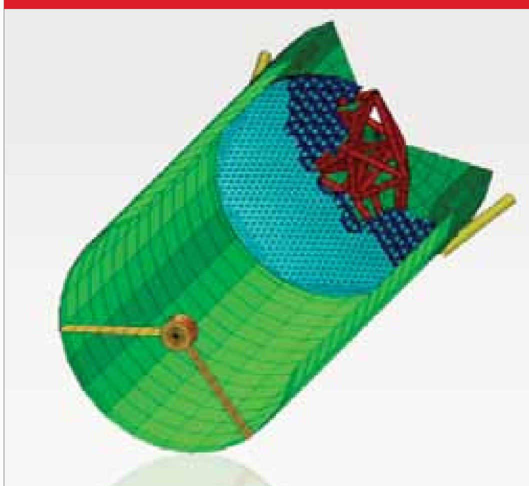
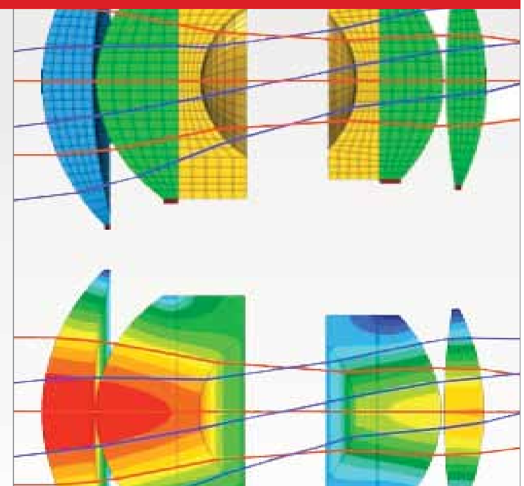
MSC Software

CASE STUDY

MSC Software: Case Study - Sigmadyne

Seeing is Believing





Environmental Factors Degrade Optical Performance

When optical systems become exposed to a non-ideal environment, their optical performance degrades. For example, a lens system which was designed to produce high quality images may produce poor quality images when subjected to the thermal effects of a laser beam. Some of the energy in the beam is absorbed by each lens, causing temperature gradients throughout each lens that deform the lens surfaces. A second effect of the temperature gradients is a change in the indices of refraction, optical material properties that are dependent on temperature. A third and less important effect is that the temperature gradients induce stresses that also change the indices of refraction. These combined effects cause image quality to decline.

As any camera buff knows, another common environmental factor affecting optical performance is vibrations. Any optical imaging system which produces quality images in a stable condition will produce lower quality images when subjected to vibrations coming through its support condition. In the case of a handheld camera the source of vibration is the instability of the person holding it. In the case of a high performance imaging system possible sources of vibration are cooling equipment, altitude control gryroscopes, aircraft vibration, and other ambient vibration sources.

A good design team must be able to predict the effects of the environment on their optical system in order to optimize their design to mitigate such effects. Such performance prediction requires the proper tools. In the examples above, MD Nastran can predict the mechanical behavior quite well. To predict optical performance, SigFit is required to convert the results from MD Nastran into a form suitable for optical analysis software.

Key Highlights:

Industry

Optics

Sigmadyne

Challenge

To predict the effects of the environment on optical systems in order to optimize design and minimize its effects

MSC Software Solutions

MD Nastran to predict the mechanical behavior and optical performance.

SigFit to convert results into a form suitable for optical analysis software

Benefits

- Behavior Prediction
- Performance Optimization

“MD Nastran reduced the weight by a factor of two, while maintaining the required optical and structural performance”

Dr. Victor Genberg, Sigmadyne

Integrated Optomechanical Analysis

Integrated optomechanical analysis combines finite element thermal and structural analysis with optical analysis. In the lens example, the temperature gradients predicted in a heat transfer analysis conducted in MD Nastran are imported into SigFit and converted to index change effects to be passed to an optical analysis. Those same temperatures cause deformations of the optical surfaces and stresses throughout the transmissive optical elements and may be predicted in a thermoelastic analysis using MD Nastran. These deformations and stresses are processed by SigFit for input to the optical analysis. With these inputs, the optical analysis program can be used to predict the combined effects of the temperature gradients on optical performance.

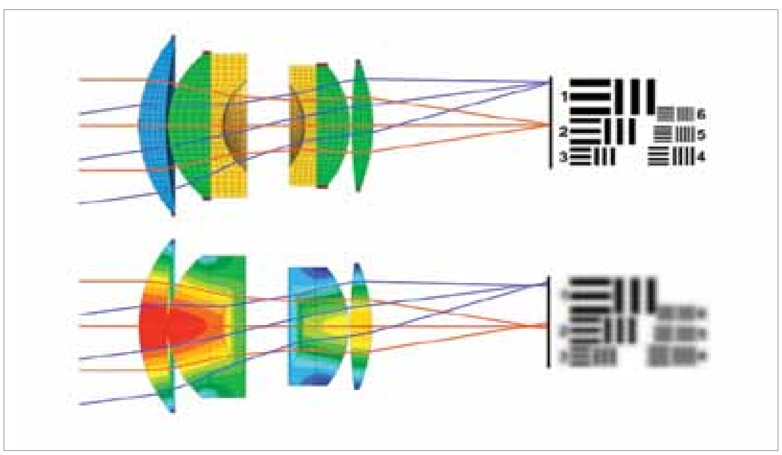
SigFit handles several practical issues associated with converting finite element data to optical input data, such as coordinate system transformations, unit conversions, and surface numbering. SigFit is most commonly used to generate such output as best fit rigid body motions and polynomial coefficients while accommodating each optical analysis code’s conventions of ordering, normalization, and format for the polynomial coefficients.

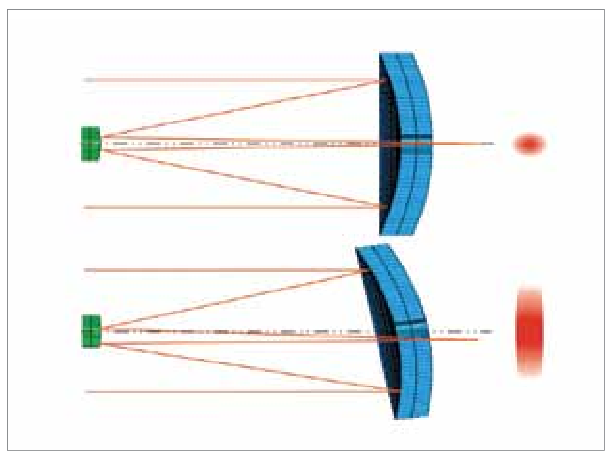
Improving the Performance of a Telescope

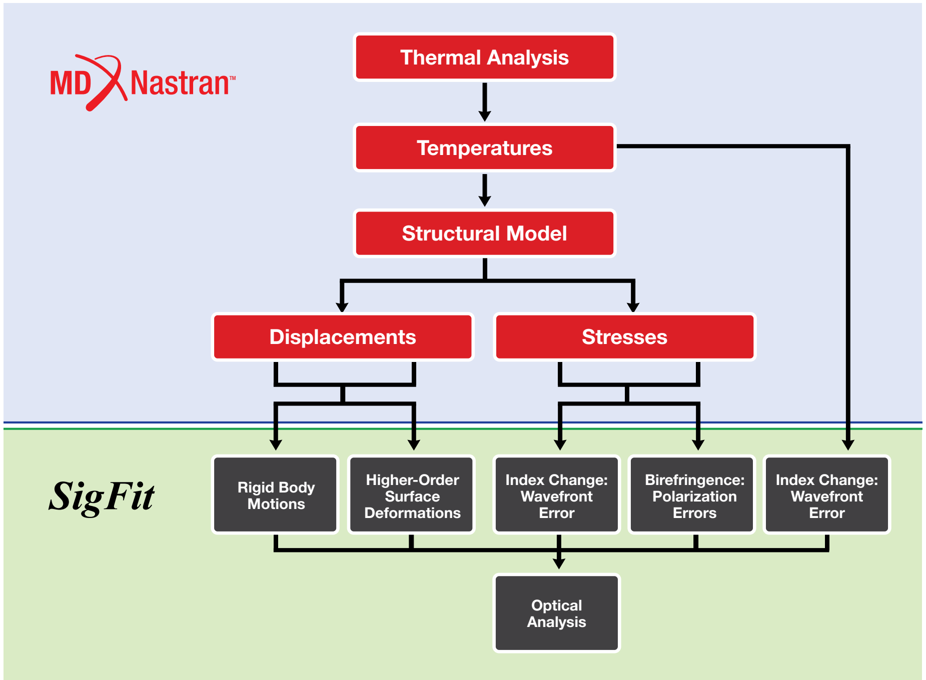
The greatest power of the integrated analysis approach is best demonstrated by combining SigFit with MD Nastran’s optimization capability. In this example, a telescope with an adaptive, lightweight primary mirror is optimized for the best geometry based on optical performance metrics.

The design variables were the mirror front and rear faceplate thickness and the mirror core thicknesses at eight separate regions. This allowed thickness increases near actuators to improve performance.

The objective was to minimize mirror weight, while satisfying constraints on natural frequency and launch stress. Constraints on optical performance were included as surface RMS limits in 1g test and an isothermal peak temperature change. The surface RMS constraints were on the adaptively corrected surface. This required SigFit to be called by MD Nastran as a DRESP3 call in solution 200.







As can be seen from the results table, MD Nastran reduced the weight by a factor of two, while maintaining the required optical and structural performance metrics.

Response	Initial Design	Optimized Design	Require-ment
Thermally Induced Wavefront Error	9 nm	20 nm	20 nm
Gravity Release Induced Wavefront Error	54 nm	60 nm	60 nm
Peak Launch Stresses	1000 psi	1000 psi	1000 psi
First Natural Frequency	231 Hz	221 Hz	200 Hz
Weight	20.8 kg	9.9 kg	Minimum
Areal Density	53.0 kg/m^2	25.2 kg/m^2	Minimum

Other SigFit Capabilities

SigFit has other capabilities closely coupled to MD Nastran.

SigFit will calculate line-of-sight equations for an optical system and write those in MD Nastran MPC format using the finite element model's node numbering and coordinate systems.

- SigFit will write best-fit polynomial coefficients for optical surfaces in MD Nastran MPC format. These coefficients are accurate for thermal or mechanical loads.
- SigFit will write residual surface RMS after selected polynomials are subtracted as MD Nastran DRESP2 entries for use in optimization.
- SigFit's adaptive analysis capability will solve for actuator forces required to minimize surface RMS error. If desired, the genetic optimizer will choose the actuator locations which provide the best corrected surface.
- SigFit will read MD Nastran modes output, then conduct harmonic or random analysis within SigFit to determine optical MTF (modulation transfer function) effects due to line-of-sight jitter effects.

Additional information on SigFit is available at www.sigmadyne.com

Summary

MD Nastran and SigFit combine to create a powerful tool for improving the performance of optical systems.

About MSC Software

MSC Software is one of the ten original software companies and the worldwide leader in multidiscipline simulation. As a trusted partner, MSC Software helps companies improve quality, save time and reduce costs associated with design and test of manufactured products. Academic institutions, researchers, and students employ MSC technology to expand individual knowledge as well as expand the horizon of simulation. MSC Software employs 1,000 professionals in 20 countries. For additional information about MSC Software's products and services, please visit www.mscsoftware.com.

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About MSC Nastran

Accurate, Efficient & Affordable Finite Element Analysis

MSC Nastran is the world's most widely used Finite Element Analysis (FEA) solver. When it comes to simulating stress, dynamics, or vibration of real-world, complex systems, MSC Nastran is still the best and most trusted software in the world – period. Today, manufacturers of everything from parts to complex assemblies are choosing the FEA solver that is reliable and accurate enough to be certified by the FAA and other regulatory agencies.

Engineers and analysts tasked with virtual prototyping are challenged to produce results fast enough to impact design decisions, and accurate enough to give their companies and management the confidence to replace physical prototypes. In today's world, nobody has time or budget to spend evaluating the accuracy of their FEA software – you need to know it's right.

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