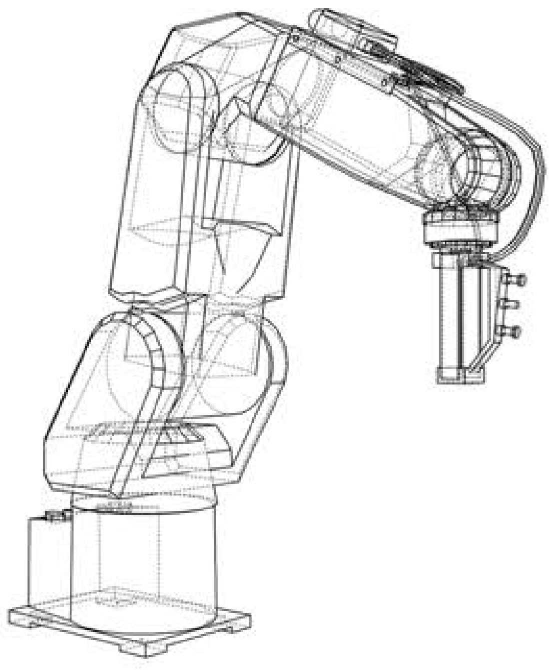
Designing a plastic robotic arm using MSC Adams & MSC Nastran

MSC Software helps Thai Steel Cable apply Multibody Dynamics & Finite Element simulations to design the structure of a Robotic Arm with Polyamide

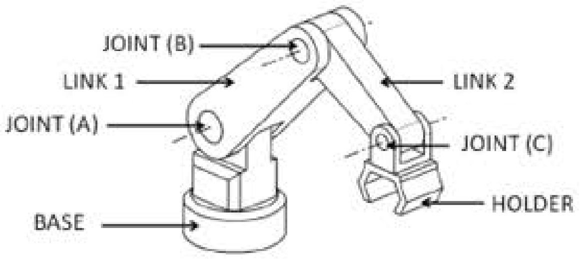


Challenge

Thai Steel Cable Public Company Limited is a manufacturer of automobile and motorcycle control cables as well as automobile window regulators. The company, which is a joint venture with HI-LEX Corporation Japan, is located at the Amata City Chonburi Industrial Estate, Chonburi Province. The company aims to be a world-class automobile parts manufacturer by producing products that are of the highest quality.

The technical research and development experts at Thai Steel Cable Public Company Limited have been focused on innovating and developing processes to pave their way towards becoming the leading automotive control cable manufacturer. The team has been working towards developing a robotic arm using plastic material such as polyamide. The company currently builds its robotic arms with cast iron, which works out to be heavy and very expensive. Therefore, the company was exploring alternate materials such as plastics with a view to reduce cost and also bring down the overall weight. In order to successfully design the robotic arm with the alternate material, Thai Steel Cable was looking for a simulation software with a user-friendly interface and the ability to provide accurate results.

Key Highlights
Product: MSC Adams & MSC Nastran
Industry: Automobile
Challenge: To develop a design of a robotic arm using plastic material instead of current cast iron
Solution: Applying Multibody Dynamics & Finite Element simulations to design the structure of a Robotic Arm with Polyamide



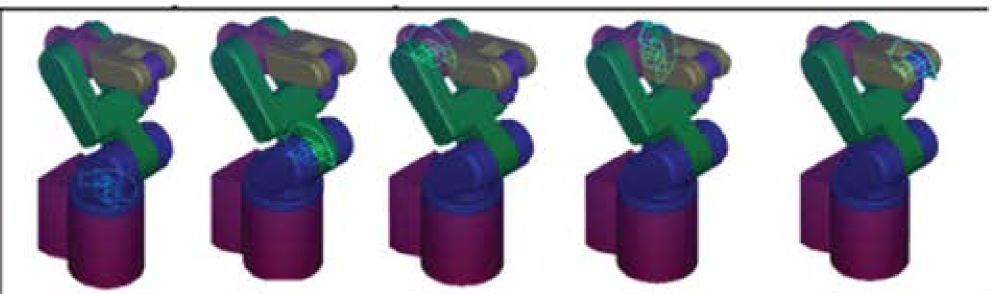
Structure of a Robotic arm

Solution

Designing a robotic arm using a completely different material with its unique properties was challenging to achieve if done purely through physical prototyping. The team then decided to perform Multibody Dynamics & FEA (Finite Element Analysis) simulations to get a better understanding of the new material and its performance in the robotic arm design. The team used MSC Adams for Multibody dynamics and Nastran for FEA simulations.

To ensure that the design was safe to operate with the new plastic materials (in this case polyamide), the team performed an MBD analysis, using Adams, to compute loads coming on various attachment points of the components for one cycle of operation.

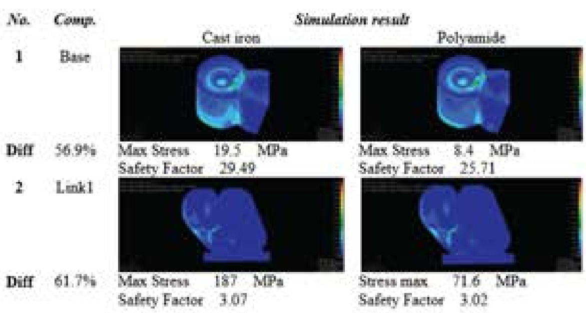
Force

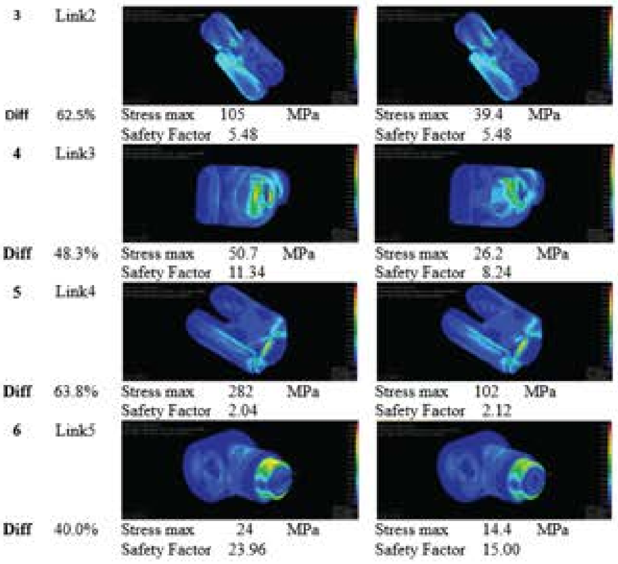


Point	Joint 1	Joint 2	Joint 3	Joint 4	Joint 5
Cast Iron (N)	F.X = -6,882	F.X = -6,787	F.X = -5,721	F.X = -4,668	F.X = -2,851
Polyamide (N)	F.X = -2,745	F.X = -2,728	F.X = -2,420	F.X = -2,181	F.X = -1,616
Diff (N)	4,137.2	4,058.8	3,300.6	2,487.5	1,234.9
Diff (%)	60.1	59.8	57.7	53.3	43.3

Simulations of Dynamics load for joint 1-5

The loads computed by Adams were then used to perform strength analysis in MSC Nastran of the individual components to ensure the stresses arising due to these loads were within permissible limits. Strength analysis of components with original cast iron material was also performed to compare the stress limits between old and new material components.





CAE by Finite Element Analysis

Given below is the comparison analyses between Cast Iron & Polyamide

CAE by Multibody Dynamics

- Reduce the total weight by 61.9 kg. and 70.1%
- Reduce the average dynamics load by 3,043.8 N and 54.8%

CAE by Finite Element Analysis

- Can reduce the average stress by 67.7 Mpa and 55.5%

Unit : Mpa

Materials	*Base*	*Link-1*	*Link-2*	*Link-3*	*Link-4*	*Link-5*	*AVG*
Cast iron	19.5	187	105	50.7	282	24	111.4
Polyamide	8.4	71.6	39.4	26.2	102	14.4	43.7

The Safety factor

Materials	*Base*	*Link-1*	*Link-2*	*Link-3*	*Link-4*	*Link-5*	*AVG*
Cast iron	29.49	3.07	5.48	11.34	2.04	23.96	12.56
Polyamide	25.71	3.02	5.48	8.24	2.12	15.00	9.93
Standard SF >1.0	Passed	Passed	Passed	Passed	Passed	Passed	Passed

Through software testing, the team was convinced that the mechanical properties of the plastic polyamide could withstand the maximum simulation stress. Also, they found that the safety factors of all components were more than 1.0. This led to the conclusion that Polyamide plastic is an excellent material for use in the robot arm. The polyamide helps to achieve the objective of light-weighting the arm. Based on the simulation values of dynamics load, strength and safety factor, the team found that both the materials (Polyamide plastic and cast iron) comply with the required standards.

Results

Through the use of multibody dynamics in CAE, the team was able to reduce the total weight of the arm by a massive 61.9 kg (or 70.1% reduction). Multibody dynamics also helped the team reduce the average dynamics load by 3,043.8 N (or 54.8 % reduction).

Also, the use of CAE for Finite Element Analysis helped achieve a 55.5% reduction in average stress, translating to a stress of 67.7 Mpa lesser than earlier. In addition, the team was able to achieve its goal of a 15 % reduction in the cost of material and 70 % lower assembly weight as compared to the cast iron arm.

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