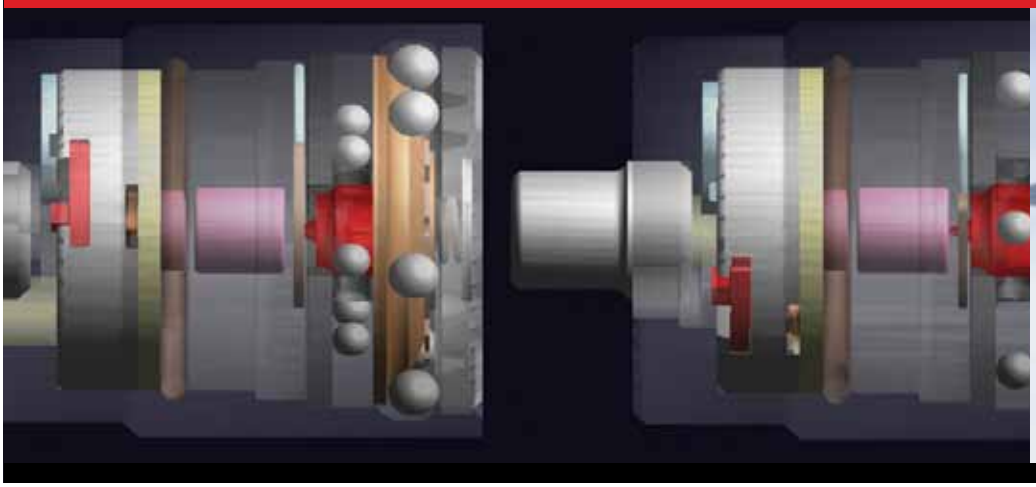
MSC Software

CASE STUDY

MSC Software: Case Study - System Design Evaluation Ltd.

High Performing Mechanisms



In the design of any new high explosive ammunition, the most complex and often problematic component is the fuzing system. The fuze must incorporate a Safe and Arm device to ensure that the projectile may only enter the armed state following exposure to firing forces and after reaching a safe distance from the muzzle of the weapon. Engineers at System Design Evaluation Ltd. (SDE) in Hertfordshire, UK have constructed rigid and flexible body MSC Adams models to study the motion and strength of the design of fuze mechanisms to identify potential design issues and assist with analysis of trials results.

“Conducting live firing ammunition trials is an expensive business,” said Eva Friis, Project Manager for the APEX ammunition development programme at Nammo Raufoss, Norway. “Analysis of recovered fuzes to determine the cause of failure is little short of forensic science and it is difficult to know how the forces imposed during recovery of the projectile affect the results. The Adams simulations have provided an insight into the operation of the fuze and enabled the team to highlight and address weaknesses with the design before manufacture and physical testing.”

Physical Testing Does Not Give The Whole Picture

The Nammo 25mm APEX projectile is a next generation armour-piercing, high-explosive ammunition designed for use with the US F-35 Joint Strike Fighter aircraft. The projectile leaves the muzzle of the 4-barrelled GAU-12 weapon system with a velocity of around 1,000m/s and experiences a peak setback acceleration of almost 80,000g. Under these conditions, coupled with severe space restrictions, it is almost impossible to instrument the fuze in order to gain an understanding of the operation and interaction of components inside. Therefore, while physical testing can be used to confirm functionality of the fuze, it often offers only limited information for post analysis in the event of a failure to function.

Key Highlights:

Industry

Aero

SDE

Challenge

To study the motion and strength of the design of fuze mechanisms to identify potential design issues and assist with analysis of trials results

MSC Software Solutions

Adams to allow rapid and fully integrated analysis of both the kinematic functionality and strength of design of complex mechanical systems.

Benefits

- Cost Reduction
- Invaluable Diagnostic Evidence
- Design Optimization

“Adams has provided significant guidance to the design and development effort, reducing the number of expensive trials required and, therefore, the overall cost of the development programme.”

Scott Bradley, Design, Modeling & Simulation Lead, System Design Evaluation, Ltd.

Adams modeling has proven invaluable in providing information to assist with the diagnosis of evidence gained from recovery tests. In one case, examination of the internal components of the fuze after recovery tests showed markings which indicated a malfunction had occurred.
A detailed flexible body Adams model of the design was developed, and analysis confirmed the nature of the problem and sequence of events within the fuze mechanism; huge centrifugal forces due to projectile spin resulting in deformation of internal components sufficient to result in the unlocking of two retaining gears.

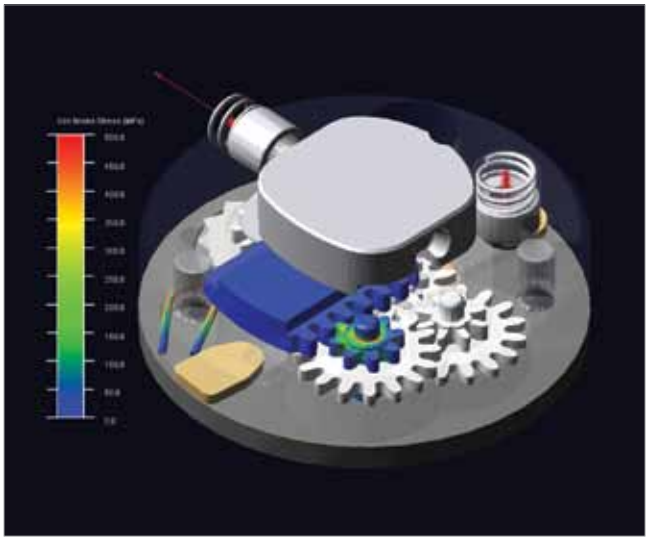
Computer modeling of ammunition fuzes has not been without challenges. Safe and Arm devices are often mechanical and operate using clockwork escapement mechanisms, similar to those found in wrist watches. Such mechanisms rely heavily on 3D contact, leading to extended run times. Further, fuze arming times are largely dependent on the definition of frictional algorithms within the models. SDE has worked closely with fuze manufacturers to overcome this and validate models against static spin tests thereby providing a firm basis from which to investigate further design permutations.

Finding The Right Software Tool

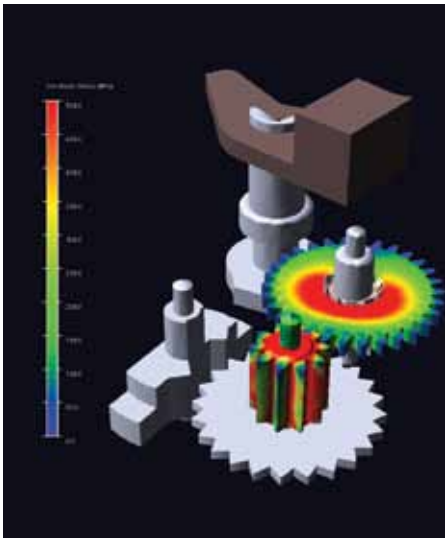
Engineers at SDE began providing computer aided engineering support to the Nammo Raufoss APEX development programme in 2004 during the conceptual design phase. Early Safe and Arm fuze modeling work was undertaken using rigid body kinematic analysis software. However, customer requirements to undertake combined analyses of component strength within more complicated assemblies prompted a search for replacement software.

Numerous commercially available packages were evaluated but none were found to offer the flexibility of Adams in allowing rapid and fully integrated analysis of both the kinematic functionality and strength of design of complex mechanical systems.

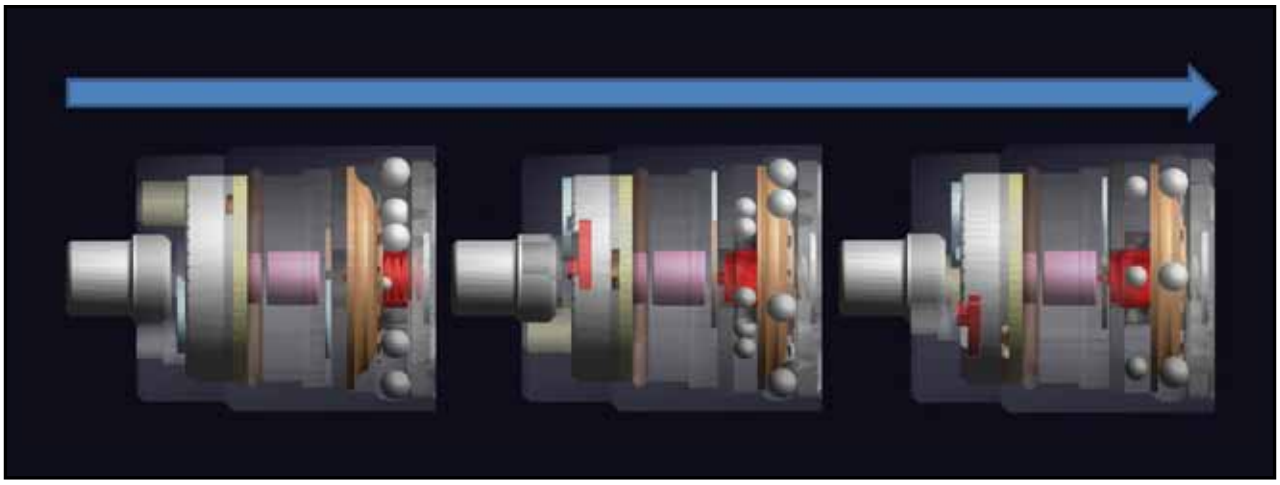
The flex to flex contact capability provided by Adams has aided significantly in simplifying the modeling of the escapement systems commonly found in mechanical Safe and Arm devices.
In particular, due to the reciprocating nature of the regulator component, considerable forces may be dissipated throughout the gear train. This can sometimes lead to catastrophic failure of the components due to shearing of gear teeth, resulting in premature arming of the fuze. The components of such mechanisms can be modeled as flexible bodies within Adams allowing an assessment to be made of the



Adams flexible body modeling of a high explosive projectile fuze Safe and Arm Device to examine kinematic functionality and strength of design



Detailed Adams flexible-body modeling of a fuze escapement mechanism allows you to see stress results real-time.



Adams rigid body modeling of a fuze impact delay mechanism to determine sensitivity to impact at various velocities, angles and with different materials

stresses and strains developed in each part during operation.

The Adams results have not only successfully predicted the failure of components on numerous occasions within various fuze designs, but have also facilitated in the redesign of components to achieve suitable strength. Importantly, by quantification of stresses within components, Adams has assisted in proving compliance with required safety factors, information which is not possible to glean from live firing trials results.

Adams Used to Assess Fuze Sensitivity

The Apex fuze is designed to provide a short delay, after impact, before initiating the high explosive fill in order to allow the projectile to first penetrate the target and deliver maximum blast and fragmentation effects inside. To achieve this, the impact delay mechanism must be robust but sufficiently sensitive to normal and oblique impact angles. SDE have used Adams, coupled with hydrocode predictions of axial and spin deceleration, to simulate the motion of the impact mechanism and assess the sensitivity of the fuze to impacts with various target materials at different impact velocities and angles of obliquity.

The sensitivity of the fuze is critical to ensuring a high probability of success. Through the use of Adams to simulate and optimize the design of the impact mechanism, the successful function of the Nammo 25mm APEX round against a wide range of targets is ensured.

“Adams has played a significant role in identifying and, importantly, quantifying the magnitude of issues in one of the most technically challenging areas of ammunition design,” concluded Eva.
“It has provided significant guidance to the design and development effort, reducing the number of expensive trials required and, therefore, the overall cost of the development programme.”

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 Adams

Multibody Dynamics

Adams is the most widely used multibody dynamics and motion analysis software in the world. Adams helps engineers to study the dynamics of moving parts, how loads and forces are distributed throughout mechanical systems, and to improve and optimize the performance of their products.

Traditional "build and test" design methods are now too expensive, too time consuming, and sometimes even impossible to do. CAD-based tools help to evaluate things like interference between parts, and basic kinematic motion, but neglect the true physics-based dynamics of complex mechanical systems. FEA is perfect for studying linear vibration and transient dynamics, but way too inefficient to analyze the large rotations and other highly nonlinear motion of full mechanical systems.

Adams multibody dynamics software enables engineers to easily create and test virtual prototypes of mechanical systems in a fraction of the time and cost required for physical build and test. Unlike most CAD embedded tools, Adams incorporates real physics by simultaneously solving equations for kinematics, statics, quasi-statics, and dynamics. Utilizing multibody dynamics solution technology, Adams also runs nonlinear dynamics in a tiny fraction of the time required by FEA solutions. Loads and forces computed by Adams simulations improve the accuracy of FEA by providing better assessment of how they vary throughout a full range of motion and operating environments.

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