TOLERANCE CALCULATIONS IN MECHANICAL WATCHES

ME251

Group 3

1 Introduction

Any Mechanical Device has got a range of tolerance. Same is the case with a Mechanical Watch, they are not exact, they also have tolerances. The tolerance of a watch is the **Maximum amount of seconds it may gain or lose per day**.
Lets say, a timepiece has a tolerance of **+3/-3**, then it means that the watch is going to deviate at most that much.

There are many factors on which the tolerance of the timepiece depends, like **Environmental factors such as Temperature, Gravity, and Shock**. Also the using conditions like **regular usage, movements of your arm**. They can influence the Gain/Loss of the watch.

2 Impact and Industry Standards

If a watch is 99.9 % accurate (which is very high as compared to industry), but then also the watch will be off by 1 minute and 27 seconds each day, which is not at all acceptable in luxury watch world.

While manufacturing, the cost of the product are generally dependent on the material and the process of manufacturing. But there is another aspect to this, which includes **The Aspect of Tolerance**.
If a timepiece has a very less tolerance, then the watch is highly accurate in time keeping, but then it is extremely heavy on costs, but on the other hand, if we increase the tolerances, then the accuracy of the watch is compromised.

A tolerance of **-20/+20** is an acceptable industrial standard and a tolerance of **-7/+7** is considered to be perfect.

ROLEX watches are extremely costly, not just because of there aesthetic aspect but also thanks to the factor of tolerance. They have one of the lowest tolerance of **-2/+2**, in the industry, leading to increased accuracy of there product.

3 Factors affecting the Tolerances

3.1 Magnetism

- One should not leave a mechanical timepiece close to magnetic objects for a long time, which include **Cell phones, television and PC speakers, magnetic necklaces, handbag clasps, hair-driers, electric razors, magnetic parts of refrigerators**.
- An affected watch remains magnetically charged even after being removed from the magnetic source, and thus this will affect its time keeping capability.

3.2 Position

- Gravity is also a culprit in affecting the tolerances and thus accuracy of the watch. It will gain/lose time if placed in a single position.
- The balance wheel has been adjusted to compensate for losses and gains in different positions.
- An adjusted watch should perform overall within the specification when worn throughout the day.
- If you remove the watch at night you may want to find the optimum position that will compensate for drift during wear.

3.3 Shock

- Any shock to the watch may also damage or move some of the internal parts, thus reducing the accuracy.

3.4 Temperature

- The modulus of elasticity of materials is dependent on temperature.
- Generally we take the material Nivarox, which is less affected by the change in temperature. But the effect of change in Elasticity plays a very important role in the affecting the tolerances.
- Normally, under high temperatures, a watch tends to lose time, and under low temperatures, it tends to gain time.
- We know the formula of a time period is as follows:

  $T = 2\pi\sqrt{\frac{I}{K}}$
  where,
  I = Moment of Inertia of the Balance wheel.

K = Stiffness constant of the Hair Spring.

We know that the value of the Stiffness constant (K) is directly proportional to the Young's modulus (E) of the material.

$K \propto E$

So, we find that the Time period of the timepiece is inversely proportional to the square-root of the Modulus of Elasticity of the watch.

$T \propto \sqrt{\frac{1}{E}}$.

So, if we increase the temperature, then the Modulus of Elasticity decreases and thus the time period increases.