DEVELOPMENT OF A TEST CONCEPT FOR INVESTIGATING THE FALSE RELEASE OF ALPINE TOURING SKI BINDINGS

Raphael Fischer[1], Stefan Schwanitz[2], Manuel Aumann[1] and Stephan Odenwald[2]
[1] Oberalp Deutschland GmbH, Saturnstr. 63, Aschheim, BY, 85609, Germany
[2] Chemnitz University of Technology, Reichenhainer Str. 70, Chemnitz, SN, 09126, Germany

The aim of this work was to experimentally verify the load case as well as the mechanism that are responsible for false releases of alpine touring ski bindings in order to improve safety in this trend sport. In literature [1], an oscillating torque around the longitudinal axis of the ski (M_x) is considered as being responsible for the unintentional release. In field tests, peak torques of 40 Nm were measured at a dominant load frequency of 2.8 Hz in the toe piece of the binding. Resonance cases as well as inertia effects of the binding are discussed as possible causes.
In this work, we examined the dynamics of six tech alpine touring bindings, commonly referred to as pin bindings. This means, at least the toe piece of the binding incorporates a set of pins to hold the boot in place during uphill. The release torque of a toe unit as such is comparable to a DIN z-value setting of approximately 2 to 3 in alpine skiing bindings. These pin based toe pieces are combined with pin heel pieces as well as more complex multi-directional release units. So called frame alpine touring bindings were not involed in this study. The study involved the following experiments:

i. Modal analysis #1: binding mounted to an alpine touring ski; single impact at half of the nominal ski length
ii. Modal analysis #2: similar to i., but boot with sole length of 297 mm (Dynafit Speedfit) mounted to bindings, bindings set to descent mode
iii. Release tests of bindings mounted to skis, using specific test boot to apply an oscillating M_x

The modal analysis yielded three natural frequencies in the range up to 100 Hz. The resonance frequencies decrease with increasing weight of the binding, which can be explained by the correlation of the vibration frequency of a structure with weight and stiffness. Consequently, large changes in frequency are noticeable when comparing bindings with a large difference in mass. As far as the modal form is concerned, bending vibrations occur almost exclusively.
With the developed test stand (Fig. 1a), the desired torques and frequencies can be introduced into the ski-binding-boot-system. The principle of a thrust crank driven by an electric motor is used for this purpose. The force generated in z-direction is converted into desired torque via a lever attached to the shoe. The force is measured at the point of force application and allows the torsional moment

Corresponding author email: raphael.fischer@dynafit.com

M_x to be calculated. The amplitude of the M_x is designed to be adjustable via the stroke of the thrust crank, while f_x can be controlled via a frequency converter using a potentiometer. In the course of the tests, a total of five false releases was observed. The causal load case is very repeatable and is 24.43 Nm at 15.8 Hz. This does not correspond to the information from [1], which postulates 40 Nm at 2.8 Hz. Regarding the frequency, [1] reports another dominant at 13.5 Hz, but with a lower amplitude. Consequently, the load frequency is the causal factor of the false release.

(a) **(b)** **(c)**

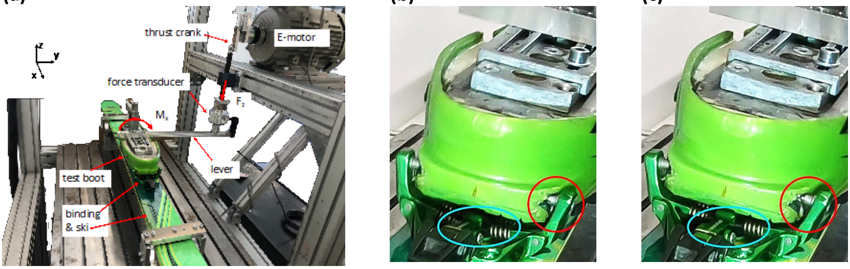

Fig. 1: (a) Test rig for applying an oscilating torsional moment Mx, (b) video footage of a toe piece briefly before false release, and (c) fully opened front jaw.

With these findings, it is now possible to estimate the mechanism of origin of the false releases. First of all, the observed frequency does not correspond to any of the natural frequencies determined from the modal analysis. Thus, a resonance case can be ruled out as the cause of the unwanted release. The analysis of the video recording during the releases (Fig. 1b, Fig. 1c) rather suggests the inertia of the front jaw in pin bindings as the cause. When the torque is in a range in which minimal opening movements occur at the front jaw, the unwanted releases occur when the associated load frequency reaches a level at which the front jaw can no longer move back to its original position in time before being hit by the subsequent impulse and the front jaw is still minimally open, which results in a further progressive opening movement. This continues until the force vector of the retaining springs are in line with the fulcrum of the pin's lever (red circle in Fig. 1b&c), and the front jaw opens fully. When transferred to reality, such a load case would be conceivable on a hard, icy slope and also coincides with the conditions under which the said literature reports the false release.

In conclusion, it can be stated that the test stand replicates reality to a good degree and that the responsible load case and the mechanism of false releases can be simulated to further improvements of alpine touring ski bindings.

Corresponding author email: raphael.fischer@dynafit.com

1. Campbell J (2016). Laboratory and Field Testing of Alpine and Alpine Touring Ski Equipment Retention and Release Characteristics (Doctoral dissertation). Retrieved from U Washington Open Access Database. (Accession No. 2017-02-14T22:41:12Z)

Corresponding author email: raphael.fischer@dynafit.com