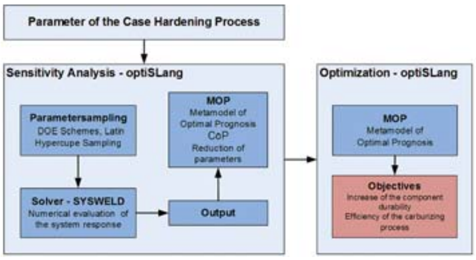
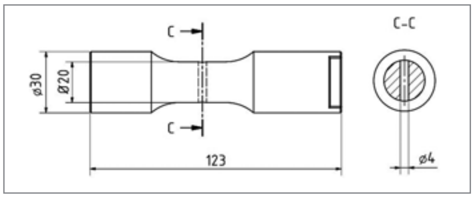
Bauhaus-Universität Weimar

Materialforschungs- und -prüfanstalt

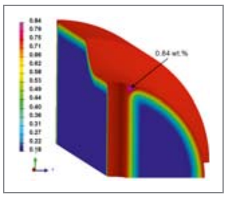
Process Engineering

FOSTA RESEARCH PROJECT "OPTIMIZATION OF CASE HARDENING PROCESSES"

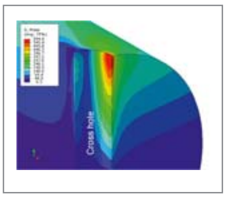




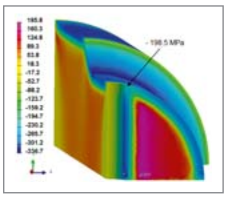
Example shaft with cross hole loaded under cyclic bending [mm]



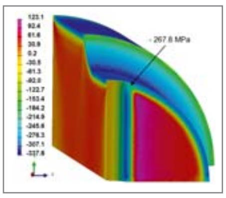
Shaft with cross-hole, high stressed volume (red) due to external bending load



Standard carburizing process, carbon concentration [wt.%]



Standard carburizing process, axial residual stresses [MPa]



Optimized carburizing process, axial residual stresses [MPa]

Initial position of the research project

- Construction details with notch effects lead to component fatigue under cyclic stress
- The shape of the construction detail has a significant influence on the results of the case hardening process
- Local residual stresses and strengths are often not optimal

Objectives of the research project

- Modification of the technological parameters of the case hardening process
- Improvement of the component durability and the efficiency of the case hardening process

Methods

- Simulation of the process with FE-program SYSWELD
- Coupling of optiSLang with the FE-program in batch mode
- Result transferring to optiSLang by text-based output of all relevant results of the FE nodes

Sensitivity analysis and optimization

- Scanning the design space with advanced Latin Hypercube Sampling (LHS)
- Creation of a Metamodel of Optimal Prognosis (MOP) based on polynomial or Moving Least Squares approximations for each output parameter (carbon content, core hardness, degree of utilization due to external loading)
- Determination and quantification of the most important input parameters by using the Coefficient of Prognosis (CoP)
- Determination of the optimal process parameters by minimizing the objective function, degree of utilization and process time using gradient based methods (NLPQL with constraints) or natural inspired methods (EA)
- Experimental validated results of the shaft with cross hole optimization process: increase of the fatigue strength by 10 %, decrease of the process time by 45 %

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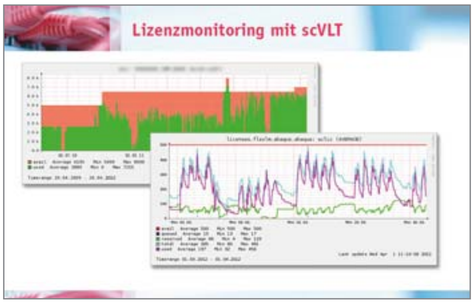
Atos | Bull | s+c

HPC-LÖSUNGEN UND IT-SERVICES AUS EINER HAND

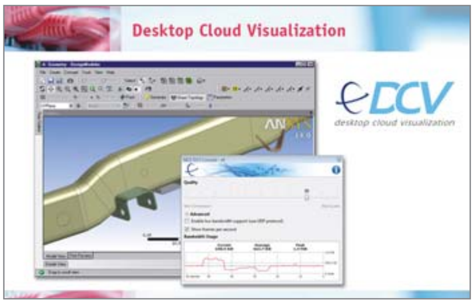
IT-Services für komplexe Rechnerumgebungen
Das scIT-Services-Portfolio

- Outsourcing: Konzentrieren Sie sich auf Ihr Kerngeschäft, wir kümmern uns um Ihre IT
- Outtasking: Nutzen Sie flexibel unser Expertenwissen, wann immer Sie es brauchen
- Projekte: Verwirklichen Sie Ihr spezielles IT-Vorhaben mit unserer Unterstützung



scVENUS License Tracker
Software-Kosten senken durch intelligentes Lizenzmonitoring

- Transparente Lizenznutzung: Anzahl und Nutzung der verfügbaren Lizenzen schnell überblicken
- Koordinierte Nutzung von Lizenzen: Softwarelizenzen abteilungsübergreifend besser auslasten
- Einfache Lizenzabrechnung: Lizenzverbrauch schnell und einfach nach Benutzergruppen oder Projekten abrechnen
- Heterogenes Lizenzmanagement: Verschiedenartige Lizenzmechanismen effizient verwalten



NICE Desktop Cloud Visualization
Remote-Visualisierung im Technical Computing

- Hochperformanter Remote-Zugriff: 3D-Software auch in Netzwerken mit niedriger Bandbreite bzw. hoher Latenz nutzen
- Schneller ROI: Ressourcen (GPU, Speicher, ...) gemeinsam nutzen und Kosten senken
- Plattformübergreifender Zugriff: Heterogene Umgebungen (Linux, Windows, ...) nutzen
- Mehr Sicherheit: Daten verbleiben im Rechenzentrum

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HPC-LÖSUNGEN UND IT-SERVICES AUS EINER HAND

Workloadmanagement-Lösungen
Bestmögliche Nutzung von Compute-Ressourcen

- Leistung steigern, Kosten senken: Hardware und Lizenzen optimal ausnutzen
- Herstellerunabhängige Beratung: LSF, Grid Engine, MOAB u.a. passgenau auswählen
- Installation, Konfiguration und Integration: Alle Leistungen aus einer Hand beziehen
- Professioneller Support: Von der s+c-Erfahrung aus hunderten von Projekten profitieren

HPC für den Mittelstand

Entwicklungszeiten verkürzen, Qualität steigern

- Schnell einsatzbereit: Vorkonfigurierte, kostengünstige Compute-Cluster
- Alles aus einer Hand: Installation, Integration und Service durch Bull - Atos Technologies
- Auf der sicheren Seite: Rundum-Service während der Nutzungszeit

High Performance Computing aus der Cloud
Rechnerressourcen bei Bedarf temporär nutzen

- Volle Kostenkontrolle: Rechenleistung mieten statt kaufen
- Engpässe überbrücken: HPC-Ressourcen bei Bedarf sofort abrufen
- Einfacher und sicherer Zugang: Auf das Extreme Factory Webportal zugreifen
- Maßgeschneiderte Lösungen: Auf viele vorkonfigurierte Anwendungen zugreifen

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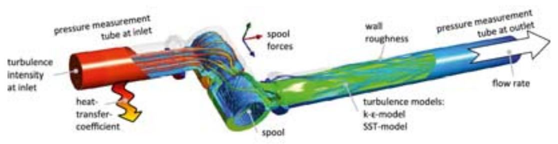
Process Engineering

SENSITIVITY ANALYSIS OF CFD-PARAMETERS WITH THE FESTO VALIDATION MODEL



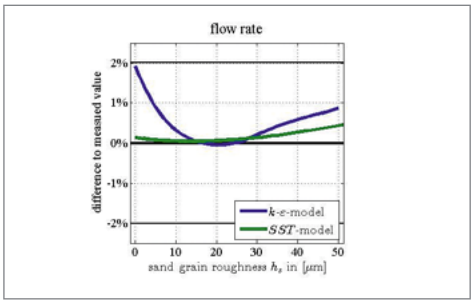


Fig. 1: Impact of wall roughness (hs) on the flow rate. The variation remains within the experiment's measurement accuracy of ±2%.

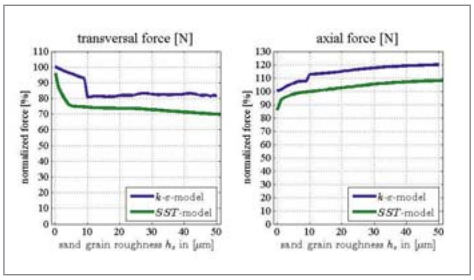


Fig. 2: Impact of wall roughness hs on transversal (left) and axial (right) spool forces. Steady increase of axial forces with hs and decrease of transversal forces. k-e-model shows slightly higher forces than SST. At under 10 um, strong change in forces due to reorganization of the flow field with both turbulence models.

Motivation

- Computational Fluid Dynamics Simulation of a pneumatic valve using ANSYS CFX
- Evaluated Flow Rate Accuracy depends on CFD model parameters and solver configuration
- Systematic analysis of influencing parameters on flow rate and spool forces by sensitivity analysis using optiSLang coupled to ANSYS CFX
- Better understanding of parameter sensitivities to improve CFD simulations

Sensitivity Analysis

- Simplified valve serves as a representative geometry for the validation model
- Choked flow within the valve at pressure difference of 6 bar
- Input: 10 parameters (physical, model and turbulence parameters)
- Output: sonic conductance (ISO 6358) and flow forces on the spool
- Separate sensitivity analysis for turbulence models k-ε and SST
- Latin Hypercube Sampling for scanning the design space

Results

- Wall roughness and choice of turbulence model have high impact on the flow rate
- Consideration of wall roughness in CFD simulations is recommended
- Adiabatic wall assumption is valid
- Turbulence intensity definition has no impact -> turbulence generation within valve is predominant

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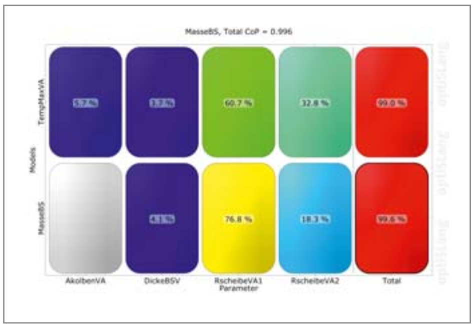
starkstrom AUGSBURG
FSE Racing Team UAS-Augsburg

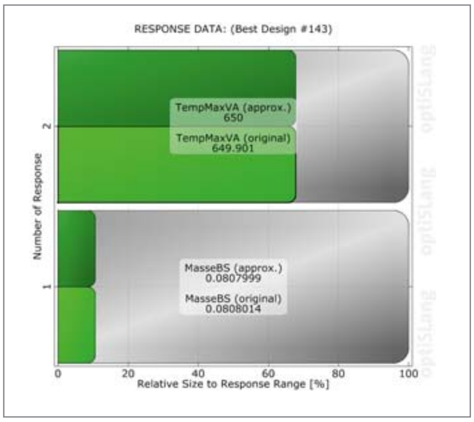
Automotive Engineering

THERMIC BRAKE SYSTEM OPTIMIZATION OF A FORMULA STUDENT RACE CAR

Cedur performing on the wet pad



Comparing the individual influences of input parameters on output parameters in a Cop-matrix



Verification of the forecasts in the response data

Objectives

- Weight reduction
- Improvement of the vehicle dynamics due to decrease of unsprung masses
- Individual development of a tailor made brake system

Structure and Parameters

- Matlab script calculating brake disc temperatures based on brake pressure and speed recorded during test drives
- Input parameters: outer and inner brake disc diameter / brake disc thickness / piston diameter
- Evaluation with optical measurement system
- Output parameters: brake disc mass / brake disc temperature

Sensitivity Analysis and Optimization with optiSLang

- Results of the sensitivity analysis: outer diameter has highest influence on brake temperature / very good prognosis ability
- Results of the optimization: best use of available installation space / decreasing brake system weight and increasing overall brake performance

Conclusion

Based on the optimization results, a weight reduction of the brake disc of 52% could be achieved. The brake pistons could also be downsized and combined with an own developed brake caliper. Here, a weight reduction of 46% was obtained. The sensitivity analysis showed that a higher acceptable break disk temperature could lead to an additional weight reduction. By changing the disk material to C-SiC, this temperature raise and even a smaller brake disk geometry with a gain of brake performance were achieved. In a nutshell, the conduction of an optimization with optiSLang afforded an overall brake system weight improvement of 56% in comparison with the purchased parts used before.

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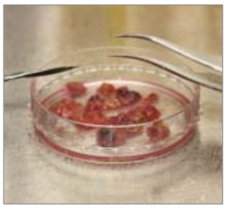
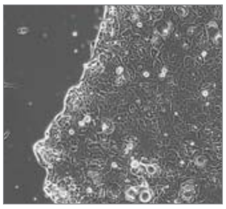
Medical Engineering

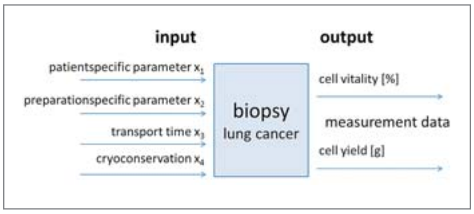
OPTIMIZATION OF A DISAGGREGATION PROCESS OF COMPLEX CANCER TISSUE (BIOPSY)



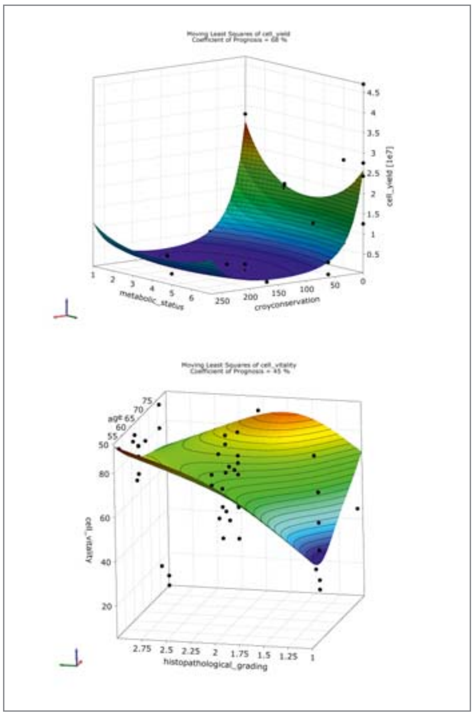
Tumor tissue



Established lung tumor cells *in vitro*



Defined input and output parameters



Response surface 3D plot for output parameter cell yield (top) and cell vitality (bottom)

Aspects of the project

- Development of a disaggregation process of biopsies to cultivate tumor cells in cell culture
- Application of modern cell culture methods
- Determination of influential input and output variables
- Optimization of disaggregation process to optimize cell vitality and cell yield
- Process automation

Methods

- Definition of the input and output factors
- Definition of the design space for parameter variation
- Determination of the design of experiment (DoE) with using a central composite design
- Correspondence with hospital to get patient background data
- Realization of DoE with 50 different lung cancer samples

Sensitivity analysis and optimization using optiSLang

- Determination of the optimal preparationspecific parameters
- Definition of parameters with bad influence
- Outlier detection: important to maintain quality of optimization
- MOP - solver to test approximation quality (compare input experimental data with prediction of the Metamodel of Optimal Prognosis - MOP)
- Compare anthill plots or 3D approximation plots
- The most important parameter is the duration of the cryoconservation (linear correlation coefficient -0,51)

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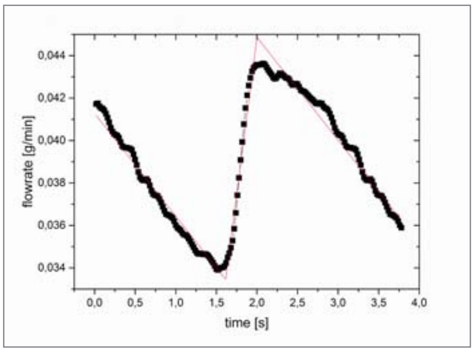
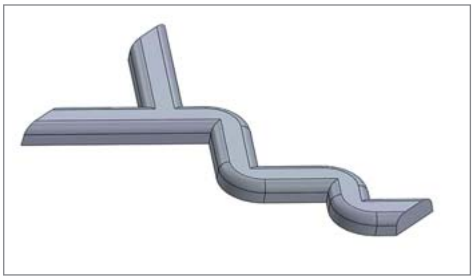
Process Engineering

OPTIMIZATION OF A MICROMIXER FOR PULSATILE MASSFLOWS



Flowrate with fitting


Start design of the micromixer

Aspects of the project

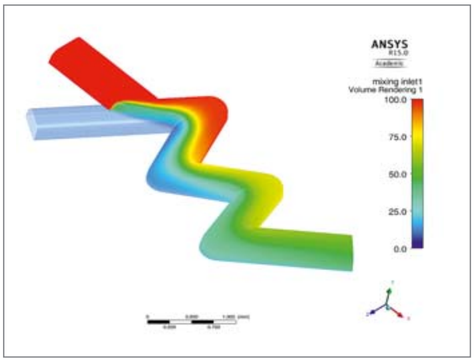
- Micromixing is an essential part of each microfluidic set up
  - Only laminar flow in microfluidics (Reynolds-Number<100)
  - Diffusion dominated mixing process
- Determination of influential input and output variables
- Optimization of a micromixer for a pulsation profile
  - Maximize mixing efficiency
  - Minimize temporal variations of the efficiency
  - Minimize the pressure drop and volume

Methods

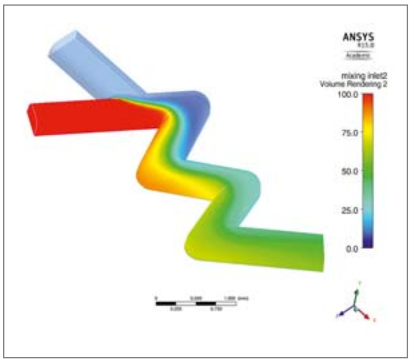
- Definition of the input and output factors
- Definition of the design space for parameter variation
- Determination of the design of experiment (DoE) with using an advanced Latin hypercube
- Transient Ansys CFX Simulation for mixing

Sensitivity analysis and optimization using optiSLang

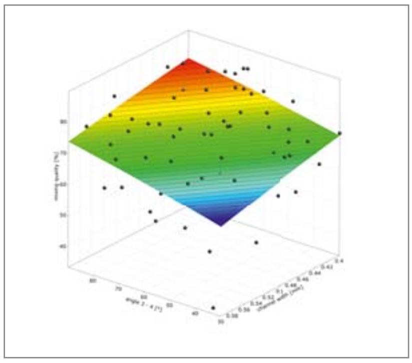
- Comparison of optimization algorithm with different mesh sizes
- Determination of the optimal geometry with a Pareto front
  - Validation of optimal design



Optimized micromixer with volume rendering for inlet 1



Optimized micromixer with volume rendering for inlet 2


Response surface for mixing quality

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