infty}t^{k+n-1}f dt$$

$$\begin{pmatrix}\mu_1 & \cdots & \mu_{N-1}\\ \vdots & \ddots & \vdots\\ \mu_{N+1} & \cdots & \mu_{2N}\end{pmatrix}\begin{pmatrix}\lambda_1\\ \vdots\\ N\lambda_N\end{pmatrix} = \begin{pmatrix}0\\ 1\\ 2\mu_2\\ \vdots\\ (N+1)\mu_N\end{pmatrix}$$

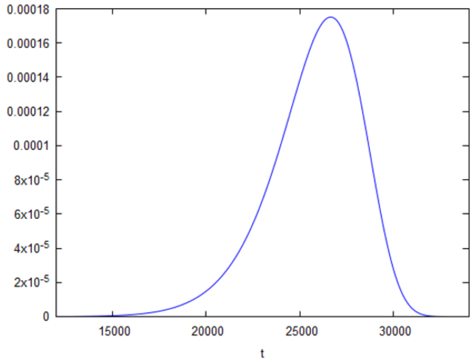
Results

23880
24210
27212
25731
25687
28213
25231
21782
33121
25103

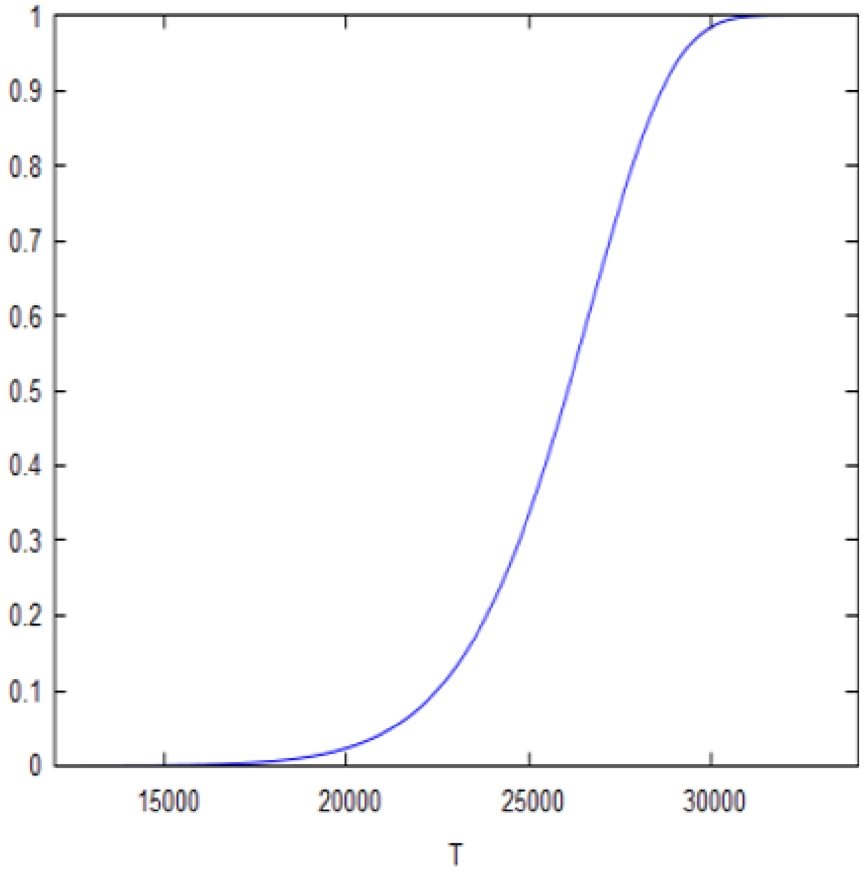
Análisis Weibull

η=26818.4; β=12.7290

$$W(t) = 5.436 \times 10^{-59} t^{11.729} e^{-4.27\times10^{-57} t^{12.73}}$$



Modelo Weibull	parámetros	MTTF
$R(T) = e^{-\left(\frac{x}{\eta}\right)^{\beta}}$	η=26818.4	~25700hrs
	β=12.7290	h(t)>26000hrs



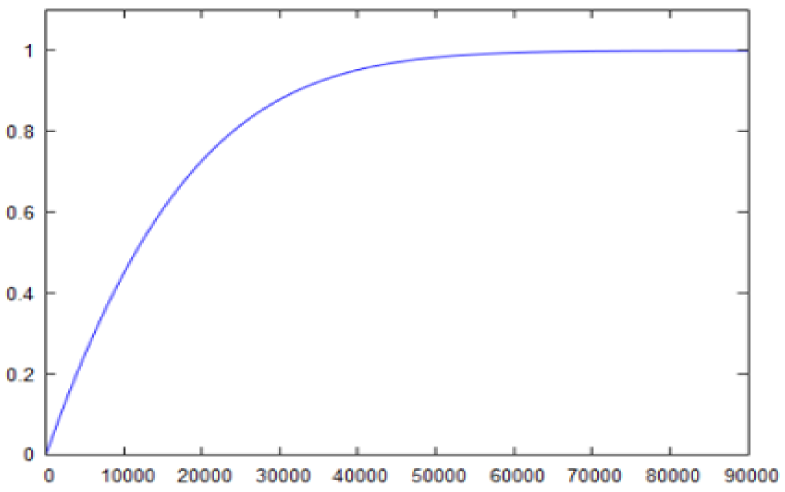
Results

Reinterpretando la muestra.

En esta sección reinterpretan los datos para compararlos con los resultados de la sección anterior.

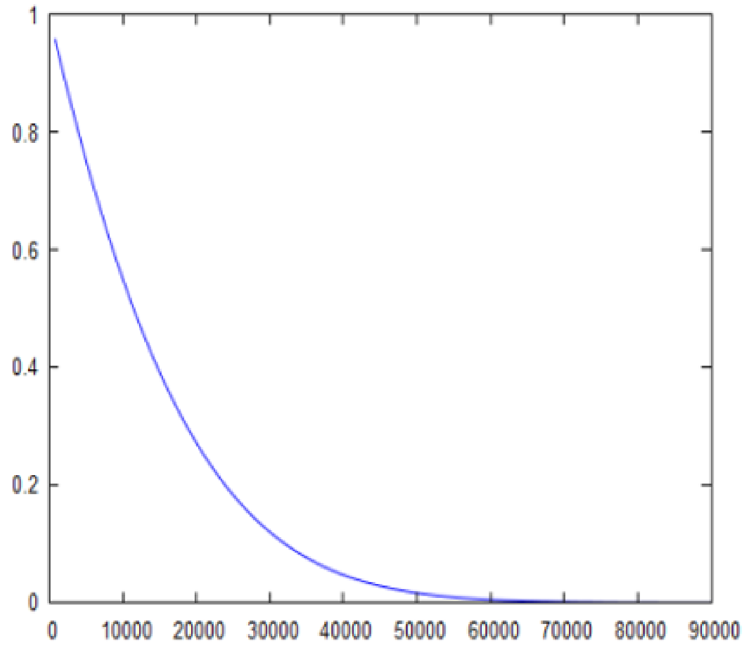
Para estimar los momentos de los datos censurados, se utilizará el MTTF que se obtiene del análisis Weibull asumiendo que los parámetros de media y varianza no se desvían mucho de los que predice el análisis Weibull

$$\mu_2 = \int_0^{\infty} (t - \mu_1)^2 W[\eta, \beta] dt + \sum_{k=1}^{N} |\phi(\mu_i)|$$



Se asume que la densidad de probabilidad Weibull de datos de servicio, puede usarse como un punto inicial de perturbación para construir a la densidad de probabilidad de máxima entropía.

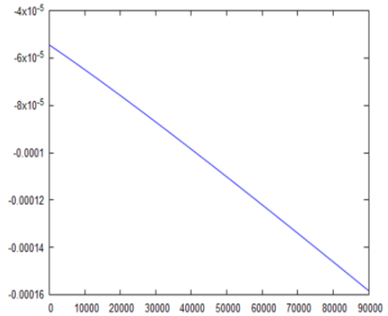
$$\mu_1 = 26818.4; \mu_2 = 6079355.823$$



Conclusions

El estado de la investigación indica que es posible elaborar planes de mantenimiento centrados en confiabilidades con la herramienta desarrollada hasta este punto.

$$h(t) = \frac{d}{dt} ln\big(R(t)\big)$$



Con ambos modelos, al rededor del 84% de las ocasiones en las que se permita a las válvulas operar por encima de las 28000 horas, *la probabilidad de falla es muy alta.*

Por otro lado, dado que el lenguaje formal de la probabilidad es la teoría de la medida, no se puede descartar el incursionar en este campo

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