

## SOUCY COMPOSITE RUBBER TRACK TECHNOLOGY

**Tommy Marcotte, Eng.**

Soucy Defense

Soucy International Inc. – Rubber Tracks Division  
Drummondville, Qc, Canada

### ABSTRACT

*Rubber tracks are now extremely competitive for vehicles up to 50 tons and fully fielded on 39 ton vehicles. They represent the best of what technology can offer for tracked vehicles, in terms of high durability, performance and low life cycle cost. This is mainly attributed to the optimization through the five (5) technological tools described in this paper. Better from its numerous distinctive advantages, rubber tracks can be adapted to suit virtually any specific need. This ductile rubber track technology can be shaped to match today's requirements, with the help of advanced rubber compounding and computer simulations.*

### INTRODUCTION

The use of M113 and 39 US ton CV90 vehicles in combat demonstrated a remarkable reliability and numerous technical advantages of this advanced technical solution.

Supported by functional analysis design, its own rubber compounding plant and R&D lab, advanced rubber compound characterization, modern dynamic simulations, controlled process, customized production equipment and finally, automated bench test, Soucy is glad to present advanced rubber track technology for 50 ton vehicles.

### THE ORIGIN OF RUBBER TRACKS

Relying on its snowmobile rubber track heritage from the 1960's, Soucy Group got its first Defense contract in the late 1980's to design and manufacture rubber tracks for the Sisu Patria Na-140 4-track articulated vehicles (6 tons). Three decades later, Soucy Defense is the exclusive OEM rubber track supplier for BAE SYSTEMS HAGGLUNDS BV206 (called SUSV in USA), BvS 10 Viking (11 to 16 tons), STK Bronco (18 tons) and Warthog (24 tons).

Counting more than 1200 armored articulate amphibious vehicles in service with Soucy tracks and many more BV206, Soucy Defense supplies a turnkey solution, including sprocket, road wheels, tensioners and much more.

The rubber tracks developed for the M113 family in the early 2000's are really at the origin of the modern rubber track technology now used on 39 to 50 ton vehicles. Initially fitted on 12 ton M113 A2 in Norway and Denmark, it was reinforced for 18 ton M113 A3 for Canadian, Danish and eventually on upgraded Norwegian M113 A3. Soon, the rubber tracks were on stretched MTVs and M113 G4 in 2008, weighting up to 23 tons.

A total of over 1500 vehicles of the M113 family were converted to Soucy rubber tracks, most end users converting 100% of their vehicle fleet. Use in Iraq and Afghanistan has proven exceptional reliability.



**Figure 1:** Warthogs vehicles at Camp Bastion  
*Photo: Flt Lt Nick Downs. Crown Copyright/MOD 2011.*



**Figure 2:** Danish M113 G4 modernized by FFG  
*Photo: Danish Army*

In 2011, Norwegian CV90 vehicles were converted to rubber tracks and fielded in Afghanistan. Virtually all Norwegian Defence Logistics Organisation (NDLO)'s CV90, weighting up to 39 tons, are now using Soucy rubber tracks.



**Figure 3:** CV90 Infantry Fighting Vehicle, Norway  
Photo: FLO / Norwegian Ministry of Defense.

**RUBBER TRACK ADVANTAGES**

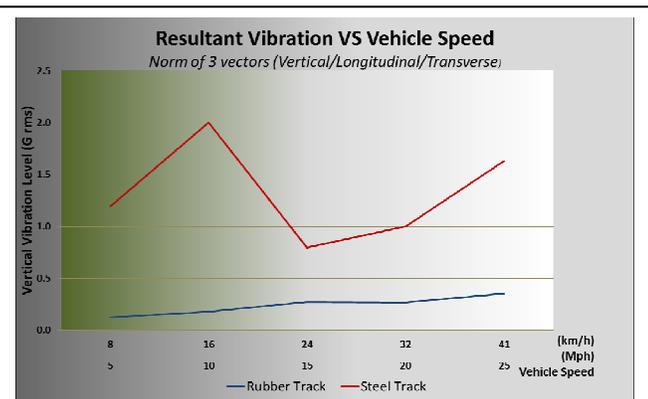
Rubber tracks have many advantages over traditional steel tracks.

**Vehicle Weight Budget**

The first advantage is **weight reduction**. Typically, weight reduction represents roughly half of the steel track weight. For example, 39 ton CV90 vehicle saves nearly 1.3 tons by replacing the T157i steel track by Soucy's rubber track. For a vehicle subjected to weight budget limitations, like the Mobile Protected Firepower (MPF), the rubber track is an alternative solution.

**Vibration**

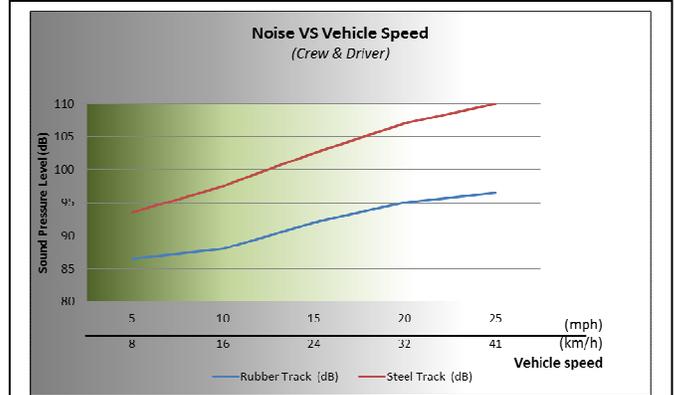
Rubber tracks also **reduce the vibration level by up to 70%**. This reduces crew fatigue, wear and tear on electronics and reduces ammunition insensitivity.



**Figure 4:** Typical reduction of vibration VS speed

**Noise**

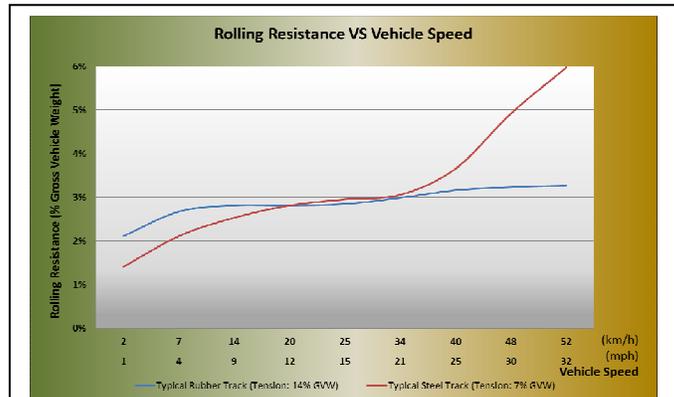
Rubber tracks also **reduce noise level up to 13 dB**, which improves crew health and safety, as well as mechanical condition awareness. Communications become more efficient and mechanical issues can be predicted or quickly diagnosed. The vehicle also becomes much stealthier.



**Figure 5:** Typical reduction of noise VS speed

**Rolling Resistance**

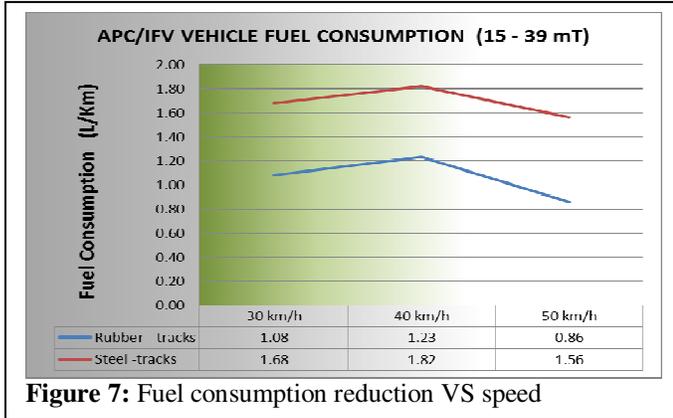
With less noise and vibration, the smoother ride, combined with reduced weight and inertia, provides a reduced rolling resistance, mainly at higher speed. At a vehicle speed of 32 mph and more, rubber tracks typically provided a **reduction of up to 50% of the rolling resistance**. This reduces wear and tear of the engine, transmission, and final drives.



**Figure 6:** Typical rolling resistance reduction VS speed

**Fuel Consumption**

The reduced rolling resistance obviously translates into reduced fuel consumption (L/km). Cost saving and improved vehicle range is then a massive gain.



**Figure 7:** Fuel consumption reduction VS speed

**Life Cycle Cost**

When considering fuel economy and track durability only, rubber tracks usually provide a reduction of 25% of the cost over traditional steel tracks. In addition, man hours are reduced by 53 hours of maintenance per 1,000 miles traveled.

**Mine Resistance**

Many mine blast tests have revealed that rubber tracks resist to a typical anti-personal mine (240g of TNT) and can still be used as a limp home, whereas traditional steel tracks will separate and create projectiles that worsen mine effects.

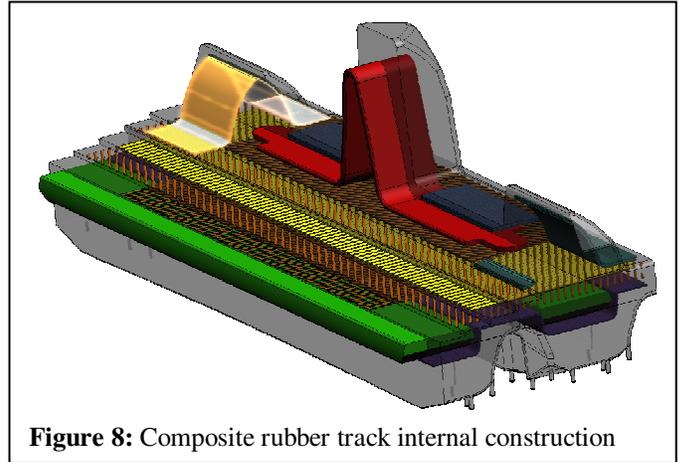
In the unlikely event that the rubber track would separate and that the vehicle is still serviceable, a rubber track repair kit is available.

**COMPOSITE RUBBER TRACK**

Rubber tracks for heavy vehicles have seamless continuous belting, on which we typically find one center guide lug, to keep the track centered with the wheels. To transfer torque from the sprocket to the track, two drive lugs are located on each side of every track pitch. Contact with the ground and soil traction is insured by the external profiles, which are rectangular-like shaped. To sustain stress, each component is strategically reinforced.

The belting has often more than one hundred (100) continuous steel cord loops, consisted of one single steel cord section, which is nearly one mile long. Over and below the steel cord, multiple layers of steel mesh are positioned in angle, providing maximized track longitudinal torsional stiffness, to prevent de-tracking from track twisting.

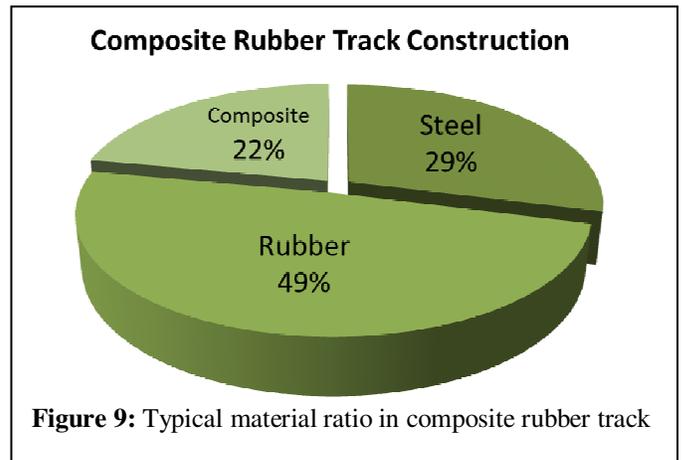
Center guide lugs are reinforced by a bent spring steel strip, highly tempered to limit plastic deformation, while providing the perfect fatigue resistance level.



**Figure 8:** Composite rubber track internal construction

Depending on the application, drive lugs may or may not be reinforced by steel, fabric or plastic sheets. The core of the drive lug is often made from a stiffer plastic-like compound. Altogether, this drive lug construction allows a stiff drive lug that will be preserved with track internal temperature rise, and after many thousand stress cycles, preventing tooth-skipping over the track's lifespan.

The external profile has composite stiffener rod reinforcement, running through the width of the track, while filling a portion of the external profile. Made of resin (e.g.: epoxy, vinylester) and fibers (carbon, glass or both), its role is to distribute road wheel load evenly to the entire track width, resulting in a uniform ground pressure on the full external profile area. It also contributes to provide a high track torsional stiffness. Being subjected to very high track internal temperatures, the stiffener's composite key feature is to have a glass transition temperature higher than 450°F.



**Figure 9:** Typical material ratio in composite rubber track

One important material of a composite rubber track is of course, the rubber compound which represents roughly half the track weight. Overall, a composite rubber track is made of more than 12 distinct rubber compounds, each having different mechanical properties.

**FUNCTIONAL ANALYSIS**

Following advanced functional analysis, each track function, and associated geometrical feature, is made of a distinct rubber compound. In fact, each rubber compound is developed to obtain specific mechanical properties to maximize its performance in its designated purpose.

For example, the **drive lug caps** are made with high abrasion resistant, high modulus, low friction coefficient and self-lubricating compound. The **drive lug cores**, on the other hand, which are completely hidden inside the track, are made of an even higher modulus compound, but reveal huge compromises on many other mechanical properties. The absence of UV protection package, very low tear, cut & chip, and abrasion resistance, would normally proscribe the use of this compound but, to the contrary, in this case, this allows maximizing modulus and tooth skipping resistance, without any negative impact on the track performance. Just as any engineering field, compounding is all about managing compromises.

The **external profiles** are made of a more compliant, softer compound, with high cut and chip resistance, and higher friction coefficient to insure traction (Soucyprene™ compound, for future reference). The base of the external profile must have a high fatigue resistance and must resist to frequent high tensile deformation.

The inside of the track continuous **belting** is made from low heat generation compounds and high temperature resistant compounds (low reversion and high blow out temperature), to avoid track internal overheating and degradation.

**PROCESS, TOOLING AND PRODUCTION CAPABILITY**

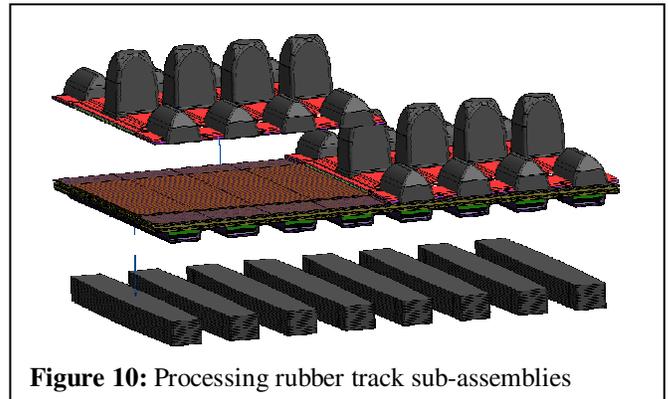
To allow the use of so many different rubber compounds in precise locations and to accurately position the different internal components, the use of rubber injection molding was quickly rejected as a potential solution. To face this demanding requirement, pre-compressed raw rubber sub-assemblies, combined with compression molding, soon became a must.

In fact, rubber components are, depending on the functional analysis, either extruded or calendered. If not simply used on rolls, the resulting rubber piece is cut to length to be either stamped in 3D shapes, die cut, pre-adhered with reinforcements, superimposed for a multi-layer

construction, and compressed. In any case, polymer chains orientation must be strategically aligned to maximize its performances.

Once each component is adequately formed, they are pre-assembled and pre-compressed, without being cured yet. Typically, the inside of the track, formed by the road wheel path, the drive lugs and guide lugs, will create a plurality of sub-assemblies. Also, each external profile is formed by one sub-assembly. Finally, the belting is one continuous piece, formed by staking multiple layers (rubber, fabric, steel mesh, steel cords...), on a rotating drum, with the same circumference as the final track length.

All components are joined at the press for curing. The press being a very specialized equipment, to ensure productivity and intellectual property, it is totally designed and manufactured within the Soucy Group. The same applies to the molds and any strategic equipment required for manufacturing the track.



**Figure 10:** Processing rubber track sub-assemblies

Among the general press specifications, it must be able to keep the steel cord under tension during all curing process, despite the steel cord thermal dilatation. It must control temperature uniformity and temperature raise rate in an independent way, for the inside versus the outside of the track (two independent sets of molds). It must also provide a molding pressure of 1000 psi, which greatly exceeds industry standards. Finally, it must facilitate manipulation of a one ton flexible track.

**OWN RUBBER MIXING PLANT**

With twelve different rubber compounds per track and different needs for its industrial, recreational, agricultural, and Defense market, Soucy has an immense need for compound development, production flexibility, and quality manufacturing.

With over 65 years of combined experiences, Soucy Techno, its research center and its dedicated chemists, it is the key to the success of Soucy Defense. Among others, from the development of adhesion compounds, low heat

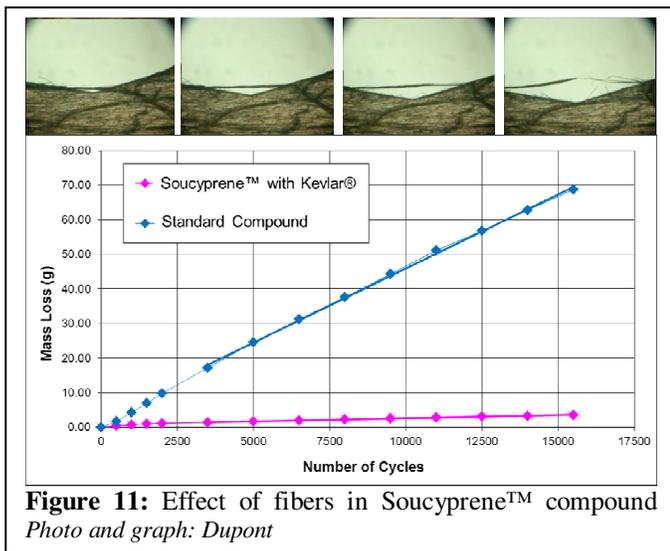
generation compounds, high cut & chip resistance compounds, Soucy Techno is very active, from the early beginning of every Defense project.

One specific example is the development of the Soucyprene™ compound, used in the track external profile.

Formulated to provide good cut and chip resistance, it allowed increasing track durability by 50% over regular natural rubber compound, setting a new standard for the off-road and mining industry.

The Soucyprene™ compound is based on high grade ribbed smoked sheet rubber, a natural rubber compound. Being made of filtered coagulated latex, it minimizes impurities and reduces crack initiations. Multi wall Carbon NanoTubes (CNT) substitutes some of the traditional black carbon. Finally, pulp of para-aramid synthetic fiber is pre-dispersed in a natural compound, either mechanically or in its latex form, to be dispersed in a rubber master batch.

The rubber is then calendered in thin layers, for improved orientation of polymer chains, CNT, and fibers. Cured at low temperature, it results in a reduced crack growth rate and increased field durability.



**Figure 11:** Effect of fibers in Soucyprene™ compound  
Photo and graph: Dupont

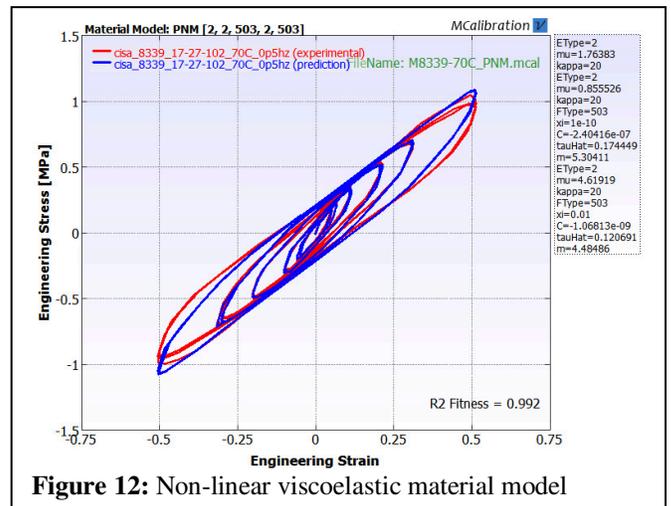
**RUBBER COMPOUND CHARACTERIZATION**

Rubber is a complex polymer. Being incompressible and subjected to large deformation, classic engineering does not directly apply. To add to the challenge, rubber modulus depends on the deformation percentage, strain rate (deformation speed of a viscoelastic material), and is even dependent of the temperature, which is evolving inside the track as it is being used.

Basic rubber compound mechanical properties (i.e.: tear, E<sub>100</sub>, Din Abrasion, Tg...) are soon becoming too limitative when advanced R&D and simulation are needed. In the early 2000's, when realizing that two compounds with identical basic mechanical properties were offering very different durability and performance levels, efforts were invested to understand the fundamental influencing factors.

Two factors are greatly affecting the durability. First, the Loss Modulus (E'') and second, the Storage Modulus (E'), which both vary in function of numerous factors. A multi-functional table (e.g.: MTS) and Dynamic Mechanical Analyzer (DMA) turned out to be the ideal tools to characterize different rubber compounds according to all variables.

Compound characterization involves monitoring the forces while varying the strain rate, deformation level (%), in both tension and compression, and rubber sample temperature, for pre-conditioned samples. The approach with shear modulus or engineering modulus can be both considered.



**Figure 12:** Non-linear viscoelastic material model

In conclusion, for every compound and every curing time and curing temperature, a matrix must be built to characterize every single compound of a track. A non-linear viscoelastic material model is then built and used as input data to finally simulate track behaviors.

**ADVANCED DYNAMIC SIMULATION**

Full scale vehicle testing is expensive and very time consuming. Computer modeling and dynamic simulations have been a powerful leverage in research and development for Soucy Defense over the last 10 years, allowing time savings in development program, while considerably increasing performances of the rubber track technology.

Over the years, many models were developed and correlated, helping to validate different designs and

applications. When pushed to the next level, those models are precious tools to push back technological limitations and to filter new concepts. Among those models are:

**Track Characterization**

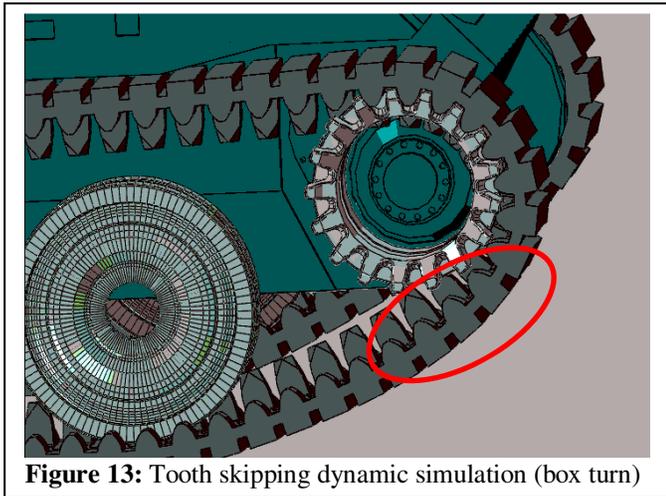
Now considered as a basic simulation, this model allows Soucy Defense to estimate, for a specific track internal construction, the multidirectional stiffness (e.g.: longitudinal stiffness, torsional stiffness ...). Once compared to the baseline, it can be used for “Go / No-Go” purposes or to fine tune and optimize rigidity output.

**Tooth Skipping Dynamic Simulations**

This model is the first of a series of complete “Tank Models”, which simulates the complete vehicle suspension behavior, chassis inertia, and full running gear.

This model is helpful to make sure the vehicle meets the Draw Bar Pull, tight turning and emergency braking requirement, usually simulated on paved road. Rubber tracks can generally provide a **pulling force exceeding the gross vehicle weight** ( $\geq 1.0$  G-force).

The model can also determine if the suspension movement will create severe track tension drop, to eventually generate frequent dynamic tooth skipping in bumpy conditions.



**Figure 13:** Tooth skipping dynamic simulation (box turn)

**De-Tracking Dynamic Simulation**

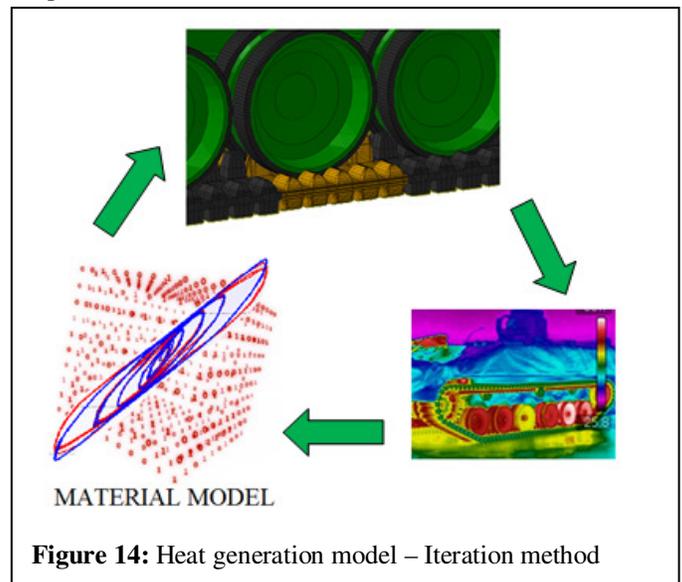
Also using the complete “Tank Model” philosophy, a forward moving vehicle is simulated, while a slowly increasing side load is simulated (e.g.: side slope or lateral acceleration due to curve negotiation). Rubber tracks usually **resist to 1.3g lateral**, while providing a safe de-tracking mode (track dislodged from the idler wheel, rubbing against the vehicle, slowing it down, as opposed to track throwing for steel tracks).

**Heat Generation Simulation**

Heat generation management is crucial in rubber track design. First, it is important to understand that rubber, under a stress cycle, will generate heat due to hysteresis. Since rubber is also a very good thermal insulator, the more rubber thickness on the track, the more the track internal steady state internal temperature will be high, and then subjected to reversion and structural instability.

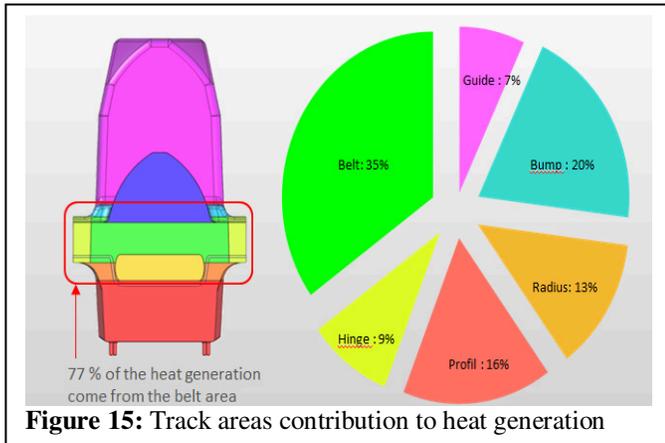
The track designer must absolutely aim a track steady state internal temperature below rubber blow out temperature, while considering maximum vehicle speed, maximum payload and maximum ambient (112°F) and paved road temperature (~185°F). On the other hand, the same track designer wants to incorporate as much wearable rubber thickness to the track, to maximize track durability and offer the most competitive life cycle cost. Facing this duality, a heat generation simulation tool is crucial to maximize track durability and reliability.

With the complete “Tank Model” philosophy, now with a small track portion with very fine meshed elements, a complete track rotation cycle is simulated for a specific track internal temperature. The evaluated stress, deformation and strain rate are evaluated and used as entry data to feed a parallel model, a thermal model. This thermal model evaluates the temperature rise. In an iterative computation manner, the new temperature determines the new material model, and the calculation re-starts, until a steady state temperature is found.



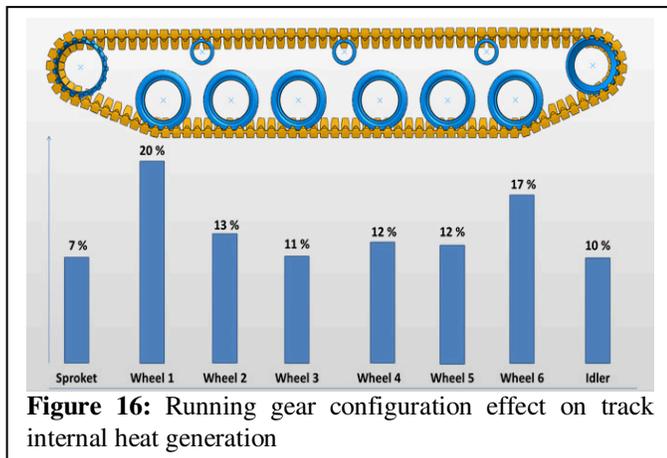
**Figure 14:** Heat generation model – Iteration method

Using this heat generation model, one can understand which track component or area mainly contributes to heat generation.



**Figure 15:** Track areas contribution to heat generation

With such a tool, it also becomes possible to determine the heat generation contribution from a specific running gear configuration. Recommendations can be made to the vehicle manufacturer to reduce heat generation, track wear an even, rolling resistance.



**Figure 16:** Running gear configuration effect on track internal heat generation

### AUTOMATED BENCH TEST

Small scale bench tests are very handy to evaluate new material and validate new concepts. However, it is often difficult to accurately reflect the real vehicle and ground conditions. Full scale vehicle tests are generally too costly and time consuming to be performed frequently. In an attempt to get the best of both worlds, an automated full scale bench test has been materialized.

This “Carousel bench test” allows a single track to roll 24/7 with representative loading, under computerized

supervision, at speeds up to 32 mph. The banking ring simulates a straight trajectory.



**Figure 17:** Carousel full scale bench test

A distance of nearly 10,000 miles can be performed each month.

### NEW 50 TON VEHICLE TECHNOLOGY

Since the official validation for the 39 ton product line, Soucy Defense has been in R&D phase for the new and improved 50 ton rubber track technology. Using low heat generation compounds, narrower center guide lug, new road wheel path design philosophy and new concave external tread, heat generation does not limit the tread rubber thickness anymore. Track durability is then improved, allowing a competitive life cycle cost even at this higher weight range.

A new track kit has been designed and a demonstrator vehicle is currently being assembled. From June to December 2016, the 50 ton vehicle, suited with rubber tracks, will undergo performance and durability trials to demonstrate the viability and maturity of the new technology for FFV, AMPV, MPF and AJAX programs.



**Figure 18:** Soucy Defense 50 ton demonstrator  
*Photo: Soucy Defense*

### REFERENCES

None