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Plausibility of Correlation between Orientaion and Strain Developed in beta-Titanium Alloy *Ti5553*.

Upendra Sharan Gupta[1], Eshan Nigudkar[2], Ashutosh Bangar[3], Arpit Soni[4]

[1] Reader Dept. of Mech. Engineering , SVITS, Indore, India

[2] Bachelor of Mech. Engineering , SVITS, Indore, India

3 Bachelor of Mech. Engineering , Indore, India

4 Bachelor of Mech. Engineering , Indore, India

ABSTRACT

High demands of Titanium and its alloys owing to the primary attributes of this boon-like element have rendered Titanium alloys under the scanner since for a while. Catching the eye of aerospace industry and materials aspects of aircraft industrie[1], Titanium alloys have given the researchers a lot to ponder. Also its applications in the field of medical sciences is a major factor why Titanium alloys are being studied vigorously. Taking things to the micro scale, study of the microstructure of these alloys is the basic requirement for altering their mechanical properties, which eventually is the main requirement according to situation to which the alloys are to be subjected. In the wake of this an experiment was conducted on a beta Titanium alloy Ti-5553 (*TI-5Al-5Mo-5V-3Cr*) sample where the effect of orientation on the change in length of the sample was taken into account, the procedure evaluation and results will be discussed in this report. The mechanism of the experiment involved processes like dilatometry, EDM.

Keywords—EDM, Dilatometry, Ti-5553.

I.INTRODUCTION

The primary properties of Titanium make it an essential element of the modern day world, where on one side it is lighter than iron while on the other side it has very high strength as compared to other metals. In our study we used a beta-Titanium alloy sample called Ti-5553 that is, *Ti-5Al-5Mo-5V-3Cr.* As from metallurgical properties we know that chromium and nickel have anti rust properties. So the involvement of chromium in the alloy composition of *Ti5553* justifies its presence. In our experiment we deal with the strain developed in the sample and the effect of orientation of the molecules of the concerned alloy. Readings were taken from a dilatometer in which the *Ti5553* samples were placed one by one with each sample having a different orientation. For this set up five different directions were chosen namely, the rolling direction, the transverse direction, the normal direction and the other two orientations at an angle of 30° and 60° to the rolling direction. The behavior of all the samples was observed and a trend was noticed in the heating and cooling curves.

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II.CHEMICAL COMPOSITION

The chemical composition of Titanium alloys plays a vital role in deciding the role the alloy is going to play when put to practical use, for example chromium[2] and nickel based alloys are used where high fatigue strength and corrosion resistance is required.

TABLE 1 : Chemical Composition Ti-5553(Weight percent).

Titanium	Balance
Vanadium	4.0-5.5
Aluminum	4.4-5.7
Molybdenum	4.0-5.5
Chromium	2.5-3.5

III.EXPERIMENTAL PROCEDURE

The Titanium sample was received in the form of a thick sheet of metal. For the experimental purpose it is very important to know about the rolling direction of the work piece. The work piece had its rolling direction along its length.

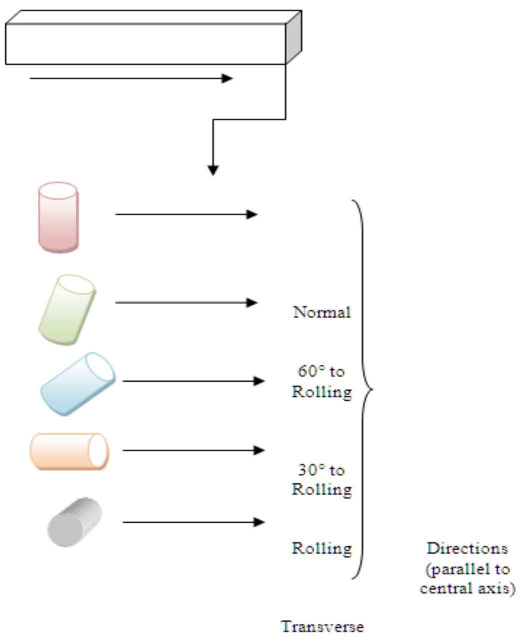

Figure 1. Sample preparation procedure

A. Electrical discharge machining, EDM

The cylindrical samples of 6mm dia and 10 mm height were cut out from the received sample through a spark eroding, spark machining or EDM. One sample for each direction was removed from the main sample through EDM.

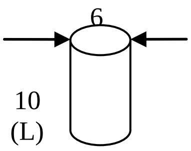

Figure 2 Sample dimensions(mm)

B. Mechanical polishing of Ti5553 alloy sample

Before the sample is subjected to any heat or tensile treatment, it is very important to carry out mechanical polishing of the work piece. This not only erradicates the irregularities on the surface but also diminishes the minute scratches which could lead to the formation of cracks, and hence failure of the procedure. For mechanical polishing both, hand polishing via sandpaper and machine polishing via a mechanical polishing machine were used. A coarse paper was used in the beginning and then a fine grit paper during the course of polishing.

C. Dilatometry of the samples

Dilatometry is a method of measuring precise dimensional changes in work pieces via a programmed apparatus, Dilatometer. There are few types of dilatometers available like *capacitance dilatometer*, *connecting rod dilatometer*, *high resolution dilatometer* and *optical dilatometer.* A n optical dilatometer was used in our experiment in which the *Ti5553* sample was heated from Room Temperature to 940°C and then cooled back to the room temperature. Dilatometer measures precise change in length i.e the strain at every instant of the process. Since the behavior of the alloy towards dilatometry can be observed better by knowing the strain produced at every instant rather than the total strain produced, we took into account the *relative change in length* of the 10 mm height sample. As we know that anything which is subjected to heat and temperature rise is subject to expansion, or technically thermal expansion and in the case of cooling vie-versa. The data received after the dilatometry is used to study the nature of heating and cooling curves plotted *relative change in length* ***Rel(ΔL)*** Vs ***Temperature***. The trends observed in the graphs hence proved the plausibility of the existence of some correlation between the orientation and instantaneous strain developed in a *Ti5553* sample.

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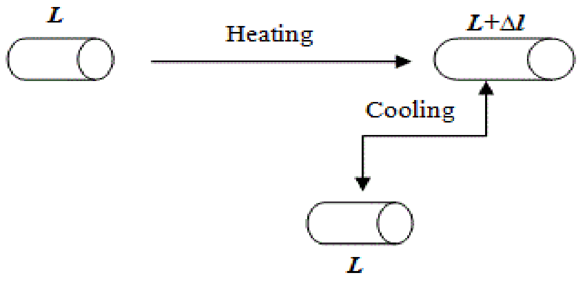
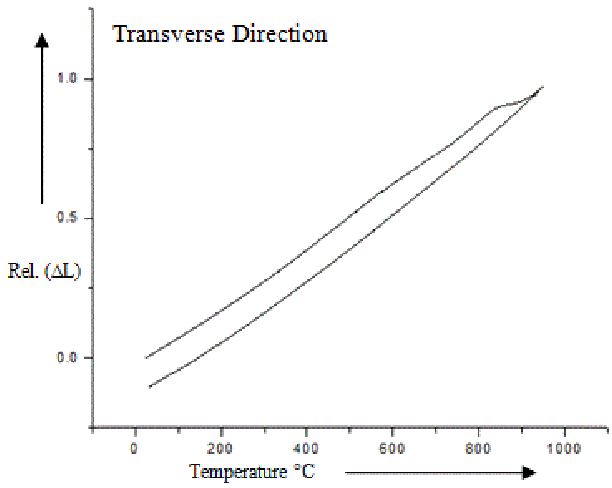
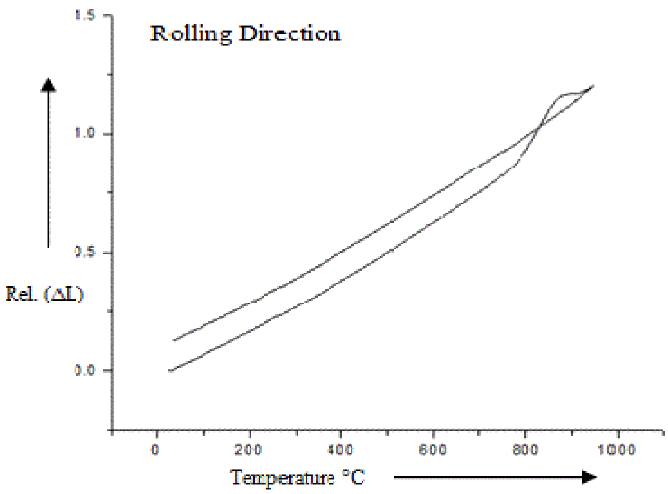


Figure 3. dilatometry procedure

IV.HEATING AND COOLING CURVES

All graphs are plotted as **Rel. ΔL (In Micro Meters) Vs Temperature °C**





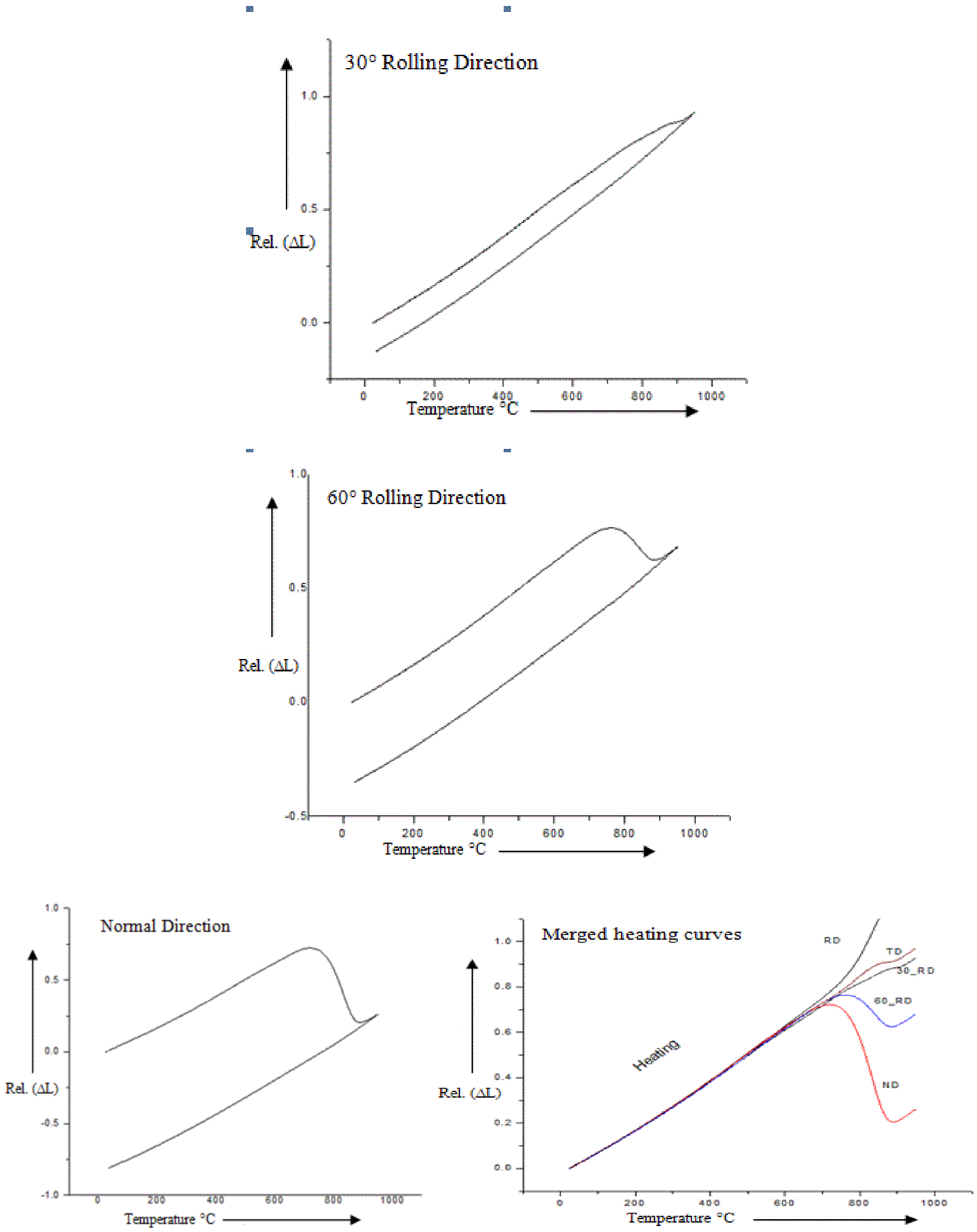


Figure 4. Dilatometry curves.

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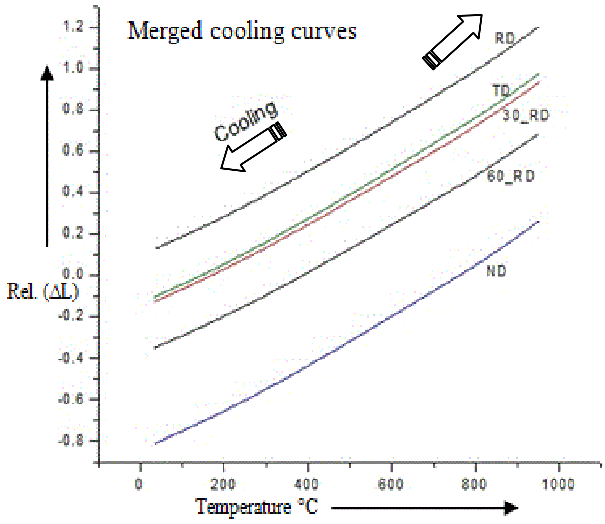

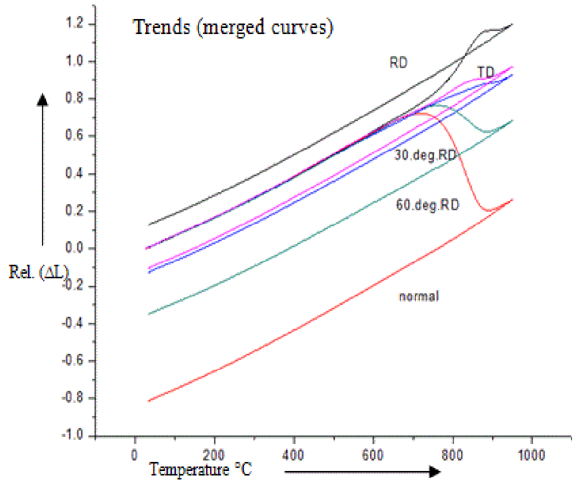

From the heating and cooling curves of *Ti5553* sample for different orientations we observe that there is a trend which the curves follow, as they show a gradual altitude change of the cooling curves. It also conveys that the heating curves of all the directions coincide upto a point after which they follow different paths owing to the phase change in a β Titanium alloy. For β Titanium the transformation into β [3] state takes place at a temperature of 833°C. However, if β Titanium is alloyed with elements like Nickel, Chromium which are better known as β stabilizers, the[4] temperature at which phase transformation occurs is lowered, i.e to stabilize the β phase. Some of the β phase may also exist at room temperature.

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V.OBSERVATIONS AND CONCLUSION

We observed the heating and cooling curves of the sample closely and found a very specific trend in the nature of curves. Hence we conclude that a correlation between the orientation of the sample and instantaneous relative change in length is plausible. Hence it can be predicted that in future a correlation can be established between the two aspects if the microstructure of the sample is further studied via various microscopic techniques such as SEM, EBSD.

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