II. Thesis

Within the realm of the design world, very rarely does a product withstand the test of time. Design solutions are evolutionary and respond to our advancements in technology along with human factors including a need for efficiency, safety, and economic value. My Integrative Thesis Project is exactly this, a design experiment that responds to particular human factors. It would be wrong to deem my design anything but an experiment. My project is only the first step towards a design solution within the world of alpine skiing. I have developed a ski design that attempts to address human factors while incorporating a unique presentation. This project presents a single-ski designs thats dimensions allow for considerable flexibility and play. While my design may very well prove to be a design success, it may also present problems, which is a risk I am willing to take as a designer.

"The greater danger for us lies not in setting our aim too high and falling short; but insetting our aim too low, and achieving our mark."

Michelangelo

The Developing Stages

In the beginning I had plans to revolutionize the ski industry. I wanted to develop a new binding system and skis that could increase the degree of the turn and its transition time. Improving the current utilized technology available has been the driving force behind my design ideas and innovations. Through several stages of development and alterations, I have developed a design that addresses some of the issues the ski industry faces today when considering new technology. Design challenges in the alpine design require you to consider injury, performance, and economic value. The process has been and will continue to be challenging, frustrating, and ultimately rewarding.

I entered the fall semester thinking about the ski and more particularly the binding of the ski. I asked myself what would happen if I created a binding that would allow for a higher degree of pivotal extension? Would a more flexible binding give the skier more

transition in the turn? How could I make this possible? Would my binding prevent or contribute to injuries? This beginning stage presented challenges for me. I had a lot of questions but no way to answer them. I began searching for a specific problem. During this period of research I developed runner's knee, a complication due to constant impact and a wear down of my patella's surrounding cartilage. I started to wonder if all those years of alpine racing could partially be to blame. Was it because of the technology? To no surprise I have found several statistics stating that the current knee injury rates among downhill skiers is in conjunction with the alpine technology utilized today, particularly bindings.

"In spite of the fact that the overall incidence of alpine ski injuries has decreased during the last 25 years, the incidence of serious knee sprains usually involving the anterior cruciate ligament (ACL) has risen dramatically since the late 1970s. This trend runs counter to a dramatic reduction in lower leg injuries that began in the early 1970s and to date has lowered the risk of injury below the knee by almost 90%." (2).

My fellow high school ski teammate who tore her ACL downhill skiing came to mind as I continued to find a plethora of injury statistics. Through my research I realized I needed to look at the epidemiology of alpine skiing since the first known reviews in the 1950's (1). To understand the injuries, I needed to look at the evolution of the ski itself. I discovered that since skis development from their Norwegian roots in the 19th century, manufacturing has evolved from the traditional Telemarks, to the twelve foot long hickory planks, up to the introduction of steel edges by Rudolph Lettner in 1928. For the next few decades skiing made a name for itself within United States with the introduction of laminations distributed by Thor Groswold (held licensing rights to produce the Norwegian lamination process called "Splitkein"), along with attempts at metal ski production by manufacturers like Howard Head. However, it wasn't until the late 1950's that skis truly began to revolutionize. The introduction of fiberglass in the early 1960s and the one-piece fiberglass cap construction, called monocque, took skis from handcrafted design to a more profitable manufacturing process (3). Thus, skiing and its technology became more accessible to the world. As skiing grew in popularity so did the amount of related injuries.

From the 1950's to the late 1960's, there was influx of lower extremity injury rates (below the knee). Manufacturers worked to improve equipment in order to address the lower leg injuries. "With the advent of higher, stiffer boots that effectively bypass the ankle, ankle sprains and ankle fractures have shown a 92% reduction since the early 1970s. Improved bindings are responsible for the reduction in tibial fractures, as well as soft tissue contusions about the shin. As bindings have progressed from a nonrelease status through two-mode release to multimode release, both spiral fractures and nonspiral fractures of the tibia have shown reductions of more than 80% from the early 1970s (1)." However, the injury rates seemed to shift from the lower leg region to the knee. "While the relative rate of knee injuries has remained fairly constant, there has been a very disturbing statistical trend toward increasing grade III ruptures to the ligamentous structures in the knee, particularly to the ACL. Johnson reported a 228% increase in grade III sprains of the knee between 1972 and 1994" (1).

I had found a problem, the ACL tearing in association with rear release bindings. I began thinking about a new binding that would allow for a unilateral pivot design, essentially causing an even extension in the rear and front binding. By studying the anatomy of the knee and how ligaments tear in an ACL injury, I found that twisting or wrenching was to blame. In a moment of epiphany I realized that the injuries among skiers were due to a frontal pivoting binding with a stationary rear binding. When a skier falls or comes out of a ski without intention, it is typically by the region of the tibia twisting in opposition to the femur, resulting in an unnatural pull of the knees anterior ligaments. My next step was to create new technology that addressed all of the problems. However, I quickly realized how many factors came into developing a new ski binding that attempted to solve the ACL injury rate. If I were to develop a new binding system that released differently, I would have to acknowledge the overall stance of the skier including the way in which one balances throughout the duration of a slope descent. How does this affect the way one may be released from the binding? The way of the skier is determined by the ski, it shape and flex, as well as the boots. Also, no one skier is the same; there are different techniques and levels of athleticism. So how is it possible to look at one centralized problem, the bindings, and alter them without consideration for the other factors that come into play?

Ski bindings are a part of an entire system. It would be impossible to take one aspect of this system, without considering the other contributors. When studying the sport of skiing one has to think about the boots, the skis, and the poles, as well as the bindings. I decided I needed to understand the ski itself. For me, the ski becomes an extension to my body. The ski is what connects me to the snow and creates the relationship I have with it, the ski is what makes the sport. This being said, I put the binding on the back burner and shifted my focus to everything I could learn about building a ski. From the onset I had this grandiose vision of new technology different from anything else on the market. I started to look specifically at ski layouts that could effectively respond to my potential binding concepts, as well as acknowledge my influences and inspirations.

Influences

The ski has always been a symbol of my character. Skiing is a sport that is a part of my being. In all of the travels, moving, and inconsistency in my life, I have found a sense of consistency through skiing. My childhoods spent in Northern Michigan gave me a sense of dedication and love for the outdoors. My upbringing through sports and the world outside have brought about this everlasting interest in kinetics. I have spent a significant amount of time in the countryside of California, where I began to succumb to "Green" Thinking. All of these factors pay tribute to my final thesis project and how I have wanted to reflect a new technology for the ski industry, more specifically, how I see the ski itself.

Originally I was dedicated to the building of an eco-friendly ski. I thought about the materials that would go into my ski. I looked at environmentally friendly alternatives to the materials used within the ski industry. I looked at bamboo as an alternate core vs. poplar or carbon. The flexibility and strength interested me, yet I feared its water-soluble properties. I tried to find the most environmentally safe epoxy resins with the lowest release of Volatile Organic Compounds. In junction with a low VOC epoxy, I considered hemp fiber as a replacement to the very toxic and carcinogenic characteristics of fiberglass fiber. Within a month I had found a multitude of materials I considered

"safer". I developed a full list of alternative materials, how much I would need, and how much it would cost. I followed skibuilders.com (4), a small web community of craftsman dedicated to the handcrafting of skis through an elaborate pneumatic press process. Their press was built within a steel frame that utilized air pressure between MDF molds. I quickly realized the ski press alone would cost a considerable amount of money. This estimation for cost was without use of alternative reclaimed wood and recycled steel parts for the press. I realized how difficult being "green" was on a student's budget. At this point it was semester's end, and though I had a vast amount of research behind me along with complicated aspirations for my project, it was brought to my attention that the feasibility and reasoning behind my ski was incoherent. Needless to say, semester break was one of confusion and disarray. However, upon return from break with guidance from fellow professors and students, I found the strength to develop my project to its current state. I embraced the changes.

The Project Now

For my senior thesis I have had to repeatedly step back and think about what variables within my ski design are most important to me. Though eco-friendliness is a factor I like to pay attention to in design, it is not something that has taken precedence in my project as originally planned. I didn't create a safer system of alpine technology and I didn't revolutionize the industry. Instead, I have forced myself to shift focus from a finished product to an experimental approach. I took the research I had culminated and decided to build my own prototype ski from a custom built press. I didn't dwell on the success of the ski, I went with what I had learned and I took a risk.

The one variable that has not been altered significantly throughout the projects onset has been my intended geometry of the ski. My ski dimensions are playing on a crossbreed between snowboards, longboard skateboards, freestyle and powder skis. Initially I had planned on building two skis with the dimensions 150-88-140, proportional references for the tip width, midsection width, and tail width. After giving it some thought, I came to the conclusion that a dual mount may require a little more midsection width. I changed the dimensions to 160-90-150. Essentially, the ski I have built is

reminiscent of a water-ski. The skier will clip into a rear entry binding system with one foot in front of the other, using the traditional poles for balance. The camber (distance from center of ski to ground with no added weight) and sidecut radius (the edge of the ski's curvature) have been increased from typical measurements to compensate for the additional weight added on a single ski. I am playing with the variable of geometry in typical alpine ski dimensions, while reducing the number of variables within the equipment. The reason for this is to create a ski that will be fun for the intermediate, all-mountain, all terrain skier that wishes to explore the ski in an entirely different way. What also became apparent was a reference to the disabled. I have raced against handicap skiers that are forced to utilize the current technology. The ski I have designed is specifically made for single skiing, catering to the handicap as well as any single ski enthusiast. There are many characteristics I would like to alternate and play with in my ski designs and geometry is just the beginning. The scale of my project has reduced itself to a more centralized focus on the ski shape combined with a more economical and attainable means of production.

The mold no longer consists of the pneumatic press design I was using for guidance from skibuilders.com. Instead with the assistance of Jan Hendrickson, a professor and designer here at the University, I found a feasible vacuum bag mold construction. The base mold consists of routed MDF board with an enveloping food saver bag compressed by means of a vacuum. I utilized a basalt fiberglass composite sleeve in combination with a light fiberglass sleeve around a ski core consisting of plywood and poplar laminated together with epoxy. First I cut the strips for the core. I cut the maple into 1inch strips and the poplar into 3/4inch strips. I then glued together the strips using epoxy to create one vertically laminated plank. Once the plank was dry I used a planar to create a consistently flat surface on each side. The next step was to cut out the core using the CNC Router. I took the dimensions I had created in CAD to the 3D print lab where my 2D layout was transferred to a 3D modeling program. The core was routed out with the tip and tail heights at about 3mm with the mid at 12mm. This routing of the core would allow me to create a camber for the ski since there would be more allowed flex as a result of less material. Using the CNC router was a great way to route out my core easily, but it

may have not been the best way in the long run. The challenge became creating the camber I wanted for my ski from a flat piece. To do this I had to dampen the ski and use a series of blocks and clamps. As a result of the pressure the core split along some of its laminations. It took a lot of patience and work to get the core to mold to the camber I wanted. The cracks, as a result from the dampening of the core, were not ideal but not of significant concern. The two layers of fiberglass would give the ski its real integrity. The first layer of light fiberglass was soaked in epoxy and put in a sealed food saver bag, which was then put in my mold to dry. Once dry the fiberglass was sanded down to a smooth finish so the second basalt fiber layer could be put on. This was not vacuum-sealed, which caused some minor imperfections in the final coat. However, I had a beautiful prototype and its name was The Libra.

Reconciliation

Libra is Latin for balance. The name only seemed appropriate, not only for the obvious reason of a single ski design. Additionally, I am referring to balance in terms of oneself. This project has been through a series of alterations over the past year, and at times I found myself questioning my motivation and giving in to my fear of imperfection. With my feelings of inadequacy I have a tendency to close in on myself, stop working, and stop communicating. I went through a period this year where I was apprehensive to outside help because I feared it insinuated my incompetence. In the end, I sought the help of Jan Hendrickson and Hank Van Gaale (fabricator). It was in our team of efforts that my project came together, that balance was attained. I realize that I cannot do everything on my own, and I cannot set unreasonable expectations for myself. I did not make the history books or the ski magazines, but built a ski different from any other. I experimented and explored. If there is one thing I have learned from this whole Integrative Project experience, it is to think big but start small. My senior thesis project is about change, transition, and development. My goal is to come to grips with how I can manipulate both the constancies and inconsistencies involved to become a better athlete, designer, artist, and human being.

"We come into this world head first and go out feet first; in between, it is all a matter of balance"

Paul Boese

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