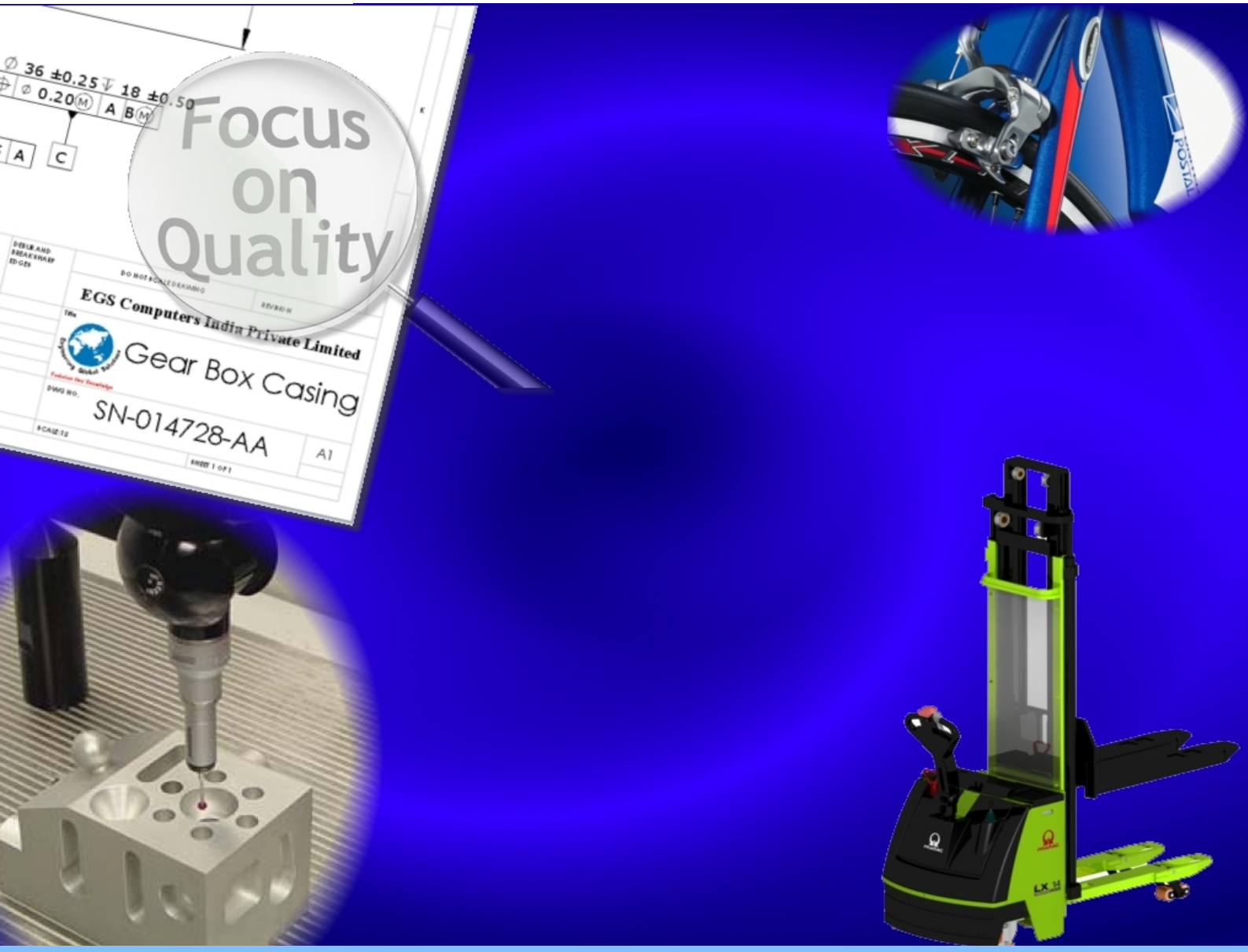
Engineering Global Solutions

Evolution thro' Knowledge

White Paper Series

Developing Sustainable Designs for Enduring Value



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Chennai * Coimbatore * Trichy

www.egsindia.com * www.egs.co.in

info@egs.co.in

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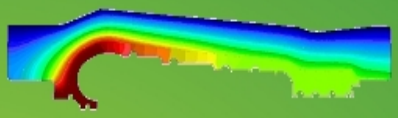

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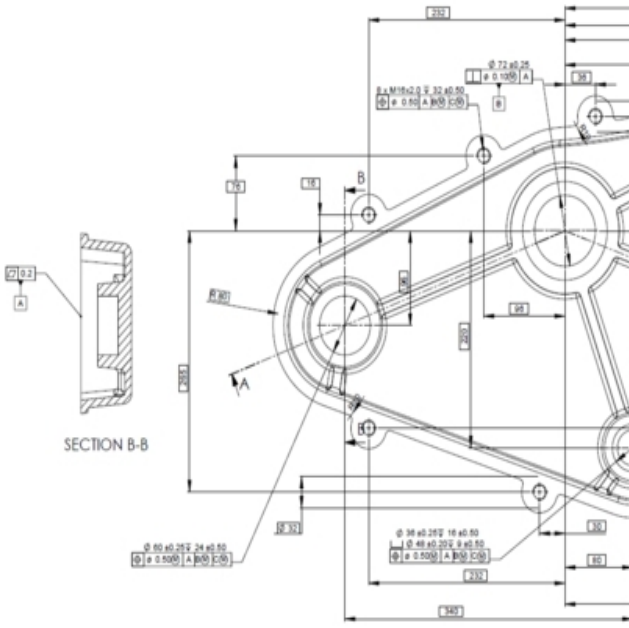

Benefits

Design Validation
Tolerance Stacks
Enterprise Data Management
Design Documentation

Engineering Global Solutions

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info@egs.co.in

Sustainable Design

Every product designed, leaves an indelible imprint on the social, economic and environmental fabric of the society. In a global market with expanding horizons, the product has far reaching implications across the entire world. Simple considerations in design can result in enormous savings in 'world-wealth' that future generations deserve.

Imagine the mountain of scrap that is generated for every automobile leaving the factory. If the scrap generated is not minimized and/or re-cycled, in addition to escalation in cost of input raw materials across the supply chain, the impact on natural resources and environment would be severe.

Simple considerations in design can result in enormous savings in 'world-wealth' that future generations deserve.

Sustainability, when addressed through design, has the following inherent benefits:

- Lower Cost
- Higher Efficiency
- Higher Profitability
- Better Concepts and Technologies

General guidelines for developing Sustainable Designs, listed as under, may be adopted to achieve success:

- Least amount of Material
- Choice of Alternate Material conducive to recycling
- Reduced number of operations/processes to manufacture parts
- Least number of components in assembly
- Enhanced Performance Efficiency and Life
- Higher Energy efficiency
- Least amount of consumables such as oil, water, coolant among others
- Re-usable configurations or re-configurable designs

How to Achieve Sustainable Designs?

History is replete with instances wherein Ideas start a revolution. New processes and technologies usually get initiated with 'out-of-the-box' thinking. While this is a unique attribute of an individual or a team, there are intrinsic processes that can be incorporated to achieve sustainable designs.

A cursory examination of the list of guidelines provided in the previous page reveals a common denominator – Design Validation. If every step in the Design process is Validated with care, in addition to avoiding redundancy and re-work downstream, a qualified design emerges that forms the Intellectual Property ownership of the Company.

The cost of a product is dictated/ influenced by Design by over 85%.

Design Validation

Validation of Designs can be addressed in more ways than one. Some of the validation methods could be broadly classified under the following categories:

- Finite Element Analysis
- Computational Fluid Dynamic Analysis
- Tolerance Analysis
- Design Process Validation using Automation, Design Knowledge Re-use and Knowledge Based Engineering
- Design Failure Modes and Effects Analysis (DFMEA)

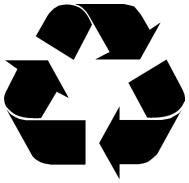
Incubator Designed using SolidWorks from Re-cycled Materials

Benefits of Design Validation

Saving on Material

Using Design Validation every feature in a Design can be validated for Fit, Form and Functional aspects of requirement specification thereby enabling considerable savings in material.

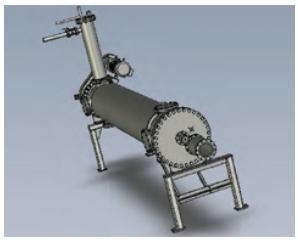
For example, if a near-net-shape valve casting has reduced flange thickness by means of optimization then the as-cast weight is considerably reduced. This results in savings in energy (due to reduced amount of molten material required), machining costs (due to reduced material removal requirement), scrap (due to smaller machining allowance) as well as handling (attributed to transportation).



Downstream savings in cost cannot be ignored or trivialized.

On a similar note, if a pressure-die-cast aluminium crank case used in automotive application has a reduced number of features, this results in considerable savings in time and energy (due to

reduced shot size and die machining complexity). Add to this the possibility of a reduced wall thickness, energy savings due to minimal shot size, fuel economy due to lighter design provide increased savings to the eco-system as a whole. This has a significant impact in large volume production.



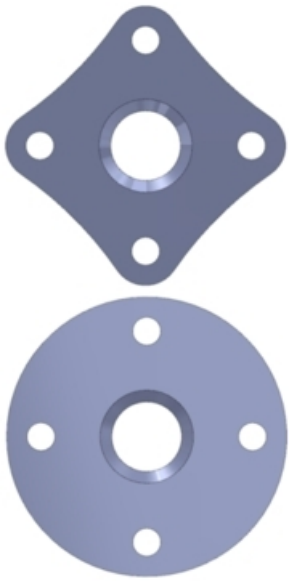
Bouldin & Lawson's patented steam chamber or Hydrolyser, one-of-its-kind design, to continuously transform the processed waste into a safe and multi-use by-product. The steam chamber makes the transformation much faster,more economical, and more environmentally friendly than other waste conversion technologies. (Diagrams courtesy of Bouldin Corp.)

Alternate Materials

Choice of alternate materials that are recyclable, bio-degradable and non-toxic opens new vistas for design innovation. In addition to protecting the health of workers, the supply chain is strengthened with very little propensity for cost escalation.

Research in usage of natural raw materials propels higher economic activity in addition to saving on processing costs. For example, the roof lining in auto-mobiles could have jute-fibre panels replacing current petroleum-based by-product materials, resulting in better interior temperatures under a hot sun, lower cost of raw material and processing and lesser load on HVAC systems (that would again result in higher fuel economy!)

Design validation helps in identifying alternate materials.



Optimization of Operations required in Part Manufacture

It is well known that if the time required to manufacture a part is reduced, cost savings are realized. If such benefits are obtained as a result of better designs that save on material removed, the energy savings are considerable. If, for example, a gearbox casing cover has 10 fasteners instead of 12, the savings can be far reaching. Some of them are:

- 2 less holes to be machined and/ or tapped on each mating flange (energy and time saving in addition to increased tool life)
- 2 less bolt set in BOM and spares list (cost and material savings)
- 2 less components to be assembled (energy, time and cost savings)
- 2 less bosses for the holes on the cover (material and energy savings)

If a simple hole can result in multi-level savings, the benefits of a deeper study would fetch rich dividends.

Least number of components in assembly

Lesser the number of parts, lesser the energy, cost and time required to produce an assembly. If the BOM is reduced by, let us say 5%, this results in direct savings of processed materials. Significant benefits in terms of profitability are directly perceivable.

For example, if 2 parts welded together, are designed using an integral-part approach, then the welding operation and its effects are eliminated. This results in energy, cost and time savings not to mention qualitative gains and enhanced reliability.

Reducing the number of components in assembly also simplifies assembly build thereby addressing tolerance stack issues.

Enhanced Performance Efficiency and Life

Greentec designs and develops energy-efficient climate control systems using ground source heat pumps and other cutting-edge technologies

Value Addition and Value Engineering (VA VE) are becoming commonplace in manufacturing organizations with an intent to reduce cost and improve profitability. Perfection in design engineering is reflected in performance efficiency and enhanced life.

For example, pump sets used in agricultural application need to have higher efficiency at lower runtime costs. Efficiency has a direct impact on energy consumption at societal level. Life in operation influences cost of ownership and better utilization of raw materials. For sustainable designs to become commonplace, both these attributes need greater emphasis.

Air conditioners having noiseless high-efficiency compressors draw lesser current resulting in huge energy savings. Condenser and evaporator coils having no-compromise efficiency result in superior performance at lower runtime costs. Energy saving with such measures help save the planet.

Needless to say, Design Validation helps achieve better performance and superior life for a greener planet.

Higher Energy efficiency

Savings in Energy is the crying need of the hour. Power generation using fossil fuel has significant

impact on environment. Energy-efficient motors designed and developed to deliver consistent performance directly addresses this issue.

Technically speaking, air gap between the rotor and stator influences performance. Temperatures on the coil winding contributes to performance efficiency, as well. Air gap control is dictated by tolerance stacks. Temperatures are influenced by thermal management at the system level. These important attributes are validated easily using Tolerance Analysis and Fluid Flow Analysis inside SolidWorks as add-on applications.

Better Motor Designs

Save Energy

Developing better heat exchangers, cyclones, pre-heaters, ducting systems at higher efficiency reduces energy consumption while delivering on performance. This finds great use in the Power and Process sector at large.

Least amount of consumables

Oil filters used in automobiles are replaced during vehicle service. In the US alone, more than 3,00,000 tonnes of processed steel is replaced every year. In spite of getting recycled, the energy consumed in producing them, involving numerous stages of manufacturing, is staggering. Growth, admittedly, should not be at the expense of sustainability.

Zero-leak designs have progressed by incorporating design validation as a part of the design process. Mission critical applications require fail-safe designs for better sustainability.

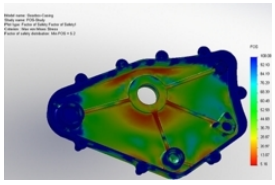
Re-usable /Re-configurable designs

Modular designs can be beneficial in many ways. Combined with configurable functionality, they provide numerous advantages to both the manufacturer and consumer. New designs or product upgrades can be done easily by the manufacturer. On similar note, the end user is also provided with a choice of upgrading his asset for a nominal cost instead of replacement.

This approach saves cost, time, energy while improving product serviceability and overall customer perception of value. An ideal example is the ubiquitous printer having a cartridge replacement vis-a-vis toner re-fill.

Design Validation Process

Simulation



Gearbox cover stiffness improved using material only where it is required

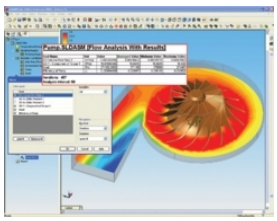
Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) is gaining popularity as a validation technology. CAD Integrated Finite Element Simulation using SolidWorks Simulation offers unparalleled benefits for the Design Engineering Community. Some of the benefits are:

- Efficient usage of materials
- Extended Life
- Higher Efficiency
- Lower Product Cost
- Development of indigenous technologies

Integrated inside SolidWorks, the CAE capabilities of **SolidWorks Simulation** range from simple static analysis to highly non-linear analyses involving contact, large displacement and a variety of material models.

Designer driven, SolidWorks Simulation provides for Optimization, study of multiple design scenarios using SolidWorks Parametric Dimensions and Multi-domain capabilities. SolidWorks Simulation performs true Assembly level Stress analysis involving contact between parts for realistic load transfer.

Flow Simulation



SolidWorks Flow Simulation has helped in design of higher efficiency pumps that draw lesser energy

Focus on energy conservation, improved performance efficiency and cost reduction have compelled manufacturers to re-visit their designs. Complexity of Fluid Flow Technology has been greatly simplified by **SolidWorks Flow Simulation** by Engineering Fluid Dynamics approach.

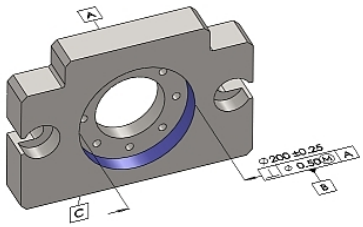
Better Pump efficiency, heat exchanger performance, flow characteristics in a valve, cooling of electronic devices, optimal sizing of heat transfer equipments, Fan performance optimization are few of a wide range of applications that SolidWorks Flow Simulation helps solve for the Engineering community.

Integrated inside SolidWorks CAD environment, Flow Simulation enables engineers to arrive at engineering decisions quickly with greater insight into performance and efficiency.

Geometric Dimensioning & Tolerancing

GD&T involves four simple steps:

1. Identify part surfaces to serve as origins and provide specific rules to establish starting point and direction for measurements.
2. Convey nominal (ideal) dimensions and orientations from origins to other surfaces.
3. Establish boundaries and / or tolerance zones for specific attributes of each surface along with specific rules for conformance.
4. Allow dynamic interaction between tolerances (simulating actual assembly possibilities) where appropriate to maximize tolerances

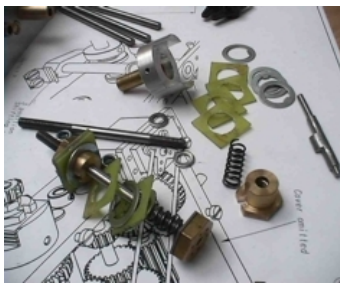


DimXpert ensures correctness and completeness of drawings

Keeping in mind the Fit, Form and Functional requirements of Design, SolidWorks exploits GD & T technology in its **DimXpert** module.

DimXpert is used to dimension a part fully using either the Automatic or Manual Dimensioning Mode. Variety of options are available to convey design specifications. This ensures correctness and completeness of Drawings per ASME and ISO Standards.

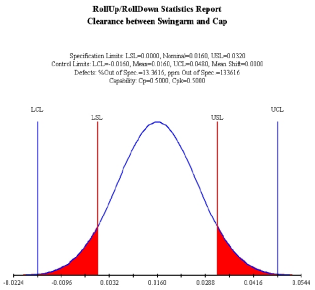
Tolerance Stack-up Analysis



GD & T Drawings convey Design Specifications evolved from Design Intent in an unambiguous manner to the Manufacturing and Inspection Teams. Often the Designer is beset with the problem of allocating appropriate tolerances at the part definition stage.

The implications of the tolerances specified at part level, in assembly build is never known. This affects assembly build, assembly functionality as well as increases rejections that affect profitability of the organization. Viewed in a different way, if assembly level tolerances for functional requirements are known, range and contribution of individual part dimensions need to be evolved with emphasis on low-cost tolerancing strategies.

SigmundWorks, integrated inside SolidWorks, performs just that to help designers arrive at optimal tolerances to ensure assemblies work all the time.



Predicting Rejection rates using SigmundWorks

Advantages of Tolerance analysis using **SigmundWorks** are many-fold:

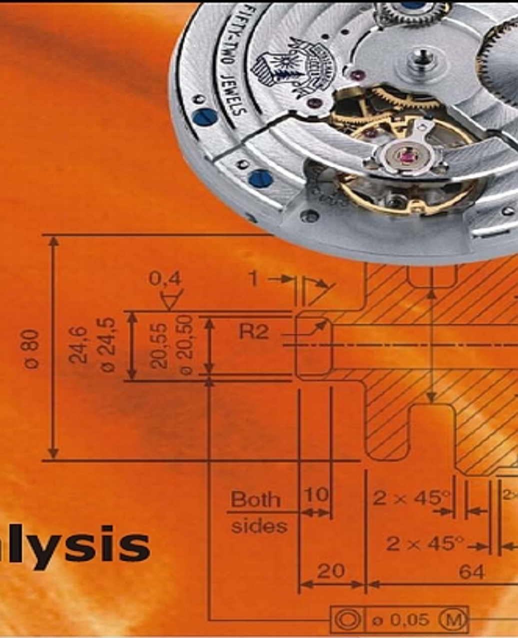
1. Understanding how part level tolerances affect Assembly Build and Allocating part level tolerances for required Assembly Build
2. Determining part level tolerances that influence Assembly Build in terms of cost
3. Influence of dimensional changes such as thermal expansion in functionality
4. Interaction with parametric SolidWorks Dimensional scheme to identify contributors as well as updating tolerances to achieve Assembly objectives
5. Least-cost tolerancing
6. Designing for Six Sigma without compromising on Cost
7. Identifying causes for parameters that affect Process deviations resulting in rejections
8. Estimate rejections based on RSS, Worst-Case, Process Centred RSS, Monte-Carlo Simulations to achieve 0 PPM

Following benefits are evident in using SolidWorks with SigmundWorks for Design and Development of Drawings for achieving required assembly build.

- Correctness and Completeness of Drawings are assured using DimXpert inside SolidWorks.
- Visual method of checking completeness of drawings avoids errors and ambiguities.
- Process centring of manufacturing processes are possible based on tolerance reports and deviation sensitivities
- Lowers cost of production and eliminates rejections
- Powerful tool in the hands of the user to give the right amount of tolerances, taking into account process capability, at part level for required assembly build specifications

Summary

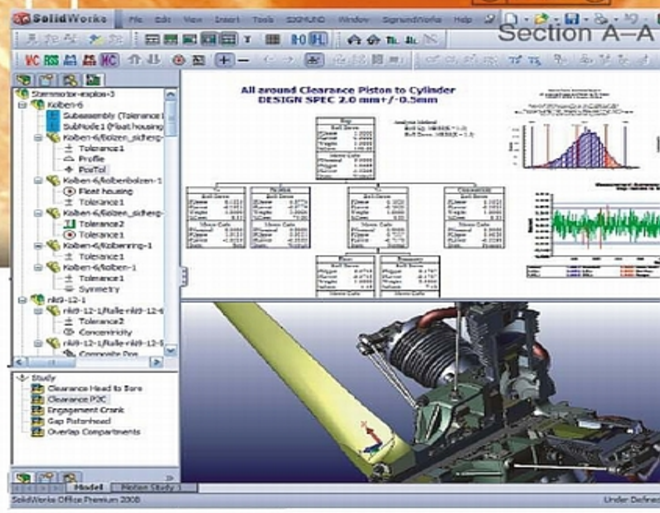
Sustainable Designs are achievable for higher efficiency, lower cost and greater reliability. SolidWorks enables engineering enterprises in developing Better Designs for a Greener Earth.

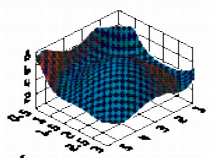


GD&T

Computer aided Tolerance Analysis

SigmundWorks





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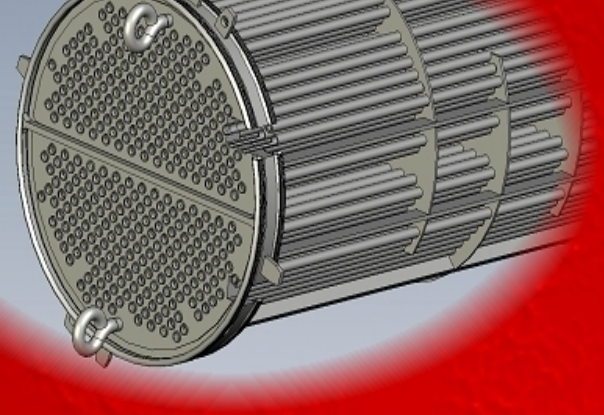
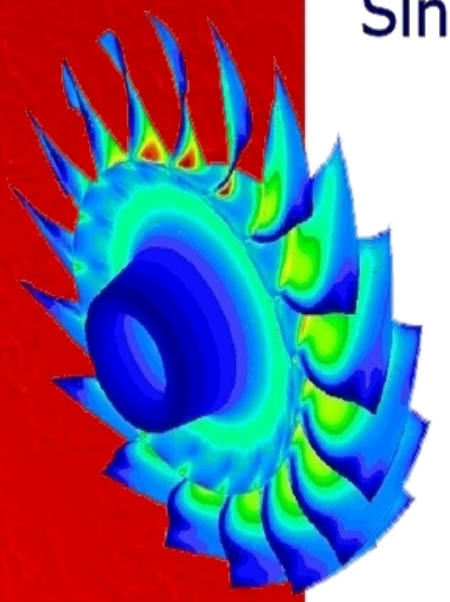
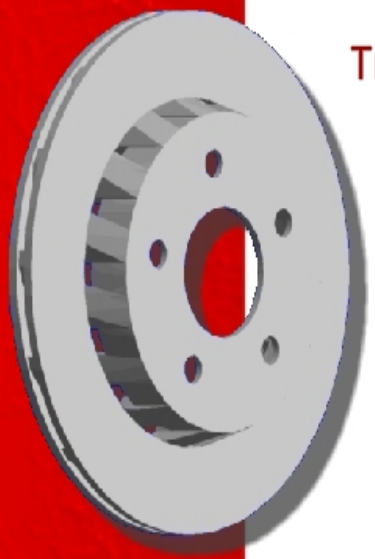




Engineering Consultancy

- Product Design
- CAE Simulation
- GD & T / Tolerance Analysis
- Design Automation
- Test Correlation



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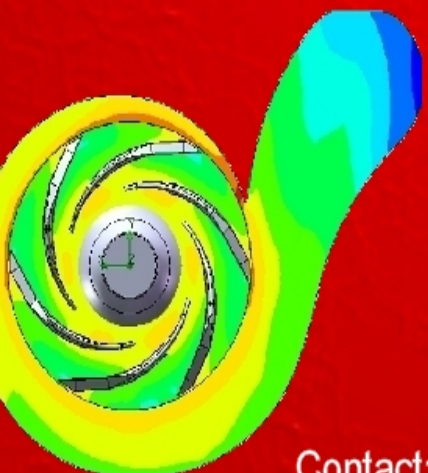

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