Experimental fatigue curves for aluminium brazed areas

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Experimental fatigue curves for aluminium brazed areas

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Abstract. An important factor for the quality of joints is the brazed area. The fatigue check occupies a major position among many test procedures and methods, especially by the joining technologies. The results of processing the fatigue data experiments for aluminium brazed samples are used to find the regression function and the response surface methodology.

The fatigue process of mechanical components under service loading is stochastic in nature. The prediction of time-dependent fatigue reliability is critical for the design and maintenance planning of many structural components.

1. Introduction

The fatigue process of mechanical components under service loading is stochastic in nature. The prediction of time-dependent fatigue reliability is critical for the design and maintenance planning of many structural components [6].

The paper focuses on the development of the new technologies in the field of materials joining by welding and brazing and the processing of the obtained data from the fatigue tests of the probes through these technologies [1;8;10]. Here the experiments are applied to aluminium small pieces:1.47 mm thick, from AL 103 cf. British Standard BS EN 1044:1999 (BSI 2) [2;5] (fig.1).

![Samples for fatigue test.](image)

The brazing operations were carried out in an electric oven radiant resistance at the temperature of 570°C and the samples were cooled in the atmosphere [6]. To assure a right orientation of researches it was tried from the start, from the first set of experimental data, to establish the dependencies and
interactions between the studied issues, respectively force or stress to which the samples have been subject, the brazed area, as dependent factor and the resultant, number of cycles until the fracture.

2. Fatigue correlation
The inherent nature of fatigue tests gives rise to a great deal of scatter in the data [4]. For example, if several specimens that have been carefully machined and polished, are tested at the same stress level, it certainly not unusual to have a variation of 10 to 20 percent in their fatigue life measured in terms of the number of loading cycles at which the specimen ruptures [3]. It therefore requires many tests to adequately quantify an S-N curve for a given material [4]. In this case it was evaluated the correlation between the stress (Y axis) and the number of cycles (X axis), corresponding to the classical fatigue tests, calculating the regression function with software CurveExpert 1.4. The small number of data offers a huge fitting flexibility of the experimental data.

Table 1. Experimental data.

| \( m_{od} \) | Area [mm\(^2\)] | Force [N] | Cycles number |
|-------------|-----------------|----------|---------------|
| 1           | 2300            | 495      | 1138500       |
| 2           | 4082            | 459      | 1873638       |
| 3           | 3064            | 477      | 1461528       |
| 4           | 3149            | 477      | 1502073       |

The yield is a lot of forms of the regression functions and a few among these were selected below:

MMF Model:

![Regression MMF Model](image)

**Figure 2.** Regression MMF Model.
Figure 3. Model Information to regression MMF Model.

Vapor Pressure Model:

Figure 4. Regression Vapor Pressure Model.

Figure 5. Model Information to regression Vapor Pressure Model.
Geometric Fit:

\[ y = ax^b / x \]

Figure 6. Regression Geometric Fit.

Figure 7. Model Information to regression Geometric Fit.

Modified Exponential:

Figure 8. Regression Modified Exponential.
Figure 9. Model Information to regression Modified Exponential.

As example it was chosen the last function, MMF Model, with a standard error of the estimate $S=0.0$ and modified correlation coefficient $r=1.0$, plotted in fig.2, which is closer to the classical fatigue curves.

3. Durability evaluation
Despite extensive progress made in the past decades, life prediction and reliability evaluation is still a challenging problem [6]. In the next step it was searched the dependency of the number of cycles, considered as an assessment of the fatigue durability and even of the reliability, following this criterion. As influence factors it was considered the stress ($X_1$), the surface of the brazed area ($X_2$), their product ($X_1X_2$) - the loading force, and the dependent variable ($Y$), the number of cycles (tab. 2).

A new regression calculus was applied, with a bivariate quadratic function, this time using Excel (tab.3) with Analysis Tool Pack (tab. 2, 3, 4).

| Table 2. Experimental data. |
|--------------------------------|
| | B | C | D | E |
|--------------------------------|
| $x_1$ | $x_2$ | $X_1X_2$ | $y$ |
|--------------------------------|
| 2300 | 495 | 1138500 | 381095 |
| 4882 | 459 | 1873683 | 1999 |
| 3064 | 477 | 1416126 | 18226 |
| 3148 | 477 | 1502373 | 12744 |

| Table 3. Experimental data. |
|--------------------------------|
| | A | B |
|--------------------------------|
| 1 SUMMARY OUTPUT |
| 2 |
| 3 Regression Statistics |
| 4 Multiple R | 1 |
| 5 R Square | 1 |
| 6 Adjusted R Square | 6563 |
| 7 Standard Error | 0 |
| 8 Observations | 4 |

After the regression calculi the following values were obtained:
Table 4. Experimental data.

| ANOVA       | df | SS   | MS   | F    | Significance F |
|-------------|----|------|------|------|----------------|
| Regression  | 3  | 9.21E+10 | 3.07E+10 | #NUM! | #NUM!         |
| Residual    | 0  | 0    | 65535 |      |                |
| Total       | 3  | 9.21E+10 |      |      |                |

\[ y = -1.9 \times 10^6 + 5031 x_1 + 40046.58 x_2 - 10.725 x_1 x_2 \]  
and the response surface was plotted with LabFit (fig.10).

4. Conclusion
The paper offers a synthesis between the engineering experimental activity and the modern statistical applications computers assisted. The applied statistical methods carried out some correlations, independences regression functions to evaluate the initial experimental results for aluminium brazing. The continuation of the experiments will offer the possibility to verify the inference of the mathematical expressions, to assure the consistency of the subsequently statistical evaluations.

5. References
[1] Pablo de Greife 2006 Handbook of Reparations (USA: Oxford University Press)  
[2] Minford J D 1993 Handbook of Aluminium Bonding Technology and Data (New York: Ed. Marcel Dekker Inc.)  
[3] American Welding Society Brazing Handbook 5th Edition 2007  
[4] Dimitrescu A, Amza Gh and Nitoi DF 2016 Studies and research on the microstructure of brazed aluminium alloys in the repair process, IOP Conf. Series: Materials Science and Engineering 145
[5] Dimitrescu A, Amza Gh and Niţoi DF 2016 Fatigue FEM analysis in the case of brazed aluminium alloys 3L59 used in aeronautical industry IOP Conf. Series: Materials Science and Engineering 145

[6] British Standard Institute, Aerospace Series Specification for Sheet and strip of aluminium-manganese alloy (Londra, Ed. BSI, 1993)

[7] Dimitrescu A, Nitoi D F, Dobrotă D and Apostolescu Z. 2015 Researches and studies regarding brazed aluminium alloys microstructure used in aeronautic industry Croatian Metallurgical Society 54 (2)