The McGILL RACING TEAM-15 calls on QUANTISWEB to meet precise aerodynamic coefficient targets to provide them with a competitive edge.

AT A GLANCE

The McGill Racing Team is comprised of undergraduate engineering students at Montreal's McGill University, a group that participates in the Formula SAE competitions. For the 2012-2013 season, the McGill Racing Team wishes to pursue its impressive trend of building their fifteenth race car to compete in a number of events such as the FSAE East Michigan, FSAE Lincoln in Nebraska, FSAE North in Ontario and Formula Student Germany in Hockenheim. Their objective is to earn a minimum of 780 of 1000 possible competition points, placing them among the top in their field.

The concept behind Formula SAE is that a fictional race engineering company is seeking investment capital to build and sell single-seat formula-style race cars. Each team of students designs, builds and tests a prototype based on a series of rules established to ensure on site event operations, project management, as well as promote clever problem solving skills. Ultimately, the prototype race car is to be evaluated for its potential as a production unit.

The goal was to design, construct and test aerodynamic devices, including a rear and a front wing composed of one or more foils, to generate down force while minimizing drag and adding minimal mass to MRT cars as part of a strategy to reduce the lap time performance of the race car by 9%, thereby enabling the racing team to be competitive within the top three contenders from last year's race held in Lincoln, Nebraska.

The McGill Racing Team was thrilled with their latest placement, which may not have been possible without the participation of Quantisweb. In sharing their results:

> **"The last FSG 2013 update has been posted! We finished 4th in Design and 14th overall! The team is very happy with this result in Germany and we look forward to the adventures to come in the next week in (Helsinki)."**

THE STAKES

Use Quantisweb to optimize geometric parameters of MRT-15's wings and more specifically, to determine the optimal sizing and spatial arrangement of a set of pre-selected air foils, to reach four quantifiable ideal property values for the wings (downward lift, rearward drag, pitching moment and aerodynamic efficiency (lift/drag)).

THE STEPS

1. Select the top three foils for each wing, regardless of position.
2. Assign the selected foils to the optimal position.
3. Optimize the geometrical combinations for each wing (2D simulation).
4. Optimize the geometrical combinations for each wing (3D simulation).
5. Optimize a setup for low drag.

SYNOPSIS

CHALLENGE

Find the best foil and its optimal position based on behavior and performance. With a possible 3,000 open-source foils available on the market and incredible combination possibilities, the Team is facing unimaginable exponential combinatorial possibilities of 786,432+. The difficulties facing the Team and Quantisweb ranged from flap gap and overlap, relative chord length, angle attack, proximity to the ground, performance and speed. In addition, the Team had to consider the optimal performance values once installed on the car and further meet the fore-aft balance requirements needed in order to be competitive.

SOLUTION

The Quantisweb software determines the behavioral laws (models) of random (stochastic) systems with a minimal number of experiments as an alternative to traditional methods, software and computer simulation to formulate and/or optimize a product recipe and its manufacturing process simultaneously.

CONCLUSION

The Quantisweb process validated the team's already intuitive knowledge and expertise. The experiments generated by Quantisweb allowed MRT-15 to reach target in as little as 120 experiments.

THE PROCESS

The Quantisweb approach is global and its methodology requires that the user determines the desired properties and characteristics of the end product to be developed. Nina Visconti, Vice-President of Strategic Development at Quantisweb Technologies Inc., lead the team in a discussion and review of the current car performances, the circuits to run and the lap performance values to exceed.

STEP 1 : select the top three foils for each wing, regardless of position

A total of 25 experiments were generated by Quantisweb, consisting of 9 discrete variables (foils) and 11-12 continuous variables for each wing. Following a rapid program execution, the results were returned to the Quantisweb software for optimization. In parallel with the team's knowledge and intuition, Quantisweb also selected three foils that seemed promising in reaching targets for the rear wing parameters. Despite three foils having been selected for the front wing, these appeared to be quite weak and did not seem very promising. The selection of additional foils was key in a successful new round of optimization using Quantisweb.

STEP 2 : Assign the selected foils to the optimal position

A total of 14 and 15 experiments for each wing were generated and tests using Quantisweb's Java Foil software were conducted. The Team eliminated the overall angle of attack (AOA) as a parameter, due to its diluting/clouding ability to recognize the interdependencies of the other variables. Quantisweb selected two foils from a possible three for the rear wing and further indicated that one foil would occupy Position 1 and Position 3 while a second foil would occupy Position 2. Further 2D and 3D simulation would be required in order to validate some concerns with possible weaknesses. However, the team opted to move forward with these selections in consideration of their limiting time constraints.

STEP 3 : Optimize the geometrical combinations for each wing (2D simulation)

Given the selected foils and their respective positions, a new set of 11 and 12 experiments respectively for each wing was generated, with revised ranges of values for each wing. Tests were performed using 2D technology and further experiments proved successful. However, three of the four properties having been reached on the front wing design, the overall design objectives were not satisfactory. Pre-established maximum range limits were extended and the OPV was then successfully attained.

STEP 4 : Optimize the geometrical combinations for each wing (3D simulation)

Early studies were carried out by the aerodynamicists using idealized 2D simulation for rapid iterations. The challenges in aerodynamic design are in large part due to the 3D nature and complexity of flow around the vehicles. Therefore, when moving forward with detailed design in 3D simulation, adjustments in parameter settings were required. The team also decided to restrain the ideal values especially for the Y2, although the goal may not be reached with a high value set for Y1. In addition, adjustments on the interval limits were addressed, which included the ground clearance modified to a range between 10-20% of overall chord length to prevent damage on rough terrain.

STEP 5 : Optimize a setup for low drag

Having completed the optimization study for a high down force setup, the last activity was to make use of the final geometry selected and to determine a new point of adjustment that would convert it to a low drag setup for an acceleration event. Finally, with only 24 hours left to test, four variables and their respective intervals were identified (front wing assembly AOA, front wing flap angles, rear wing assembly angle and rear wing flap angles). Two ideal properties were targeted: minimizing front aero distribution to reduce rolling resistance on the front tires and minimizing overall drag. Quantisweb required a mere five experiments and within minutes provided the Team with the optimal combination of values for the four variables (OPV). The OPV was modelled in 3D and the optimal parameter values surpassed the target property values, along with the Team's expectations!

"Quantisweb won't do your groundwork for you, but if you know what ingredients to give it, it is an incredible tool and guide to get you right into the zone you want to be in, and where to focus your efforts if you want to push even further." — stated Luke Beaton, Head Aerodynamicist with MRT-15.

The idea of using Quantisweb in designing both the front and rear wings of MRT-15's race car piqued the interest and curiosity of both parties.

The McGill Racing Team's aerodynamicists worked from a blank slate in order to design and meet precise coefficient targets within a very limited and constrained timeline.

Nina Visconti, Vice-President of Strategic Development at Quantisweb Technologies Inc., saw an opportunity for the company to explore yet unchartered grounds.

Both parties agreed on the potential of the opportunity at hand, leading to the application of Quantisweb in the aero design of both front and rear wings in order to meet down force and drag goals of MRT-15's race car.

"I am still a bit shocked at how well it worked; how we used Quantisweb's software to design something from scratch. And how it obviously is a very competitive design!" — MRT-15 Team Leader, Adam Mansuri.

Quantisweb and MRT-15 succeeded in optimizing the optimal sizing and spatial arrangement of a set of pre-selected foils to minimize the pitching moment while maximizing aerodynamics efficiency (lift/drag) simultaneously to below 1.

Considering limiting time constraints, the design experiments generated by Quantisweb allowed MRT-15 to reach target in as little as 120 experiments, successfully selecting foils and their positions, flap overlap and flap gap and so many more variables.

THE BENEFITS

Quantisweb proposed a simplified process for foil selection and determined their positioning in order to define behavior as well as optimize performance to provide the Team with the competitive edge they needed.

- Quantisweb uses an approach that works opposite any other method available today.

- Working toward reaching defined product objectives minimizes the amount of experiments required for each possible scenario.

- Reduces the amount of experiments actually required in reaching target goals.

Component parameters, process variables and their respective intervals and any constraints that may exist among these variables are entered into the Quantisweb system. The specialized software chooses an experiment method from an extensive internal library and generates a minimal number of experiments to be conducted in-house or on the production line. The results of these experiments are then entered into the software and Quantisweb provides the behavioral laws of the proposed solution, which is then used with the objectives function to generate an optimal formula in order to reach the Team's desired properties.

ABOUT QUANTISWEB

Quantisweb is a multivariate optimization methodology and software for the integrated development of both complex materials and industrial processes required to manufacture them.

This patented application combines a number of mathematical fields and generates a formula for veritable or virtual products or processes.

Quantisweb helps develop high performance products with the input of users' knowledge and expertise. The desired properties, ingredients, manufacturing processes and constraints are used to determine the product formula required to achieve the product's desired properties.

To learn more about Quantisweb,
visit **WWW.QUANTISWEB.COM**

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ABOUT FSAE

FSAE — Formula Society of Automotive Engineers — the North-American circuit of Formula Student, is a student design competition which requires students to conceive, design, fabricate and compete with a small formula style racing car. The vehicle is then judged in static and dynamic events and is evaluated for its engineering design, marketability, lateral and longitudinal acceleration capabilities and autocross and endurance style racing.

ABOUT SAE

SAE — The Society of Automotive Engineers — is the world's largest professional group in the automotive industry, with members in over 97 countries. SAE is involved with schools on an international scale. Its Collegiate Design Series challenges over 120 university students from around the world to participate in these organized and extremely competitive events in building high tech units such as race cars and robots. These groups are invited to exchange on their ideas, creations and concepts. The purpose of the SAE is to challenge students to go the extra mile and acquire invaluable work experience in design and fabrication which will later serve them when heading into industry.

RESSOURCES

WWW.QUANTISWEB.COM

WWW.FSAE.MCGILL.CA

WWW.SAE.ORG