

CALCULATION MODEL FOR CORROSION CALENDAR LIFE OF METAL PARTS

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ABSTRACT

A certain kind of approximate linear relationship is found between corrosive temperature (T) and corrosive time (H) for metal part within a certain range of temperature. It is called the T-H curve in this paper, which is similar to the S-N curve in the fatigue field. On the basis of T-H curve, the author deduces the formula of calendar life for corrosion damage of metal under many kinds of medium environment. As for the form, it looks like the Miner theoretical formula in fatigue field. Using this formula, the calendar life for corrosion damage of metal can be estimated simply under varied complicated medium surrounding.

Key words

T-H curve, calendar life, corrosion damage calculation model

INTRODUCTION

Up to now, there is not a applicable model which can be predicted at home and abroad, because the factors effecting on aircraft corrosion calendar life are complex. Therefore, the aircraft calendar life is not given scientifically in engineering, so that some great accidents often occur. In order to solve this difficult problem, this paper makes the study and gets following three respects of conclusion.

1. Approximate linear variation between corrosion damage amount and corrosion time for some of metals

This linear variation rule can be demonstrated not only by <Faraday law> but also by some tests. For example, 12 groups of curve shown in fig.1, between corrosion amount and corrosion time are approximate linear rule, which is useful for setting up an aircraft calendar life model.

2. A relation of corrosion temperature (T) and corrosion time (H)

A relation of corrosion temperature (T) and corrosion time (H) for some of metals appears the variation rule shown in fig.2. i.e. when some of metals in certain corrosion medium are corroded to the same corrosion amount

D, increasing corrosion on temperature T requires decreasing corrosion time H , decreasing corrosion temperature T requires increasing corrosion time H . When the temperature decreases to a critical value T_c , the infinite corrosion time (no corrosion) is required, which is called corrosion T - H curve in this paper. This kind of variation rule is deduced by <Faraday Law>and also is verified by many groups of curve for high temperature corrosion test and middle-low temperature corrosion test, as shown in fig 4 to fig 7, which is useful for setting up an aircraft calendar life model.

Fig 1 Test curve of corrosion amount and corrosion time [2]

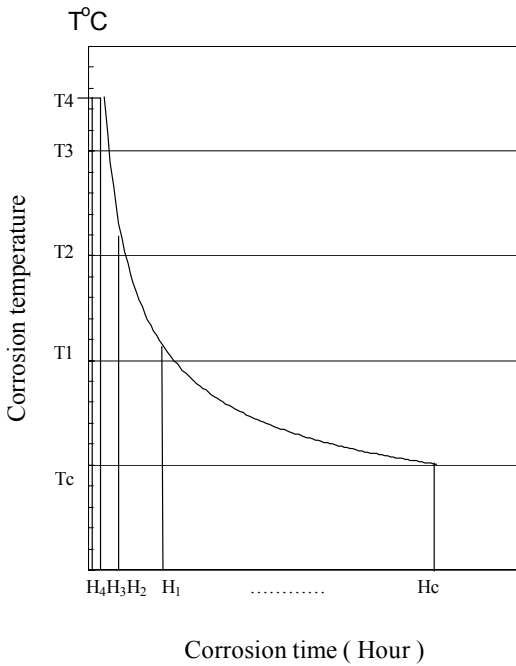
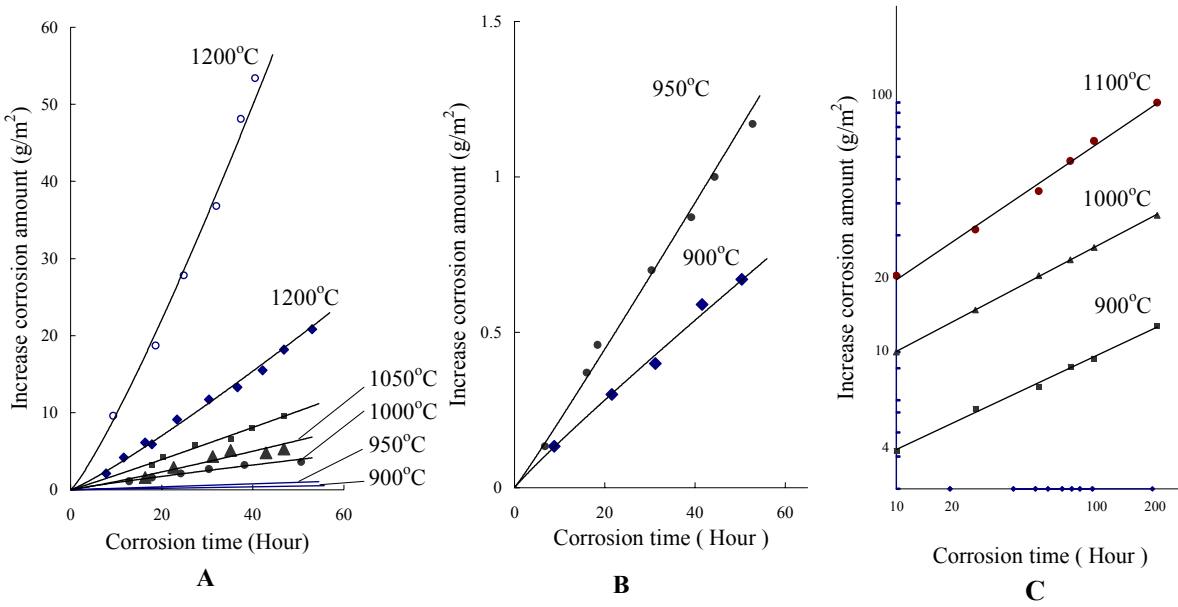


Fig .2 Standard T - H Curve to be deduced

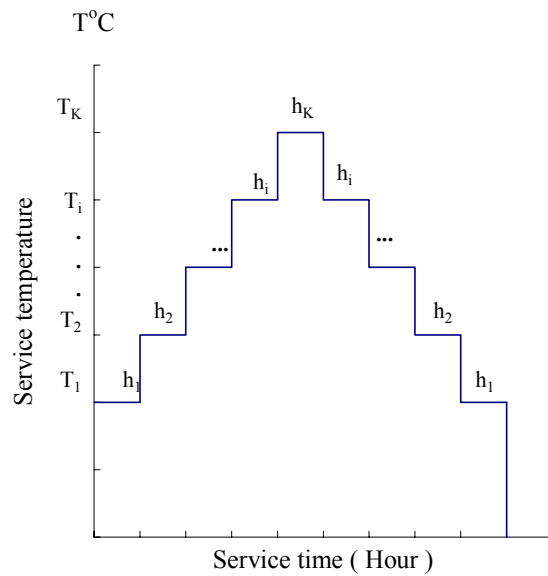


Fig.3 Assuming service temperature-time corrosion spectrum

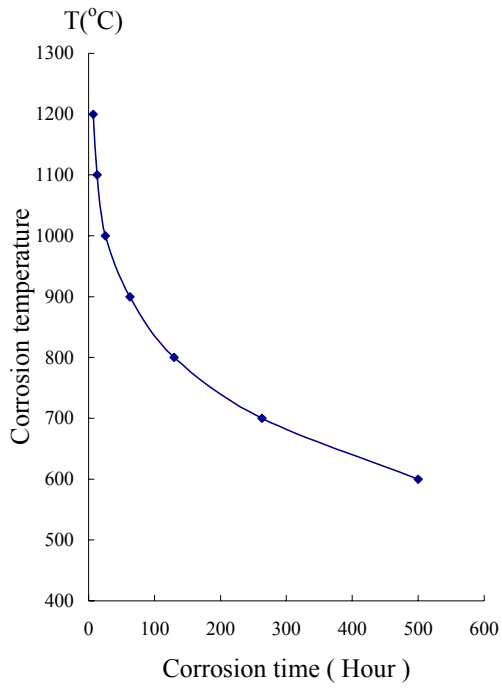


Fig.4 T-H test curves for 18 kinds of alloy^[2]

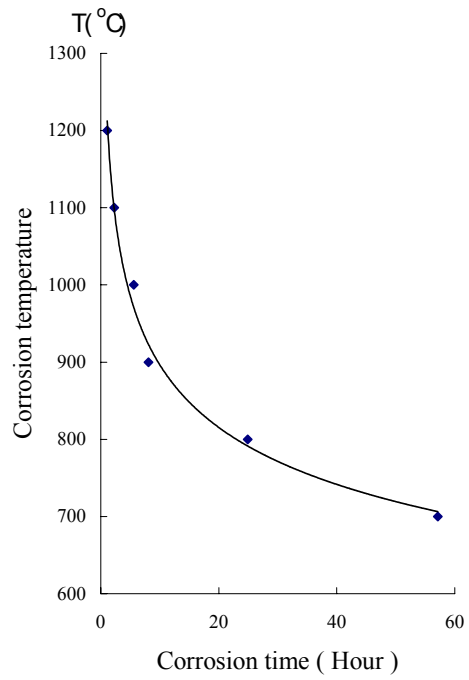


Fig.5 T-H test curves for 9 kinds of alloy^[2]

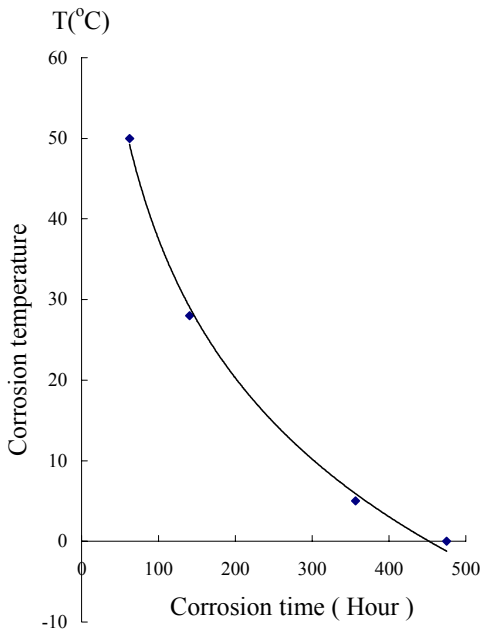


Fig.6 T-H test curve for Ly12C2 alloy

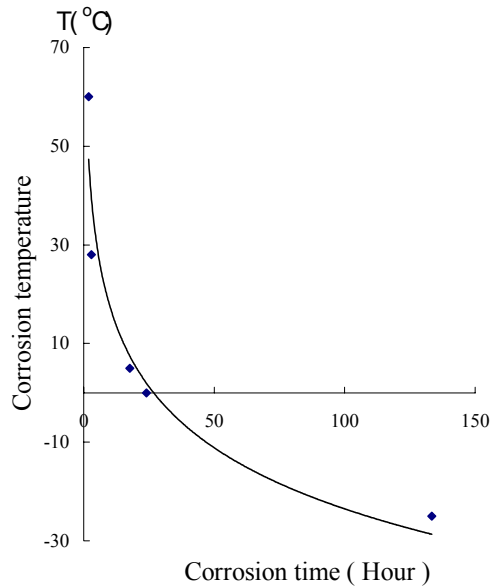


Fig.7 T-H test curve for 30CrMnSiA alloy

3. Calculation mathematical model of calendar life for corrosion damage of metal parts.

3.1 In order to get the calculation mathematical model of corrosion calendar life easily to use in engineering now assuming that:

- ① T_1-T_4 segment of the T-H curve shown in figure 2 is nearly straight line ,so it can be considered that corrosion amount caused at different temperature T can be accumulated linearly;
- ② any corrosion parts have a critical corrosion amount D_c , which can be corrosion area, volume, deep or corrosion loss amount and corrosion increments;
- ③ a part has a corrosion spectrum of using temperature T -- time H as shown in figure3;
- ④ when a part is corroded to critical corrosion amount D_c , total cycle block number of corrosion temperature—time spectrum is λ , i.e. that is under acting at corrosion temperature—time spectrum, after passing λ cycles, the critical corrosion amount D_c will reach.

3.2. Calculation mathematical model for corrosion calendar life of metal parts

It can be got through analyzing complexly T - H curve shown in figure 2 and using temperature – time spectrum shown in figure 3 that in order to get corrosion amount D_c on T – H curve under temperature T_1, H_1 hours will be required, but in using temperature-time spectrum only h_1 hours will be exited under temperature T_1 . Therefore, in according to the linear relation of corrosion amount and corrosion time under a certain temperature it only occupies h_1/H_1 of total corrosion damage amount, which is named corrosion damage degree.

Similarly, the corrosion damage degrees at $T_2, T_1 T_k$ can be got in using temperature - time spectrum, which are $h_2/H_2, h_i/H_i, h_k/H_k$. In according to the assumption of linear accumulation of corrosion damage, the accumulation corrosion damage degree of a one corrosion temperature spectrum block is

$$\frac{h_1}{H_1} + \frac{h_2}{H_2} + \dots + \frac{h_i}{H_i} + \frac{h_k}{H_k} = \sum_{i=1}^k \frac{h_i}{H_i}$$

which only occupies $1/\lambda$ of total cycle spectrum block damage degree, thus

$$\sum_{i=1}^k \frac{h_i}{H_i} = 1/\lambda$$

that is
$$\lambda \sum_{i=1}^k \frac{h_i}{H_i} = 1$$

If corrosion parts are acted by using temperature – time spectrum for m kind of mediums at the same time, it can be got that

$$\lambda \left[\left(\sum_{i=1}^k \frac{h_i}{H_i} \right)_1 + \left(\sum_{i=1}^k \frac{h_i}{H_i} \right)_2 + \dots + \left(\sum_{i=1}^k \frac{h_i}{H_i} \right)_i + \left(\sum_{i=1}^k \frac{h_i}{H_i} \right)_m \right] = 1$$

that is
$$\lambda \sum_{j=1}^m \left(\sum_{i=1}^k \frac{h_i}{H_i} \right)_j = 1 \quad (1)$$

where,

H_i is the hour number when corrosion parts are corroded to specified corrosion amount D in a certain medium environment under i stage of temperature;

h_i is the hour number corresponding to i stage of temperature in using temperature -time spectrum;

λ is the total cycle block number when corrosion parts acted together by m kinds of medium environment are corroded to specified corrosion amount D;

k is the stage number of a certain using temperature-time spectrum;

m is the number of corrosion medium

Formula (1) is a theoretical formula of corrosion damage accumulation which is got in this paper, that is, a calculation formula getting corrosion damage calendar life under *m* kinds of medium environment. A prediction of calendar life for two kinds of aircraft is made successfully by using this model and good results.

4. Conclusion

4.1 The linear accumulation theoretical formula (1) of corrosion damage is given through deduction and verification. As long as there is the T-H curve of metal corrosion and using corrosion temperature-time spectrum of a metal corrosion, the corrosion calendar life of the metal parts is calculated using formula (1). So the problem to predict complex corrosion calendar life of metal parts is reconverted into predicting “fatigue” life, which is a significant research. It is available and applicable for determining calendar life of metal parts which are in no loading or constant loading, for example, it is applicable for determining calendar life of aircraft which place on the earth’ s surface for long time.

4.2 The study range of this paper only is limited to corrosion conditions where the relation between corrosion time and corrosion amount is nearly linear, other conditions will remain to study further.

Reference

1. 周希沅.(1996).飞机结构的当量环境谱与加速试验谱.航空学报, ,17(5):613—616
2. 李金桂、赵闰彦主编,(1984).航空产品腐蚀及其控制手册,北京:航空工业部第 621 研究所