Comparing of methods of cycle calculating and counting to the rain flow method

Majid Roshanfar*, Mohammad Hossein Salimi

Department of mechanical engineering, KNTU University of Technology, Tehran, Iran

**Corresponding author:** Majid Roshanfar

**ABSTRACT:** Many parts that are subjected to periodic loads may be loads domain is constant or variable to time. In cases that the stress domain is constant, counting applied cycles are comfortable but the main problem is counting cycles with variable stress. To estimate fatigue life should analysis applied stresses and strain on the piece over time so as can used the S-N diagram. For the relationship between materials S-N curve and the history of stress changes, it is need to use the appropriate method for counting the number of different levels of cycles stress. In this article, four cycles counting method is evaluated: the range counting, the level crossing counting, the peak counting and the rain flow counting. The results of the surveys show that counting with rain flow method is more accurate. The range counting method has similar results with the level crossing counting method and the peak counting method has worst results.

**Keywords:** Fatigue; periodic load; S-N diagram; the rain flow method; variable stress amplitude

**INTRODUCTION**

With the advancement of fatigue life models, different types Classification has emerged that in these methods physical properties such as stress, strain, etc. during the test is measured. Normally, for calculating the stress, the load that subjected to the building is used over time, but in systems that have different vibrational modes amplitude and frequency should also be considered. The simplest test in labs is life- stress calculation that is made by a sine wave, although in reality loading is random [1,2].

Therefore, for actual measurement variety information is available but there is not any classification. Some practical applications, dealing with periodic loading in constant amplitude, but there are many problem that contribute to irregular applied loading. For drastic load changing with time, it is not clear how these cases should be distinguished and are defriended as cycles. For cases that the amplitude of stress is between a minimum and a maximum amount, which is known as stress with constant amplitude, there is not any problem for cycle counting. In this case a cycle defines as a peak to a next peak. But if this definition is used for irregular Alternating loading, big errors occur.

In fact, there are a small cycle that have most fatigue damage. Thus, removal of these cycles leads to non-conservative life estimation. For cycles Identification the comprehensive approach that is known as cycle counting, is used. In fact, cycles counting goal is the calculation of the damage limit. The Palm-Miners law is used for life estimation. This law was defined by Palm in Sweden in the 1920s to estimate the age of spherical bearings and then was developed by Langer was used in 1937. Before this law was published in Miners paper in 1945, this law was completely unknown [3]. Rain flow method was introduced by Professor Endo and colleagues in Japan in 1968. Then after discussion and studies that was done by researchers of different industry such as aviation, energy, steel this method was presented for fatigue analysis [4,5]. The aim of this project is cycle counting of alternating with variable stress amplitude loading. So this method receives the stress history and checks them. After that number of cycles are available as output. Each of calculated cycles can be viewed separately.

**MATERIAL AND METHODS**

**Level crossing counting methods**

According to this method, first, in the force-time curve, the force axial is classified in several ranges. For counting in each range, basic load should be defined, if the slope which is over the basic load is positive counting is done. For counting under the basic load negative slope is considered. Usually, the basic load is considered as the average of the perfect force-time curve. This method can count all surfaces with positive
slope (or negative slope), in the other words, is containing all force ranges. Then the number of positive slope (or negative slope) is registered in a table.

When the counting is done, they are used to forming the cycle. According to the law of the cycle, the most destructive cycle forms the largest possible range. Then second range is formed and this procedure continues to the end of counting and forming. If the rippling force passes thorough basic load is counted, otherwise this is not counted as the number of cycles. It should be noted that in this method, with small changes in the basic load, can be obtained more or less cycles. According to the basic load and various ranges, different cycles will be counted. However, this method gives sufficient results for complex loading. The analysis of the result of this method is done easily and can be used in fatigue computers programs.

Rain flow method

A history of irregular stress is a collection of peaks and valleys. The peaks and valleys are points that change the direction of loading. The stress history divide stresses into smaller parts called simple and general region and measure differences between peak and valley. A simple region is defined the region that place between one peak and the next valley or between a valley and the next peak. The general range is measured between peaks and valley which is not placed after the peak or between a valley and peak which is not placed after the valley [6]. As shown in Figure 3, a compound X-Y-Z, peak - valley-peak or valley - peak - valley in the history of the loading is considered as a cycle if in the second region, the range is greater than $\Delta \sigma_Z$ or equal to $\Delta \sigma_{XY}$ [7].
Figure 3. The condition of cycle counting in rain flow method

**Range counting method**

In this method an interval is defined that counting is done according to the interval. When a peak placed on the top, this interval should be positive and if placed at the bottom should be negative [8]. If the interval (from negative to positive or vice versa) is less than the basic interval, it is not considered. Given that a fatigue failure in some of the load is important, this method is widely used. This method is more common when:

1) The counting interval of time signal that measures going up or down between two points.
2) The counting pair of equal intervals or full time cycle, that analyzes the number of full cycles or their amplitude and report as output [9,10]. In figure 4 the history with the number of counted cycle based on change interval is shown.

![Diagram](image)

Figure 4. The number of counted cycle in the range method

In this method, first the maximum and minimum points in each interval are determined on the force-time curve [11]. Peaks of the function are the points that place on the top of the basic load and change form a positive slope to a negative slope. Valleys of the function are points that place under the basic load and change their slope from a negative to positive. These points for an arbitrary history are shown in Figure 5.

![Diagram](image)

Figure 5. Relative maximum and minimum point in stress history

Then possible cycle that can be achieved from the combination of these intervals is formed (so that has the least harm to the cycle composition). As shown in Figure 6, cycles from the largest to the smallest is sorted and is counted. To remove small changes that cause cycles counting, in some references is used their average.
RESULTS AND DISCUSSION

In the rain flow cycle counting method, first, the initial history is specified as peaks and valleys that can be identifiable completely. According to the used program in this project, all information converted to a matrix. Next for each stress and its time component an element of the matrix is considered. The peaks and valleys in the form of a matrix are connected to each other. It should be noted that the interval between peaks and valleys is not important, and just relative position to each other is important. Cycle counting starts from the beginning of history. Because usually users deal with the periodic history, it is better that input history be adjusted that its start set with the maximum or minimum history tension. This trick is done for more comforting in the calculation and to get accurate answers.

Figure 7 shows the stress history that is expressed as matrix. If the values are not integer, it is necessary that round them, and then it can be an element in the matrix. All numbers should are rounded equally to disturbing does not happen in calculation of the cycle number.

Figure 8 is the prior stress matrix but some parts of it have been removed. In this figure first cycle is calculated and after counting, this cycle is eliminated. As can be seen in contrast to a simple cycle that have continuous manner, the counted cycle in this case is not necessarily continuous. The counted cycle also can include the initial and final history stress and can be recognized as a distinct cycle. As already explained this type cycles are included generally range.
This process continues and cycle counting one after another and then eliminated. In figure 9 is shown the last calculated cycle of this history. As can be seen this cycle is to include simple range.

After counting and remove all cycles, as shown in Figure 10, only the peaks and valleys (the relative maximum and minimum) remains that actually are the data that are given as input to the program.

According to the results, is observed rain flow method has better results. In fact, in the rain flow method, counting cycle is done on a half cycle and why this counting method is more accurate than other methods. In the level crossing counting method, the major problem is the time base selection. Even though, the basic load is considered as the average of applied load, but, number of calculated cycles changed with a slight change in basic load. This is shown extreme changes in extent of damage and Palm-Miner equation. The range counting method has similar results with the level crossing counting method and the peak counting method has worst results.

CONCLUSION

295
REFERENCES


Matsuishi, M. (1968), Fatigue of metals subjected to varying stress. Presented to the Japan Society of Mechanical Engineers, Fukuoka, Japan.[3]


