

THE SIXTH
**SWEDISH PRODUCTION
SYMPOSIUM**

2014

SEP 16-18, GOTHENBURG
CLARION HOTEL POST

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Committees

Scientific Committee

Mats Björkman (Chair), LIU
Johan Stahre (Co-Chair), Chalmers
Jan-Eric Ståhl, LTH
Lena Abrahamsson, LTU
Peter Almström, Chalmers
Alf Andersson, Chalmers/Volvo
Carin Andersson, LTH
Mats Andersson, LTH
Monica Bellgran, LKAB
Gunnar Bolmsjö, HV
Åsa Fasth Berglund, Chalmers
Cecilia Berlin, Chalmers
Danfang Chen, KTH
Björn Johansson, Chalmers
Christer Johansson, MDH
Hans Johannesson, Chalmers
Jan Johansson, LTU
Mats Jägstam, JTH
Alexander Kaplan, LTU
Henrik Kihlman, Chalmers
Anders Kinnander, Chalmers
Torsten Kjellberg, KTH
Minna Lantz, TUT
Bengt Lindberg, KTH
Thomas Lundholm, KTH
Lena Mårtensson, KTH
Lars Nyborg, Chalmers
Per Nylén, HV
Mauro Onori, KTH
Hans-Börje Oskarsson, Chalmers
Lars Pejryd, ORU
Bengt-Göran Rosén, HH
Anders Skoogh, Chalmers

Kristina Säfstén, JTH
Rikard Söderberg, Chalmers
Marco Taisch, Polimi
Reijo Tuokko, TUT
Leo de Vin, HIK
Lihui Wang, KTH
Mats Winroth, Chalmers
Jinming Zhou, LTH
Roland Örtengren, Chalmers

Programme Committee

Johan Stahre (Symposium Chair),
Chalmers
Björn Johansson (Co-Chair),
Chalmers
Cecilia Berlin, Chalmers
Åsa Fasth-Berglund, Chalmers
Christina Haglund, Chalmers
Kate Larsson, Chalmers
Anders Skoogh, Chalmers
Bengt-Göran Rosén, HH
Lillvor Wahlberg, Chalmers

Preface

Dear Friends


On behalf of the Swedish Production Academy and the Production Area of Advance at Chalmers, I am proud and happy to welcome you to the sixth Swedish Production Symposium!

The 2014 Symposium will focus on how sustainability and competitiveness can be achieved through production research, education, and innovation. In emerging and old economies, huge investments are being made in production research, to reclaim vital manufacturing industries and jobs. As a research community, we always need to emphasize that production research and education are key enablers for future industrial and societal development.

When I had the pleasure of opening our first symposium in 2007, the Swedish Production Academy was a young organisation. Seven years later, the Production Academy is well-established and pursuing strong collaboration with industry, research institutes, and policy makers towards production excellence in Sweden and in Europe. Several programmes for production research, education, and innovation have been launched as a collaborative result and among them, Chalmers' Production Area of Advance. We gratefully acknowledge the Swedish Innovation Agency Vinnova's and Teknikföretagen's strong support for SPS'14 through the National Innovation Programme, Produktion2030.

It is important that we have gathered in Göteborg, the industrial heart of Sweden. We are here to share knowledge and ideas, and also to establish new friendships and maintain old. The Swedish Production Academy is an open, inclusive, and growing organisation. We invite you to take the opportunity to get even more involved in the Academy during the three days of the Symposium. Please get inspired and connected, the future is up to us!

Once again, on behalf of all of us organisers, a warm welcome to the Swedish Production Symposium 2014!



Johan Stahre, Professor

Chairman of the SPS'14 organising committee

Secretary of the Swedish Production Academy

Programme

Tuesday, September 16

09:00	Registration opens	Clarion Hotel Post ground floor
12:00-13:00	Lunch	Clarion Hotel Post ground floor
13:00-13:15	Welcome to SPS 2014	Brevsorterarsalen
13:15-13:45	Keynote Johan Stahre, Chalmers	Brevsorterarsalen
13:45-14:15	Coffee break	Wintergarden, Clarion Hotel Post ground floor
14:15-15:30	Parallell sessions	Brevsorterarsalen 1, 2 & 3 and Post 4 & 5
15:30-16:00	Coffee break	Wintergarden, Clarion Hotel Post ground floor
16:00-17:40	Parallell sessions	Brevsorterarsalen 1,2 & 3 and Post 4 & 5
18:00	Registration closes	Clarion Hotel Post ground floor
19:00-21:00	City of Gothenburg reception in "Dicksonska palatset"	Departure from Clarion Hotel Post Lobby at 18:40 for a 15 minutes walk to Dicksonska Palatset, Parkgatan 2. Event starts at 19:00

Wednesday, September 17

08:30-08:45	Introduction	Brevsorterarsalen
08:45-09:15	Keynote Marco Taich, Politecnico di Milano	Brevsorterarsalen
09:15-09:30	Keynote Anna Davidsson, Volvo Cars	Brevsorterarsalen
09:30-10:00	Keynote Eva Wigren, Teknikföretagen	Brevsorterarsalen
10:00-10:30	Coffee break	Wintergarden, Clarion Hotel Post ground floor
10:30-12:10	Parallell sessions	Brevsorterarsalen 1,2 & 3 and Post 4 & 5
12:00-13:30	Lunch	Clarion Hotel Post ground floor

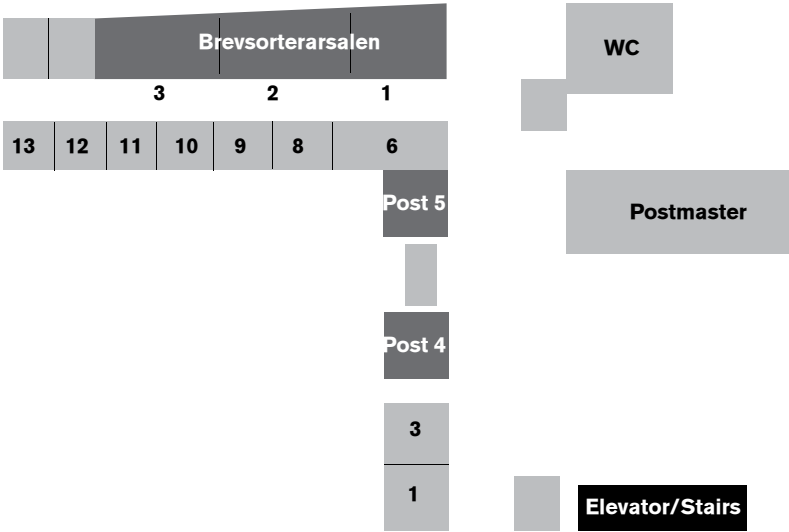
13:30-15:10	Parallell sessions	Brevsorterarsalen 1,2 & 3 and Post 4 & 5
15:10-15:30	Coffee break	Wintergarden, Clarion Hotel Post ground floor
15:30-17:10	Parallell sessions	Brevsorterarsalen 1,2 & 3 and Post 4 & 5
17:45-19:00	Guided tour around Gothen- burg with Paddan	Meet up at Clarion Hotel Post Lobby 18:45
19:00-23:00	Conference dinner	Drottningporten at Clarion Hotel Post
19:00-23:00	Alde Nilsson Award Ceremony	Drottningporten at Clarion Hotel Post

Thursday, September 18

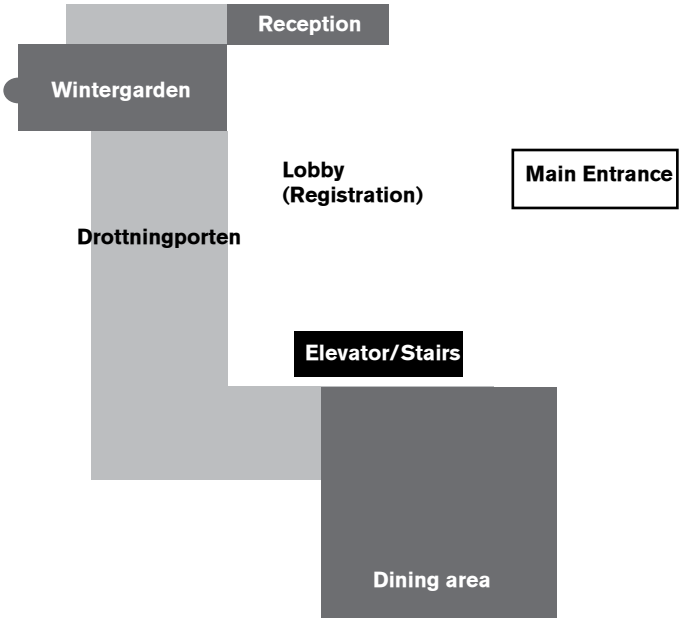
08:50-10:30	Parallell sessions	Brevsorterarsalen 1,2 & 3 and Post 4 & 5
10:30-11:00	Coffee break	Wintergarden, Clarion Hotel Post ground floor
11:00-12:00	Closing session	Brevsorterarsalen
12:00-13:00	Lunch	Clarion Hotel Post ground floor

Floorplan

Level 2



Ground Floor



Programme Details

Opening Session

Tuesday 13:00 – 13:15

Location: Brevsorterarsalen

Speakers: Johan Stahre (Chalmers University of Technology)
Mats Björkman (Linköping University)

Welcome to SPS2014

Keynote Sessions

Tuesday 13:15 – 13:45

Location: Brevsorterarsalen

Future Work?

Speaker: *Professor Johan Stahre (Chalmers University of Technology)*



Wednesday 08:30 – 10:00

Location: Brevsorterarsalen

Mind the Gap – Attracting young talents to Manufacturing

Speaker: *Professor Marco Taisch (Politecnico di Milano)*



The all new XC90 – Production challenges and achievements

Speaker: *Dr Anna Davidsson (Volvo Car Corporation)*



Production – a National Priority

Speaker: *Eva Wigren (Teknikföretagen)*



Conference Dinner – Award Ceremony

Wednesday 19:00 – 23:00

Location: Drottningporten at Clarion Hotel Post

Alde Nilsson Award Ceremony

Speaker: *Helene Gamstedt (ABB Corporate Research)*

About: The Alde Nilsson scholarship is awarded to encourage research in Production Technology and Engineering at the technical universities in Sweden. The scholarship was established in 1987 to honor Mr Alde Nilsson on his 70th birthday. For 17 years Alde Nilsson was executive vice president in charge of production, for which at the time was called ASEA, and today is the Swedish part of the global company ABB. ABB has a large part of processing in Sweden and also responsibility for global products. Constantly ongoing and significant productivity improvements are absolutely essential in order to be competitive in the global market. For ABB, automation is thus very important in order to provide a flexible production capacity!

Closing Session

Thursday 11:00 – 12:00

Location: Brevsorteraren

Session Chairs: Johan Stahre (Chalmers University of Technology), Mats Björkman (Linköping University)

VINNOVA Research Agenda

Speakers: *Tero Stjernstoft (VINNOVA) och Jens von Axelson (VINNOVA)*

Produktion2030

- A Strategic Research and Innovation Programme

Speaker: *Cecilia Warrol (Teknikföretagen)*

Best Paper Award Ceremony

Speakers: *Johan Stahre (Chalmers University of Technology), Björn Johansson (Chalmers University of Technology), Mats Björkman (Linköping University), Lihui Wang (KTH Royal Institute of Technology), Bengt-Göran Rosén (Halmstad University), Jan-Eric Ståhl (Lund University)*

Invitation to SPS 2016

Speaker: *Jan-Eric Ståhl (Lund University)*

Farewell

Speaker: *Johan Stahre (Chalmers University of Technology)*

Conference Sessions

Tuesday – Thursday

Parallel sessions

A.	Resource efficient and sustainable production
B.	Flexible manufacturing processes and systems
C.	Virtual production development and simulation
D.	Human-centred production systems
E.	Product and production services
F.	Integrated product and production development
G.	Education in manufacturing, on all levels

TUESDAY 14:15 – 15:30

A. Resource efficient and sustainable production I

Location: Brevsorterarsalen 1

Session Chair: Jan-Eric Ståhl (Lund University)

Machinability and Process Stability When Turning Alloy 718 with Standard and Produced by Selective Laser Sintering Toolholders

Authors: Oleksandr Gutnichenko (Lund University), Volodymyr Bushlya (Lund University), Jinming Zhou (Lund University), Jan-Eric Ståhl (Lund University), Pajazit Avdovic (Siemens Industrial Turbomachinery AB), Ulf Simmons (Siemens Industrial Turbomachinery AB)

Abstract: The paper presents the results of a comparative analysis of machinability and dynamic stability when turning a nickel-based superalloy with whisker reinforced alumina (WRA) tools in a conventional and prototype toolholders. The use of the prototype toolholder with a spatial structure is shown to significantly suppress vibrations during the machining and stabilize the process within the cutting speed range between 200 and 400m/min. The above mentioned benefits are demonstrated to be owing to damping properties of the proposed toolholder.

Design and Properties of Binderless CBN and its Performance in Hard Turning

Authors: Volodymyr Bushlya (Lund University), Igor Petrusha (Institute for Superhard Materials), Oleksandr Gutnichenko (Lund University), Oleksandr Osipov (Institute for Superhard Materials), Jinming Zhou (Lund University), Jan-Eric Ståhl (Lund University)

Abstract: The paper present the results of the analysis of sintering, microstructure, properties, and performance of a binderless cBN tool material sintered. The optimum range of sintering temperatures was found to be 2200 – 2300 °C. Lower temperature results in incomplete diffusion bonding between cBN grains, while higher temperature results in high degree of recrystallization of initial structure, grain growth, and even formation of hexagonal boron nitride in triple joints. Introduction of stress-inducing β -Si₃N₄ minor inclusions resulted in high overall mechanical and thermal properties: HK \approx 41 GPa; KIC = 12.6 MPa·m^{1/2}; $\lambda \approx$ 200 W/(m·K). Machining experiments show that the material provides high performance in terms of resistance to tool cratering, chipping, and tool fracture.

Experimentation and Modeling of Chemical Interaction of PCBN and Inconel 718

Authors: Volodymyr Turkevych (*Institute for Superhard Materials, Lund University*), Volodymyr Bushlya (*Lund University*), Jinming Zhou (*Lund University*), Igor Petrusha (*Institute for Superhard Materials*), Jan-Eric Ståhl (*Lund University*)

Abstract: The paper investigates the mechanisms governing the wear of pcBN tool materials when high speed machining superalloy Inconel 718. The approach includes application of diffusion couples that were exposed to high temperature (1250 °C) and high pressure (2.5 GPa). Two grades of pcBN tool material were selected for the analysis: binderless materials and grade with low cBN content and TiC-based binder. Results indicate that the interaction proceeds with intensive formation of Nb₂N, Mo₂B and NbB₂ for binderless grade and less intensive reaction also including formation of Nb₂C, TiB, and TiN for the grade with TiC binder.

TUESDAY 14:15 – 15:30

B. Flexible manufacturing processes and systems I

Location: Brevsorterarsalen 2

Session Chair: Bengt-Göran Rosén (Halmstad University)

Characterizing the Mechanical Properties of Skin-Core Structure in Polymer Molding Process by Nanoindentation

Authors: Johan Persson (*Lund University*), Jinming Zhou (*Lund University*), Jan-Eric Ståhl (*Lund University*)

Abstract: Quality of the polymer product produced by injection molding process are strongly affected by the mechanical properties of the skin-core structure formed during injection molding operation. It is desirable to know the mechanisms of the skin-core structure and the influence from process parameters and material properties to the skin-core formation in the injection molding. This paper focuses on characterisation of the hardness, modulus, elastic and viscoelastic properties in the skin-core structure of the HDPE polymers by using nanoindentation approach in order to understand the formation of mechanism of skin-core structure, and to facilitate design and dimensioning the polymer part, optimize molding process. The distribution of hardness and modulus were also measured with grid mapping technique by using sharp berkovich indenter.

New Test Method for Detection and Analysis of Burrs and Slivers in Trimming and Punching Aluminium Sheet Metal

Authors: Johan Berglund (*Swerea IVF*), Mikael Kjellberg (*IUC Olofström*), Magnus Liljengren (*IUC Olofström*), Kenneth Kjellsson (*Volvo Car Corporation*)

Abstract: A large problem when trimming or punching aluminium sheet is the creation of burrs and slivers which degrade the quality of the produced parts. A semi-industrial test for evaluating trimming of aluminium has been further developed to include pre-stressing and pre-straining of the sheet material before trimming. The semi-industrial test results now show good correlation to industrial production outcomes.

Induction Heating of Carbon Fiber Structures – Properties and Challenges

Authors: *Kenneth Frogner (Lund University), Oscar Wiberg (Lund University), Ville Akujärvi (Lund University), Tord Cedell (Lund University), Mats Andersson (Lund University)*

Abstract: Carbon fiber reinforced plastic is constantly gaining market shares due to its unique properties. By heating this kind of materials using induction, many new applications occur. The high resistivity and anisotropic properties of carbon fiber composites means there are a number of challenges to overcome. This work emphasizes the key components related to induction heating of complex materials and present ways to characterize the important properties using non-contact methods. Successful experimental results are presented and the work also shows very good agreement between measurements and simulations.

TUESDAY 14:15 – 15:30

C. Virtual production development and simulation I

Location: Brevsorterarsalen 3

Session Chair: Juhani Heilala (VTT Technical Research Centre of Finland)

A Cloud-Based Platform for Waste Electrical and Electronic Equipment (WEEE) Recovery

Authors: *Xi Wang (KTH Royal Institute of Technology), Lihui Wang (KTH Royal Institute of Technology)*

Abstract: Due to the rapid changes in technologies, shifting in media (tape, CD, DVD, MP3, etc.) and falling prices, the total volume of electronic wastes is growing fast globally. Waste Electrical and Electronic Equipment (WEEE) belongs to this type of discarded devices. In this paper, recent Cloud Manufacturing paradigm is presented. Next, a novel serviceoriented remanufacturing platform is introduced based on Cloud Manufacturing paradigm. Product tracking and service evaluate mechanisms are also developed to support the remanufacturing processes based on Cloud. In a case study, an LCD television model is taken to evaluate the proposed system and mechanisms.

ICT-Tools Support Toyota Way Principle 6

Authors: *Vanesa Garrido Hernandez (Chalmers University of Technology), Åsa Fasth Berglund (Chalmers University of Technology)*

Abstract: This paper pursues to discuss how the implementation of Information and Communication Technologies (ICT)-tools could support standardized work (The Toyota Way, principle 6). This will be done through a theoretical discussion. Furthermore, a case study will show a practical example, -a web application as an ICT-tool solution to support standardized tasks-. The web application is intended to help the standardization of assembly instructions, help learn novice and experienced operators, and increase the knowledge sharing. The case study has no documented instructions, and as a consequence, there is a high risk that all this knowledge can be lost in the future.

Defining 'Benefit' When Making Production Investments – An Inquiry of Current Standards

Authors: *Sten Grahn (Swerea IVF), Anna Granlund (Mälardalen University), Magnus Wiktorsson (Mälardalen University), Niklas Friedler (Mälardalen University)*

Abstract: Investments in production equipment are made to generate desired production benefit. This work examines how benefit generally is defined and to what extent the benefit is well defined when equipment investments are made. The study revealed that benefit from investments often is unclearly or inconsistently defined, with a narrow system view and often has a weak correlation with benefit for a production system with broader boundaries. This could hamper the possibility to capitalize on industrial trends that indicate a shift in focus, from products, to the benefit utilization of the products can deliver.

TUESDAY 14:15 – 15:30

D. Human-centred production systems I

Location: Post 4

Session Chair: Åsa Fasth Berglund (Chalmers University of Technology)

The Future Swedish Shop-Floor Operator – Interviews with Production Managers

Authors: *Magnus Holm (Högskolan i Skövde), Göran Adamson (University of Skövde), Lihui Wang (KTH Royal Institute of Technology), Philip Moore (Falmouth University)*

Abstract: This paper is based on a study in which production and HR managers at six Swedish manufacturing industries have been interviewed about the role of the shop-floor operator, taking off in today's situation in trying to identify the future one. As well as the production methods and the machines etc. in the production system continuously evolve, so does the environment of the shop-floor operator. Increasing complexity in the production systems raises demands on the operators' ability to handle ICT-tools to gain decision support and knowledge needed in the future shop-floor environment.

How to Improve Productivity by 160%

Author: *Peter Almström (Chalmers University of Technology)*

Abstract: There is a large capacity increase potential in Swedish industry through increasing productivity of existing resources without investing in more machines or personnel. This article presents a case study where the capacity could increase more than 160% percent. This was proven by a test in running production. This tremendous increase was made possible through standardization and time setting of all work tasks. A new scheduling system was made up of product activity sequences based on a vast library of over 800 standardized generic activities.

Mapping the Current Social Sustainability Practices of the European Manufacturing Industry

Authors: *Caroline Adams (Chalmers University of Technology), Cecilia Berlin (Chalmers University of Technology), Paola Fantini (Politecnico di Milano), Johan Stahre (Chalmers University of Technology)*

Abstract: A survey among European production companies was carried out to map the level of understanding and action regarding social sustainability practices. In order to determine whether sufficient measures are in place to tackle upcoming demographic challenges. The study explored topics of labour practices, human capital development, job design, work-life balance, talent management, employee turnover & satisfaction management and stakeholder and community practices. The results indicate that although many companies report having a strategy in place for social sustainability, practices in place appear to only address the fundamental hygiene factors of the workplace, rather than focusing strategically on combating demographics challenges.

TUESDAY 14:15 – 15:30

A. Resource efficient and sustainable production II

Location: Post 5

Session Chair: Danfang Chen (KTH Royal Institute of Technology)

Material Efficiency in Manufacturing

Authors: *Sasha Shahbazi (Mälardalen University), Martin Kurdve (Swerea IVF)*

Abstract: Developments, industrialization and mass production have triggered rapid increase of raw material consumption and great volumes of industrial waste, while industrial waste management infrastructure has not been developed with the same pace. One mean in striving for industrial waste management is the management of process materials. This paper introduces the performance measure sorting rate for each segment of waste material, along with a method for sorting analysis to help improving overall material efficiency and industrial waste management. The results revealed that more than 50% of combustible bins' content could be separately segregated as plastic, wood, paper, cardboard and bio-degradable.

Minimum Time for Material and Information Flows Analysis (MiniMifa) – A Method to Identify Challenges and Improvement Opportunities

Authors: *Jelena Kurilova-Palisaitiene (Linköping University), Erik Sundin (Linköping University)*

Abstract: Material and information flows are often complex at remanufacturing companies. Minimum time for Material and Information Flows Analysis (MiniMifa) is a data collection workshop in which material and information flows' challenges and improvement opportunities are investigated. By carrying the idea of Value Stream Mapping (VSM), MiniMifa turns to an act of cartography of industrial processes. After the workshop, companies have a holistic view of their processes, the current "pains"- challenges, and possible "painkillers" – improvement ideas, including lean-inspired solutions. This paper demonstrates a pilot MiniMifa at a forklift truck remanufacturer where a potential improvement in e.g. lead time reduction by 93% was discovered.

Improvements in Vain – The 9th Waste

Authors: *Marcus Bengtsson (Mälardalen University), Christer Osterman (Scania)*

Abstract: Eliminating waste in processes through problem solving and continuous improvements is one of the main ambitions in Lean. However, as the paper will elaborate on, improvement attempts itself are in many cases waste. In worst case they can create continuous waste in processes as a result. The purpose of this paper is to exemplify, discuss, and elaborate on the concept of improvements in vain. The paper is built on reasoning from industrial experience.

TUESDAY 16:00 – 17:40

A. Resource efficient and sustainable production III

Location: Brevsorterarsalen 1

Session Chair: Bengt Lindberg (KTH Royal Institute of Technology)

Temperature Monitoring of Induction Hardening Using Spectral Pyrometry

Authors: *Petter Hagqvist (University West), hans Kristoffersen (Swerea IVF), Anna-Karin Christiansson (University West)*

Abstract: In this study, a recently developed multispectral temperature measurement method is applied for temperature monitoring of induction hardening of steel. An industry-like induction heating process is used for evaluating the method and an automatic calibration procedure is presented. Thermocouples and a conventional pyrometer are used for comparison, showing that the multispectral method gives more accurate results than the conventional pyrometer. These results confirm that the multispectral method is well suited for accurate, non-contacting temperature measurements for induction hardening processes. Enabling measurements which have previously not been possible. This enables fast selection of process parameters which can improve productivity.

Design and Development of a Roller with Embedded Heating for Uniform Temperature Generation

Authors: *Kenneth Frogner (Lund University), Leif Siesing (Lund University), Ville Akujärvi (Lund University), Tord Cedell (Lund University), Mats Andersson (Lund University), Avo Reinap (Lund University)*

Abstract: This paper provides design experience based on 2D FE electromagnetic and heat transfer analysis that are used to support product development. An induction in-roll heater is analyzed, tested and verified. The scientific challenge is to develop fast and fair models to provide design guidelines for layout specification, material selection and performance estimation. The transferred energy capability and efficiency are the essential performance figures focused on the first hand in prior to temperature distribution and profiles.

Effects of Cooling Rate and Silicon Content on Al/SiCp MMC

Authors: Volodymyr Bushlya (Lund University), Mikael Hörndahl (Lund University), Emma Bengtsson (Lund University), Stefan Kristiansson (Volvo Car Corporation), Jan-Eric Ståhl (Lund University)

Abstract: This paper reports the results of the study of the microstructural and mechanical properties of metal matrix composites (MMC) based on Al-Si matrix alloy and silicon carbide particulates. The scope of the study is to investigate the effects of cooling rate and silicon content on the microstructure and the mechanical properties of MMC. Samples were cast in moulds of different temperature in order to identify the effects of the cooling rate while silicon content was varied from 7 to 12.5 % in the matrix material. The conclusion is that the cooling rate has little effect on the properties unless it is taken to the extreme and the effects of the silicon content is no more pronounced than for non-reinforced aluminium.

HP-HT Sintering, Microstructure, and Properties of B₆O- and TiC-Containing Composites Based on cBN

Authors: Dmytro Turkevych (Lund University), Volodymyr Bushlya (Lund University), Igor Petrusha (Institute for Superhard Materials), Jinming Zhou (Lund University), Nadezhda Belyavina (Institute for Superhard Materials), Volodymyr Turkevych (Institute for Superhard Materials, Lund University), Jan-Eric Ståhl (Lund University)

Abstract: Ceramic-matrix composites with a low-cBN content and different matrix compositions including B₆O and TiC have been sintered in a toroid-type high-pressure apparatus at pressure of 7.7 GPa and temperatures from 1500 to 2000°C. The microstructure, phase and elemental compositions of the produced composites have been studied using electron microscopy and XRD analysis. Mechanical properties and the performance of the sintered tool materials when turning hardened cold work tool steel have been studied.

TUESDAY 16:00 – 17:40

B. Flexible manufacturing processes and systems II

Location: Brevsorterarsalen 2

Session Chair: Fredrik Sikström (University West)

Microstructural Analysis of Laser Cladding of Stellite 6 on Ductile Iron

Authors: *Ebrahim Harati (University West), Farshid Malek Ghaini (Tarbiat Modares University), Mohammad Javad Torkamany (Tarbiat Modares University)*

Abstract: Stellite 6 alloy in the form of powder was deposited on a ductile cast iron substrate using a low power pulsed Nd:YAG laser. The effects of process parameters on the resulting microstructure and hardness were studied with emphasis on the single and multi-track deposits. The results revealed that the clad layers consist of carbides dispersed in a Co-based solid solution matrix with a dendritic structure. Multi-track clad layers have coarser dendrites compared to those of single-track clad layer due to a longer exposure time at high temperature and slower cooling rates as more layers were deposited.

Economical Viability of Laser Metal Deposition

Authors: *Andreas Segerstark (University West), Joel Andersson (GKN Aerospace), Lars-Erik Svensson (University West)*

Abstract: Reports on large economic savings using Additive Manufacturing (AM) has been found in literature when exploiting the positive capabilities of AM. This paper evaluates the economic potential of, the AM method, laser metal deposition (LMD) in production of add-on features compared to conventional manufacturing methods. This is done by theoretical case studies, which explore factors critical to the cost of manufacturing a jet engine flange. LMD has the potential to be an economical viable alternative to conventional manufacturing methods when the manufactured component has a high buy-to-fly ratio, the component is small and complex, if the operator time can be kept to a minimum, and/or when the design freedom of LMD can be capitalized into lighter and more efficient components.

Optical Methods for In-Process Monitoring of Laser Beam Welding

Authors: *Fredrik Sikström (University West), Morgan Nilsen (University West), Ingemar Eriksson (GKN Aerospace)*

Abstract: This paper addresses the issue of evaluating and selecting optical sensors to be integrated with a 1 μ m laser beam welding system. The method used for this evaluation is mainly a survey of relevant research literature. The result of this work is a matrix showing the different methods and distinct features related to relevant process conditions that can be estimated or detected with respective methods. This evaluation also includes considerations on the required sensor bandwidth in relation to inertia and time constants in the physical process.

TUESDAY 16:00 – 17:40

C. Virtual production development and simulation II

Location: Brevsorterarsalen 3

Session Chair: Amos H.C. Ng (University of Skövde)

Process Chain Based Workpiece Variation Simulation for Performance Utilisation Analysis

Authors: Mats Bagge (*Scania CV AB*), Mikael Hedlind (*Scania CV AB*), Bengt Lindberg (*KTH Royal Institute of Technology*)

Abstract: Propagation of shape variations in multi-step manufacturing processes, constrained by tolerance chains, is the consequence of sequenced operations defined in process planning. A key task in process planning is to define in-process workpiece (IPW) tolerances for efficient production ensuring conformance to the product design specification and good utilisation of the manufacturing resources. A dimension dependency chart has been developed for analysis of linked IPW tolerance chains and simulation of shape variation propagation caused by systematic and random errors. The results show how the traditional process capability index, used as an acceptance criterion for IPW tolerancing, limits the process performance utilisation.

An Interactive, Cloud-Based Simulation Optimization System for Knowledge Discovery and Decision Support in Manufacturing

Authors: Ingemar Karlsson (*University of Skövde*), Amos H.C. Ng (*University of Skövde*), Tehseen Islam (*University of Skövde*), Catarina Dudas (*Volvo Group Trucks Operations*)

Abstract: Designing or improving a manufacturing system involves a series of complex decisions over time to satisfy the strategic objectives of the company. To select the optimal parameters of the system entities so as to achieve the desired overall performance of the system is a very complex task that has been proven to be difficult, even for a seasoned decision maker. One of the major barriers for more efficient decision making in manufacturing is that whilst there is in principle abundant data from various levels of the factory, these data need to be organized and transferred into knowledge suitable for decision-making support. The integration of decision-making support and knowledge management has been identified to be more and more important in both scientific research and from industrial companies. The concept of deciphering knowledge from multi-objective optimization was first proposed by Deb with the term innovation (innovation via optimization). By integrating the concept of innovation with simulation, a new set of powerful tools for manufacturing systems analysis, in order to support optimal decision making in design and improvement activities, is emerged. This method is so-called Simulation-based Innovation-

tion (SBI), which has been proven to produce promising results in our previous application studies. Nevertheless, to promote the wider use of such a new method requires the development of an integrated software toolset. The goal of this paper is therefore to outline a Cloud-computing based system architecture for implementing such a SBI-based Interactive Decision Support System.

Optimised Control of Sheet Metal Press Lines

Authors: *Emile Glorieux (University West), Bo Svensson (University West), Fredrik Danielsson (University West), Bengt Lennartson (Chalmers University of Technology)*

Abstract: Determining the control parameters for sheet metal press lines is a large scale and complex optimisation problem. These control parameters determine velocities, time constants, and cam values of critical interactions between the equipment. The complexity of this problem is due to the nonlinearities and high dimensionality. Classical optimisation techniques often underperform in solving this kind of problems within a practical time-frame. Therefore, specialised techniques need to be developed for these problems. An existing approach is simulation-based optimisation, which is to use a simulation model to evaluate the trial solutions during the optimisation. In this paper, an efficient simulation-based optimisation algorithm for large scale and complex problems is proposed. The proposed algorithm extends the co-operative coevolutionary algorithm, which optimises subproblems separately. Hence, the optimisation problem must be decomposed into subproblems that can be evaluated separately. To optimise the subproblems, the proposed algorithm allows using embedded deterministic algorithms, next to stochastic genetic algorithms, getting the flexibility of using either type. It also includes a constructive heuristic that creates good initial feasible solutions to expedite the optimisation. The extension enables solving complex, computationally expensive problems efficiently. The proposed algorithm has been applied on an automated sheet metal press line from the automotive industry. The objective is to find control parameters that maximise the line's production rate. The results show that the proposed algorithm manages to find optimal control parameters efficiently within the practical timeframe. This is a step forward in press line optimisation since to the authors' knowledge this is the first time a press line has been optimised efficiently in this way.

Monte Carlo Simulations of Production Costs in Discrete Manufacturing

Authors: *Kathrine Spang (Lund University), Jan-Eric Ståhl (Lund University), Christina Windmark (Lund University)*

Abstract: When calculating the production costs input data can vary considerably in quality between different cases. When costs pertain from products, which are already in production, complete and reliable data may already be available. For new products, new production systems or new production technology it might be hard to find applicable and reliable data. The cost and performance parameters needed can then be achieved by examining similar products or processes, these parameters will inevitably differ from the new case. The aim of this paper is to try to Monte Carlo simulate production costs, with less reliable data.

TUESDAY 16:00 – 17:40

D. Human-centred production systems II

Location: Post 4

Session Chair: Per Gullander (Swerea IVF)

Managing Production Complexity by Supporting Cognitive Processes in Final Assembly

Authors: *Sandra Mattsson (Chalmers University of Technology), Åsa Fasth Berglund (Chalmers University of Technology), Johan Stahre (Chalmers University of Technology)*

Abstract: Managing production complexity in final assembly includes understanding and supporting the operators cognitive processes. In this paper three models for information handling and decision-making are combined to better describe intuitive processes in this context. The combination form a conceptual model that was tested using two case scenarios. The scenarios show that by supporting cognitive processes e.g. by simplifying information and presenting it in a better way, production complexity could be better managed, thereby increasing operator performance and satisfaction.

Design Criteria for a Conceptual End Effector for Physical Human Robot Production Cell

Authors: *Varun Gopinath (Linköping University), Kerstin Johansen (Linköping University), Åke Gustafsson (Volvo Car Corporation)*

Abstract: Speed, precision and repeatability are virtues of industrial robots which are relied on by manufacturing firms but also necessitates segregating them within controlled fenced areas. Therefore, industrial robots cannot cooperate with line workers in assembling task. With recent developments in robotics, new possibilities have emerged that can enable manufacturing firms to be flexible and cost effective. This paper presents preliminary results from investigations into the possibility of a man-machine production cell where plastic panels are assembled under the car. A conceptual man-machine collaborative production cell will be presented detailing characteristics required to ensure safety.

Development of Simple Guidelines to Improve Assembly Instructions and Operator Performance

Authors: Anna Johansson (*Chalmers University of Technology*), Camilla Söderberg (*Chalmers University of Technology*), Sandra Mattsson (*Chalmers University of Technology*)

Abstract: Assembly instructions is an important means for supporting operator performance in final assembly. An operator at a production line, whether experienced or novice, will encounter situations that include the assembly of new products or new variants. Instructions that are developed without consideration of these processes can cause unnecessary cognitive load and lead to poor operator performance. This paper describes an experiment that shows that assembly instructions can increase operator performance and presents nine simple guidelines. The Importance of including the operator view is stressed and how the guidelines should be implemented in practice is discussed.

ICT Usage and Benefits in Swedish Manufacturing and Process Companies

Authors: Malin Karlsson (*Chalmers University of Technology*), Anders Gustafsson (*Luleå University of Technology*), Camilla Grane (*Luleå University of Technology*), Johan Stahre (*Chalmers University of Technology*)

Abstract: Information and communication technology (ICT) tools could be used to enable the operators to perform their tasks as efficiently as possible. This paper investigates ICT use among Swedish industry operators in six companies representing both manufacturing and mining industry. It was concluded that the availability and usage of these tools is lower in industry than at leisure time. Many operators saw possible benefits with having more ICT tools available in their work. The results suggest both efficiency and economical gains through an increased usage of ICT tools.

TUESDAY 16:00 – 17:40

A. Resource efficient and sustainable production IV

Location: Post 5

Session Chair: Peter Almström (Chalmers University of Technology)

Developing a Concept for Sustainability Indicators and Reporting Systems for Finnish Manufacturing Industry

Authors: Mikko Tapaninaho (*Tampere University of Technology*), Mikko Koho (*VTT Technical Research Centre of Finland*), Juhani Heilala (*VTT Technical Research Centre of Finland*), Hannele Tonteri (*VTT Technical Research Centre of Finland*)

Abstract: This paper reports the results and outlines the progress of an on-going research project that aims to support Finnish manufacturing companies in sustainability measurement and reporting. The target companies' current state and future needs as well as challenges and opportunities of implementing sustainable indicators and reporting practices are described. Then, an early design concept of a new indicator framework is proposed. The framework suggests dividing and categorizing sustainability indicators based on two domains: level of organization and temporal focus. This is intended to assist companies in selecting relevant and useful sustainability indicators.

Social Sustainability KPIs in Operations Management: A Gap between the Reactive and the Proactive Stance

Authors: Naghmeh Taghavi (*Chalmers University of Technology*), Caroline Adams (*Chalmers University of Technology*), Cecilia Berlin (*Chalmers University of Technology*)

Abstract: Manufacturing companies increasingly evaluate sustainability outcomes using key performance indicators (KPIs). But when it comes to social sustainability, currently established KPIs do not give appropriate decision support to address future challenges proactively. Upcoming demographic trends point to the challenge of a shortage of qualified labour in the manufacturing industry. To counteract this risk, manufacturing companies must set visions to become attractive and socially sustainable workplaces. This paper identifies a set of characteristics for a socially sustainable and attractive workplace based on previous literature, and proposes that a gap must be bridged between the KPI-oriented approach and creating socially sustainable workplaces.

Positive Externalities in Design for Sustainability

Author: *Bengt Steen (Chalmers University of Technology)*

Abstract: Human concern for environment began as a reaction to single episodes of damage to environment and human health. As a consequence, today, the assessment of environmental impacts consists mostly of negative externalities. When social and economic aspects were considered together with environmental aspects to assess sustainability, the tradition of looking for negative externalities has continued. However, when considering satisfaction of human needs, which is the ultimate goals for sustainable development, it becomes obvious that there are many positive externalities that are not taken into account. Capacity and efficiency to satisfy basic human needs characterize such externalities.

Implementation of Sustainable Production Principles within Swedish Manufacturers

Authors: *Claudia Alayón (Jönköping University), Glenn Johansson (Jönköping University), Kristina Säfsten (Jönköping University)*

Abstract: Both, a common understanding on sustainable production principles and the identification of sustainable production practices within manufacturers constitute key starting points when the aim is to study how Swedish manufacturers are working towards sustainable production. Using an interview guide based on the sustainable production principles by the Lowell Center of Sustainable Production (LCSP), this paper provides an overview of how Swedish manufacturers comply with these set of principles.

WEDNESDAY 10:30 – 12:10

A. Resource efficient and sustainable production V

Location: Brevsorterarsalen 1

Session Chair: Mats Andersson (Lund University)

The Measurement of Weld Toe Radius Using Three Non-Destructives Techniques

Authors: *Ebrahim Harati (University West), Leif Karlsson (University West), Lars-Erik Svensson (University West)*

Abstract: The three non-destructive methods Weld Impression Analysis, Laser Scanning Profiling and Structured Light Projection were employed to measure the weld toe radius of fillet welds. All three methods could be used successfully but results are dependent on evaluation procedure. The results show that the weld toe geometry cannot be considered uniform and varies along the weld. It was also found that the measured weld toe radii do not vary significantly with minor variations of the surface profile orientation.

Weld Joint Tracking System in an Automatic Inspection Cell by Using Emissivity Variation

Authors: *Guillaume Batungwanayo (University West), Anna Runnemalm (University West), Mikael Ericsson (University West)*

Abstract: Thermography has proven to be a suitable nondestructive testing method for automatic crack inspection of welds. However automatic weld inspection raises challenges. E.g. the position of the weld might not be exactly as the predefined weld seam, and a weld joint tracking system is needed. To reduce the number of equipment used, a solution is presented in this paper. The infrared camera in the thermography system is a carrier of information of the weld path. This is used for the weld joint tracking system built to control the robot movement in an automatic inspection cell.

Impact of Gaps on Resource Efficiency in Heavy Welding Industry

Authors: Anna Ericson Öberg (Chalmers University of Technology / Volvo CE), Sofia Wikstrand (Chalmers University of Technology), Victor Mattsson (Karlstad University)

Abstract: This paper describes a study investigating the current situation concerning plate gaps in welding operations at a company producing welded products. A varying gap between the plates has been identified as a root cause for quality issues and unnecessary costly welds, hence affecting resource efficiency.

The result showed signs of vast variations of gaps, both concerning the size of gaps and presence of an extra weld. The investigation indicates a large potential, possible to achieve without heavy investments.

Modelling of Electrode - Arc Coupling in Electric Arc Welding

Authors: Alireza Javidi Shirvan (University West), Isabelle Choquet (University West), Håkan Nilsson (Chalmers University of Technology)

Abstract: Modelling of the arc in electric arc welding is significant to achieve a better process understanding, thus gain better weld quality and a more efficient production process. It requires knowing the conditions at the surfaces of the anode and cathode. These conditions are very difficult to set from measurements and should be calculated. This requires modelling the complex physics of the electrode layer coupling electrode and arc. This paper presents a self-consistent electrode layer model that 1) is suited to welding applications, 2) accounts for the known physics taking place, and 3) satisfies the basic conservation requirements. The model is tested for different conditions. Its potentiality for welding applications is shown through calculations coupling plasma arc, electrode and cathode layer models. The calculations are done for both tungsten and thoriated tungsten electrode.

WEDNESDAY 10:30 – 12:10

B. Flexible manufacturing processes and systems III

Location: Brevsorterarsalen 2

Session Chair: Fredrik Schultheiss (Lund University)

Influence of the Workpiece Material Properties on the Cutting Forces

Authors: *Fredrik Schultheiss (Lund University), Volodymyr Bushlya (Lund University), Jinming Zhou (Lund University), Jan-Eric Ståhl (Lund University)*

Abstract: This study focuses on modelling the cutting resistance as a function of the workpiece material properties. Thus, for a workpiece material the cutting resistance may be predicted from the material properties without using any experiments. The cutting resistance may then be used to determine the cutting forces, data which in turn may be used to determine appropriate process parameters and select cutting tools for a new machining operation. The model obtained produces adequate results having a variation coefficient of approximately 5 to 16 % as compared to measured values.

Tool Life and Wear Modelling in Metal Cutting, Part 2 – Based on Combination between the Archard and the Colding Equations

Authors: *Jan-Eric Ståhl (Lund University), Daniel Johansson (Lund University), Fredrik Schultheiss (Lund University), Jinming Zhou (Lund University), Volodymyr Bushlya (Lund University)*

Abstract: In this article an analytical and empirical model for describing tool life and tool wear in metal cutting is presented. The model is based on combining the Colding tool life equation and an extended version of the Archard wear function. It is shown that through the combining of these two models a substantial saving of resources can be achieved in terms of the workpiece material required, as well as the manpower and machine time needed for determining the model constants and the optimum cutting data to be employed.

Machinability of Ductile Single-phase Materials Used in Accelerator Components – A Study with Focus on Surface Integrity

Authors: Mike Olsson (*Lund University*), Anders Andersson (*Lund University*), Fredrik Schultheiss (*Lund University*), Volodymyr Bushlya (*Lund University*), Jan-Eric Ståhl (*Lund University*)

Abstract: The focus of this article has been to analyse the machinability, with focus on surface integrity, of oxygen-free copper (OFC) and niobium during turning operations. The results from machining OFC proved that all of the tools that was tested can be used to achieve a surface roughness below $R_a = 0.8 \mu\text{m}$ with the correct cutting data. From the results when machining niobium it showed that only the cemented carbide tool with a nose radius of 1.2 mm was able to achieve a surface roughness of $R_a = 0.8 \mu\text{m}$ or greater. The cutting resistance based on the measured cutting forces was high for both of the materials.

Nanoindentation and Microstructure Analysis of High Chromium White Cast Iron for Machinability Study

Authors: Ling Chen (*Lund University*), Krystof Turba (*Lund University*), Jan-Eric Ståhl (*Lund University*), Srinivasan Iyengar (*Lund University*), Jinming Zhou (*Lund University*)

Abstract: The investigation carried out in this paper analyses the microstructure of the HCCI materials before and after the heat treatment using nanoindentation technique and scanning electron-microscopy in order to understand the effect of metallurgical factors such as morphology and volume fraction of carbides as well as mechanical properties on the further study of machinability of the materials. Present results show that changes in carbon and silicon contents as well as heat treatment strongly affect the mechanical properties and their variation in the material. The sample with higher C-Si contents has more eutectic carbides in a bainite matrix leading to a lower hardness in the as cast sample, while the sample with lower C-Si contents has higher hardness with austenite and martensite in the matrix. After annealing treatment, both sets of materials are softer than before, with the higher C-Si material being a little harder due to the presence of more eutectic carbides. Both low and high C-Si samples show similar hardness after the hardening treatment and the microstructure consists of secondary carbides and martensite surrounding the interconnecting eutectic carbides. In general, the larger volume fraction of the primary carbides associated with higher C-Si contents leads to a decrease in hardness.

C. Virtual production development and simulation III

Location: Brevsorterarsalen 3

Session Chair: Johan Vallhagen (GKN Aerospace Engine Systems)

Applicability of Value Stream Mapping to Software Development Context

Authors: *Hakan Akillioglu (KTH Royal Institute of Technology), Maria Dahlman (KTH Royal Institute of Technology), Ulrika Olsson (KTH Royal Institute of Technology)*

Abstract: The study investigates the applicability of Value Stream Mapping in a specific software development context through a case study. Practically this is done by a transformation of some fundamental lean concepts from production systems into their counterparts in the software development environment. The proposed transformation is experimented by means of a case study in an ICT company in Sweden. The value stream of two software components are studied by applying the lean tool Value Stream Mapping and the results indicate that the lean tool of Value Stream Mapping is applicable to the software development context with the aim of decreasing wastes and improving the efficiency of the value streams.

A Change Process: Transition from 2D to 3D by Model Based Definition

Authors: *Anna Malm (Linköping University), Henric Andersson (Saab Aeronautics)*

Abstract: The purpose of the study is to investigate factors that are important for the transition from 2D to 3D by Model Based Definition (MBD). Within MBD, 3D models are used as sources of information for design, production, distribution, technical documentation, services and the overall product lifecycle. The introduction and development of MBD at Aeronautics can be described in five transitions that illustrate how knowledge enhancement from project to project and between the projects and the linear organization has evolved. The largest challenges have been in the start-up of the transitions, people are gathered with different prerequisites, seeing solutions or problems from different perspectives.

Lessons Learned from 3D Laser Scanning of Production Systems

Authors: Erik Lindskog (*Chalmers University of Technology*), Jonatan Berglund (*Chalmers University of Technology*), Björn Johansson (*Chalmers University of Technology*), Johan Vallhagen (*GKN Aerospace Engine Systems*)

Abstract: 3D laser scanning is a technology that can be used for creating accurate and realistic virtual representations of production systems. The purpose with this paper is to present lessons learned from how to carrying out the 3D laser scanning. These lessons learned derive from a review of six industrial studies that applied 3D laser scanning to solve different production related problems. The review shows that good planning and preparation is key factors for high quality and accuracy of the resulting scan data.

Strategies for Value Stream Mapping and production planning – experiences from low volume production in the aerospace industry

Authors: Johan Vallhagen (*GKN Aerospace Engine Systems*), Torgny Almgren (*GKN Aerospace Engine Systems*)

Abstract: This paper addresses the dilemma of designing and operating production systems with high resource efficiency and at the same time high flow efficiency in an environment with low volume mixed model production and large variations in the supply chain. The consequences of performing Value Stream Mapping (VSM), and using Lean, in such a variable environment have been analysed in this paper. The analysis is based on about ten years of experiences from conducting VSMs and performing production planning in this particular environment. One of the key issues is how to create a system that is flexible enough to manage variations and changes.

WEDNESDAY 10:30 – 12:10

D. Human-centred production systems III

Location: Post 4

Session Chair: Cecilia Berlin (Chalmers University of Technology)

Mixed-Product Assembly Line: Characteristics and Design Challenges

Authors: *Natalia Svensson Harari (Mälardalen University / Volvo CE), Jessica Bruch (Mälardalen University), Mats Jackson (Volvo Construction Equipment)*

Abstract: Customized demands accompanied by assemble-to-order strategies require that the assembly system needs to handle uncertain market changes based on specific customer orders and adapt to new products or variants. This article will describe the characteristics of a mixed-product assembly line (MPAL) concept and its design challenges, based in an ongoing case study. The study shows that aspects of flexibility in assembly systems can be considered in an early conceptual design phase.

Creating Strategies for Global Assembly Instructions – Current State Analysis

Authors: *Åsa Fasth Berglund (Chalmers University of Technology), Magnus Åkerman (Chalmers University of Technology), Sandra Mattsson (Chalmers University of Technology), Pierre Johansson (Volvo GTO), Anna Malm (SAAB Aeronautics), Anna Perenstål Brenden (Scania)*

Abstract: This paper present result from three global companies regarding strategies for creating global instructions, the studies are from a current state perspective. The result is based from a survey with 65 respondents. The designers are responsible for instructions and are from two different areas; assembly and service market. Furthermore a workshop has been arranged were two of three companies participated.

Three main issues towards formulating a strategy will be discussed;

- (1) Information carrier; the results reveal that the most common information carrier for instructions are, Paper, Personal meetings and Desktops.
- (2) Who is responsible for quality assurance, most answers were production engineers.
- (3) Are there any standards concerning instruction at your company today? The respondents answered yes or under development in over 80 % of the cases on the question; if it exist any standards today.

Refining the Needs: an Exploratory Study Through Usability Testing

Authors: *Magnus Åkerman (Chalmers University of Technology), Malin Karlsson (Chalmers University of Technology), Lars-Ola Bligård (Chalmers University of Technology)*

Abstract: Factory competitiveness can be enhanced through the use of cognitive support tools at all levels, especially for shop floor operators. To get the most value from implementing a tool it has to fit the needs of tasks, environment and users. The aim of the study presented here was to examine how a usability test of a high fidelity prototype can add value to the need analysis phase. Results show that when using the prototype as a mediating object it can provide new insights to further refine the need analysis, especially when using an environment of high ecological validity.

How Changes in Cognitive Automation Can Affect Operator Performance and Productivity

Authors: *Dan Li (Chalmers University of Technology), Anna Landström (Chalmers University of Technology), Sandra Mattsson (Chalmers University of Technology), Malin Karlsson (Chalmers University of Technology)*

Abstract: To predict system performance, understanding what affects operator performance and productivity is important. This notion was tested in a LEGO experiment including 40 students. After introducing changes in cognitive automation e.g. assembly instructions and material façade, operator performance and productivity was increased. The aggregated results give an indication of how cognitive automation affects the operators' initial assembly performance. Industrial studies are needed to ensure observed trends and to further study the impact of cognitive automation characteristics. The trends however point toward that the perception of cognitive support has an impact on the final assembly.

E. Product and production services I

Location: Post 5

Session Chair: Torbjörn Ylipää (Chalmers University of Technology)

Working with Forces Promoting or Hindering Implementation of Strategies for Maintenance – Experiences from Swedish Industry

Authors: *Torbjörn Ylipää (Chalmers University of Technology), Ulf Sandberg (University of Skövde)*

Abstract: This paper is based on six Swedish companies' effort to define and use a maintenance strategy. Using an analysis tool to define the present situation, the companies can describe, analyze, and evaluate the road from a present situation to a new one. Factors hindering and promoting the implementation of their strategies have been identified. They slowed down work, and also hindered the implementation of targeted and prioritized areas in their strategies! Finally, the paper report about an in-depth analysis of one of the most wanted achievements in maintenance organizations – an increase of preventive work in relation to corrective measures.

Lean Principles and Engineering Tools in Maintenance Organizations – A Survey Study

Author: *Jon Bokrantz (Chalmers University of Technology)*

Abstract: This paper presents a questionnaire survey mapping how Lean principles and engineering tools are applied in a maintenance context in Swedish industry, based on a high-level strategic view from 76 respondents representing 71 companies. Results from the study cover different work practices according to Lean principles, to what extent risk assessment tools and software are used, to what degree companies are employing reliability engineers to conduct risk and reliability analysis, and how this relates to the safety of maintenance operations. The results indicate a gap between applying Lean in production and maintenance, and low use of valuable engineering tools.

Next Generation Condition Based Predictive Maintenance

Authors: *Bernard Schmidt (University of Skövde), Ulf Sandberg (University of Skövde), Lihui Wang (KTH Royal Institute of Technology)*

Abstract: Maintenance of assembly and manufacturing equipment is crucial to ensure productivity, product quality, on-time delivery, and a safe working environment. Predictive Maintenance is an approach that utilises the condition monitoring data to predict the future machine conditions and make decisions upon this prediction. The main aim of the presented research is to achieve an improvement in condition based Predictive Maintenance through the Cloud-based approach with usage of the largest information content possible. The objective of this paper is to outline the first steps of a framework to handle and process maintenance, production and factory related data from the first life-cycle phase to the operation and maintenance phase.

More Reliable Aircraft Engine Maintenance Optimization by a Classification Framework for On-Condition Parts

Authors: *Veronica Fornlöf (University of Skövde and GKN), Ulf Sandberg (University of Skövde), Anna Syberfeldt (Högskolan i Skövde), Torgny Almgren (GKN Aerospace Engine Systems)*

Abstract: An aircraft engine is a complex and advanced system with high demands on safety and reliability. Maintenance and how it is performed is therefore of outmost importance. Each maintenance occasion must be as effective as possible and execute the maintenance needed without performing excessive maintenance. A previous research project has developed an optimization model to calculate the optimal balance between the remaining lives in engine components and the cost related to each maintenance occasion. A potential to further improve the optimization using the model has been identified if the life-length of all the components used can be estimated. Hence, the aim of this paper is to describe a research challenge on how to develop a framework for estimation of the remaining life in aircraft engine components and by that group the components in different life-length classes.

WEDNESDAY 13:30 – 15:10

A. Resource efficient and sustainable production VI

Location: Brevsorterarsalen 1

Session Chair: Lars Pejryd (Örebro University)

Efficient Welding of High Strength Steel

Authors: Leif Karlsson (*University West*), Lars-Erik Svensson (*University West*), Kjell Hurtig (*University West*)

Abstract: Producing welds with properties matching those of the steel is a challenge at high strength levels. The present study investigated how cooling rates and dilution affects strength and toughness when welding steels with yield strengths of 777 MPa and 1193 MPa. Overmatching weld metal strength was achieved for the less strong steel and weld strengths >1000 MPa were recorded for the stronger steel. Fracture in transverse tensile testing was always located in base material or HAZ. Low dilution, rapid cooling and single pass welding contributed to higher strength. Impact toughness was higher for lower strength and low dilution.

Optimising Quality and Productivity in Welding of Duplex and Superduplex Stainless Steels

Authors: Maria Asuncion Valiente Bermejo (*University West*), Leif Karlsson (*University West*), Lars-Erik Svensson (*University West*), Kjell Hurtig (*University West*)

Abstract: The aim of this work was to study the influence of shielding gases and welding positions on properties of duplex and superduplex stainless steel circumferential pipe welds. Corrosion resistance, microstructural features and weld defects were assessed and related to the welding procedures. Horizontal and vertical upward welding positions produced high quality welds. However, welding in the overhead position resulted in less good results in terms of porosity and corrosion resistance. Shielding gases containing 30% helium showed best results, whilst using a mixture Ar+2%CO₂ resulted in undercuts and porosity in all welding positions.

Analysis of the Influence of the Composition of the Shielding Gas on Pressure Force and Heat Fluxes in Arc Welding

Author: *Isabelle Choquet (University West)*

Abstract: A main problem raised by arc welding manufacturing is the determination of the optimal process parameters to ensure weld quality as well as resource efficient and sustainable production. To address this problem a better process understanding is required. In this study thermal magneto hydrodynamic modeling of a welding arc is used to reach a deeper insight into the influence of the composition of the shielding gas on the pressure force and the heat fluxes to a workpiece. The model was implemented in the open source simulation software OpenFOAM. Four different shielding gas mixtures combining argon and carbon dioxide were studied. When increasing the fraction of carbon dioxide the results show a significant increase of the arc velocity and temperature with constriction of the temperature field, a decrease of the pressure force and a significant increase of the heat fluxes on the base metal.

A Modified Work Process for Manufacturing Strategy Formulation: A Case Study of a Small Industrial Company in Sweden

Authors: *Veronica Lindstrom (Linköping University), Sinan Habib (Linköping University), Simon Torstensson (Linköping University)*

Abstract: Manufacturing is a crucial part to organisational success in an industrial SME, and therefore manufacturing strategy formulation is of great importance for small businesses. Recent research suggests that there is a need to adapt frameworks and procedures for manufacturing strategy formulation to small- and medium sized companies. This study describes a modified work process, which was also tested for formulation of manufacturing strategy formulation in a small industrial company in Sweden.

WEDNESDAY 13:30 – 15:10

B. Flexible manufacturing processes and systems IV

Location: Brevsorterarsalen 2

Session Chair: Gunnar Bolmsjö (University West)

The Third Wave of Automation: Critical Factors for Industrial Digitisation

Authors: Örjan Larsson (*Blue Institute*), Magnus Wiktorsson (*Mälardalen University*), Stefan Cedergren (*SICS Swedish ICT*)

Abstract: The scope of industrial automation is shifting into a third wave of automation based on extreme information availability, cyber-physical systems and data analytics. This paper present critical factors and way forward for the development of the Swedish industrial automation sector, both users and suppliers. Based on literature and practice studies, and a survey including some 40 respondents, ten factors for realising the third wave of automation was identified with four key factors: Technology, Processes, Business models and Competence. Finally, initial steps on a way forward are proposed for the development of Swedish automation industry and research.

Automating a Car Production Line Adjustments by Using Case-Based Reasoning

Authors: Ivan Tomasic (*Mälardalen University*), Alf Andersson (*Volvo Car Corporation*), Peter Funk (*Mälardalen University*)

Abstract: As a test bed for the Case-Based Reasoning (CBR) approach for automating processes adjustments, the Volvo Car manufacturing process for parts known as crossmembers is chosen. To test the CBR based system, a subset of solved cases is selected and fed as simulated new cases, to develop prototype CBR system. The results show that the CBR is a valuable and promising methodology that can be used for improving this, and other similar industrial processes.

Introducing the Hoshin Kanri Approach in Small and Medium Sized Companies

Authors: *Malin Löfving (Jönköping University), Anders Melander (Jönköping University), David Andersson (Träcentrum), Fredrik Elgh (Jönköping University), Mikael Thulin (Jönköping University)*

Abstract: In order to grow, small and medium-sized enterprises (SMEs) have to balance the inherent flexibility of the small firm with formal work division and administrative routines. This balancing is apparent in SME's approach to strategy work. In order to address this need of balancing in strategy work we in this paper introduce the Hoshin Kanri approach to the SME context. Based on an extensive literature review we identify the principles of Hoshin Kanri and develop an adapted approach to small and medium sized companies. Finally we report on the lessons learnt after initiating the adapted approach in four SMEs.

Flexible Automation as a Competitive Business for Manufacturing SMEs

Authors: *Kerstin Johansen (Linköping University), Anna Öhrwall Rönnbäck (Linköping University)*

Abstract: This paper describes and analyzes the establishment of an automation SME cluster. The cluster aims to strengthen the participating companies' as well as the region's competitiveness by offering flexible automated production solutions. It was observed that the combined know-how in the cluster could match the future needs of customers, and that leverage could be obtained if the cluster proceeds in its ambitions to use the collected production technology competence. However, the major challenge will be to find collaboratively developed automated solutions between customers and suppliers that are favorable both for individual companies and the longterm development of the cluster.

C. Virtual production development and simulation IV

Location: Brevsorterarsalen 3

Session Chair: Alf Andersson (Volvo Car Corporation)

A Business Case Tool as Decision Support in Early Production Location Project Stages

Authors: *Christina Windmark (Lund University), Carin Andersson (Lund University)*

Abstract: Globalisation makes companies enter the global market both in sale and production. Previous studies have shown that one of the main reasons for relocation and outsourcing is cost saving. There are also studies showing that companies today may benefit from a decision support model based on costs. This paper provides a business case tool to be used in the scoping phase where different location alternatives are to be roughly analysed for further investigation. The tool is to be used together with strategic analyses and more extensive risk analyses to make a solid information platform for decisions.

Information Requirements and Management for Service Based Business Models

Authors: *Zihan Xu (KTH Royal Institute of Technology), Farazee Asif (KTH Royal Institute of Technology), Mattias Löfstrand (Signifikant Svenska AB), Amir Rashid (KTH Royal Institute of Technology), Sergii Tymoshenko (Lviv Polytechnic National University)*

Abstract: Anticipated scarcity of natural resources and concern for the sustainable development forcing manufacturing industries to emphasise on conservation of resources on one hand. On the other hand high competition in the manufacturing industry is forcing companies to look for innovative value propositions. Service based business models are emerging business solutions that fulfil the functional needs of customers. Such business approach demands extensive and sophisticated information collection, sharing and management systems. However, there are evidences of knowledge gap when it comes to defining information requirements, information management and sharing systems needed to adopt such business models. The objective of this paper is to provide an overview of research done in the area of service based business models in terms of information management and communication systems. The paper also includes result of two case studies done in two different manufacturing companies with the purposes to understand information requirements to adopt service based business models.

Collaborative Product, Process and Service Development with Eco Process Engineering System

Authors: *Juhani Heilala (VTT Technical Research Centre of Finland), Reino Ruusu (VTT Technical Research Centre of Finland), Jari Montonen (VTT Technical Research Centre of Finland), Saija Vatanen (VTT Technical Research Centre of Finland), Pablo Bermell-Garcia (EADS), Santiago Quintana Amate (EADS), Conroy Iwhiwhu (EADS), Carlos Kavka (ESTECO SpA), Fabio Asnicar (Esteco), Sebastian Scholze (ATB), Alberto Armijo (Tecnalia), Mario Insunza (Sistepiant)*

Abstract: The focus of engineering on achieving a superior product, processes and services from functional and economic factors is now shifting towards sustainable development. The aim is to provide customer business value and decrease environmental impacts. New easy to use tools are needed in the collaborative development of complex product-services. The EPES project carries out development to improve the sustainability performance of end-users products, operations and services. The Eco-Process Engineering System (EPES) provides a methodology and related ICT tools as a service for the development and management of product-services. This paper is an introduction to EPES system.

Usage of Strategies and ICT Tools in Automotive Industries during Recovery Tasks – A Literature Review

Authors: *Floriane Saène (Chalmers University of Technology), Malin Karlsson (Chalmers University of Technology), Björn Johansson (Chalmers University of Technology)*

Abstract: Products end of life is increasingly important and there are stronger demands on manufacturers to provide viable options at the end of the product life cycle. In the automotive industry stronger legislations combined with other factors contributes to this importance. Thus, the decisions for recovery are also gaining importance. Strategies and ICT tools could assist decision making in the recovery process. This paper summarises a literature review regarding the existence and usage of strategies and ICT tools, mainly in the automotive industry.

WEDNESDAY 13:30 – 15:10

G. Education in manufacturing, on all levels I

Location: Post 4

Session Chair: Mats Winroth (Chalmers University of Technology)

Digital Learning Factories: Conceptualisation, Review and Discussion

Authors: Azadeh Haghighi (*KTH Royal Institute of Technology*), Navid Shariat Zadeh (*KTH Royal Institute of Technology*), Gunilla Sivard (*KTH Royal Institute of Technology*), Thomas Lundholm (*KTH Royal Institute of Technology*), Yvonne Eriksson (*Mälardalen University*)

Abstract: Learning factory is a modern approach toward educating future production engineers with emphasis on product realization. To date, many publications have presented methodologies and implementations of virtual environments for training production engineering students. However, the advantages/applications of the virtual environments have not been clearly highlighted specifically for learning factories and their study scenarios. This work discusses and further develops the concept of digital learning factory where virtual environments are applied as complementary tools beside the physical teaching approach to boost the learning experience and discusses the benefits. Furthermore, a case study has been considered to further elaborate the concept.

Knowledge Transfer and Delivery Forms for Continuous Education in Small and Medium Sized Enterprises

Authors: Ove Bayard (*KTH Royal Institute of Technology*), Magnus Areskoug (*KTH Royal Institute of Technology*), Bente Nørgaard (*Aalborg University*), Páll Jensson (*Reykjavik University*), Niels Hannemose (*VIA University College*), Kamilla Reynisdóttir (*Reykjavik University*)

Abstract: This paper brings the preliminary results of interviews with Scandinavian managers and engineers asking questions regarding their previous experiences and knowledge on diverse continuous education methods and further encourages them to gaze into the crystal ball to identify requests and expectations to future methods of continuous education. The interviews have been done within a project titled: Processer til håndtering af skræddersyede efteruddannelsesforløb (PHASE), financed by the Nordplus Programme. The partners are: Aalborg Universitet from Denmark, Reykjavik University from Iceland and KTH Royal Institute of Technology from Sweden.

Using Videos to Record Lessons Learned from Production and Aftermarket Phases: Preliminary Results

Author: *Koteshwar Chirumalla (Mälardalen University)*

Abstract: Learning from experience has turn out to be the basis of every manufacturing company in creating and sustaining competitive differentiation. Many companies put effort in capitalizing these experiences through continuous improvement initiatives such as lessons learned practices. However, these practices are failed to address the distinct, complex settings available in manufacturing, serial production, use, and maintenance phases, where much of the learning is still tacit nature and difficult to articulate. In this context, based on three case studies in the aerospace industry, the author previously proposed a lesson learned methodology using videos as an enabling media. This paper presents some preliminary results based on the validation activities performed in the aero-engine component manufacturing company.

WEDNESDAY 13:30 – 15:10

F. Integrated product and production development I

Location: Post 5

Session Chair: Kristina Säfsten (Jönköping University)

User-Supplier Integration Throughout the Different Lifecycle Stages of the Production Equipment

Authors: *Jessica Bruch (Mälardalen University), carin Rösiö (Mälardalen University), Monica Bellgran (Mälardalen University), Anna Granlund (Mälardalen University)*

Abstract: As production equipment is often designed and built by equipment suppliers rather than made in-house, a collaborative buyer-supplier-relationship could be utilized in order to create robust solutions and enhance innovative ideas. The purpose with this paper is to explore critical user-supplier collaboration activities throughout the different lifecycle stages of the production equipment development. The purpose is accomplished by a literature review and a case study including more than 30 semi-structured interviews at four companies. The challenges vary depending on equipment life cycle phase and user/supplier perspective. A life cycle model with eight stages is proposed including critical interconnected activities for each stage.

Usability of a Manufacturing Strategy Framework Developed for SMEs

Authors: *Kristina Säfsten (Jönköping University), Mats Winroth (Chalmers University of Technology), Malin Löfving (Jönköping University)*

Abstract: Still, 45 years after Skinner's (1969) call for manufacturing strategies, explicit manufacturing strategies are scarce in manufacturing industry, especially in SMEs. Together with a number of SMEs, we have developed a manufacturing strategy tool, aimed at supporting manufacturing strategy formulation. In this paper, the focus is on requirements on a manufacturing strategy tool related to the usability in SMEs. Results from evaluation of the tool during development is presented. The resulting tool was considered to be useful to the participating companies, helping them to get over the initial threshold of working with manufacturing strategies.

Increasing Patient Accessibility to a Surgery Department Through Operations Management Principles

Authors: *Torbjörn Jacobsson (Chalmers University of Technology), Carina Iversen (Chalmers University of Technology), Linnéa Johansson (Chalmers University of Technology), Louise Sandén (Chalmers University of Technology), Taraneh Vosough (Chalmers University of Technology), Viktor Widerberg (Chalmers University of Technology)*

Abstract: This paper investigates how the application of operations management principles can be used to increase patients' access to an inpatient care facility that supplies acute and non-acute care, in a Swedish University Hospital. This paper also identifies problems and solutions related to patient flow, as well as facilitators and barriers to implementation process. The study shows that patient accessibility can be increased by using operations management principles such as separated flows. The implementation was facilitated by short term gains, management support, and visible leadership. The barriers to implementation were identified as lack of operations management knowledge, deficiencies in improvement work and regulations.

Competitiveness of Finnish Manufacturing Networks: Challenges and Recommendations

Author: *Mikko Koho (VTT Technical Research Centre of Finland)*

Abstract: This paper reports the initial results and suggestions of a research project focusing on the competitiveness and efficiency of Finland's manufacturing industry and networks. Radical changes in structure and operation of supply chains and manufacturing networks pose grand challenges to both OEMs and subcontractors. Based on literature reviews, interviews, surveys and expert workshops, this paper reports and outlines solutions for the key challenges that were identified in relation to competitiveness, efficiency and manufacturability in Finnish manufacturing networks and supply chains.

WEDNESDAY 15:30 – 17:10

A. Resource efficient and sustainable production VII

Location: Brevsorterarsalen 1

Session Chair: Lars Nyborg (Chalmers University of Technology)

Self-Generated Vibrations and Process Instability When Turning High Chromium White Cast Iron with PCBN Tools

Authors: Oleksandr Gutnichenko (*Lund University*), Jinming Zhou (*Lund University*), Ling Chen (*Lund University*), Volodymyr Bushlya (*Lund University*), Jan-Eric Ståhl (*Lund University*)

Abstract: The dynamic instability and related problems when turning high chromium cast iron (HCCI) with two polycrystalline cubic boron nitride (PCBN) tools in wide range of cutting speeds and feed rates were studied in the article. The tool wear mechanisms and specifics for both tools as a main criterion of appearance of process instability were investigated. In spite of the chatter-like surface of machined workpieces it was shown the dynamic stability of process by two method ‘0-1 test’ and determination of maximum Lyapunov exponent. Taking into account the strong periodicity of process with several clear harmonics it was concluded that such process is related to self-resonant phenomena.

Tool Life and Wear Model in Metal Cutting, Part 1 – Influence of Varying Flank Wear Criterion on Colding’s Tool Life Equation

Authors: Daniel Johansson (*Lund University*), Fredrik Schultheiss (*Lund University*), Volodymyr Bushlya (*Lund University*), Jinming Zhou (*Lund University*), Jan-Eric Ståhl (*Lund University*)

Abstract: The tool life model formulated by Bertil Colding is limited to the use of a specified tool life criterion. The Colding equation describes the relationship between tool life, cutting speed and the equivalent chip thickness. The Colding equation is based on five constants which have unique values for each selected value of the tool life criterion. This paper investigates how these Colding constants can vary for different selected wear criteria.

Influence of the Delivery State on Machinability of Austenitic Stainless Steels when Using CVD and PVD Coated Tools

Authors: *Stefan Cedergren (Chalmers University of Technology), Lars Nyborg (Chalmers University of Technology), Göran Sjöberg (Chalmers University of Technology)*

Abstract: Designers of austenitic stainless steel parts do not always specify in detail in what state the work material should be delivered, e.g. annealed or annealed with subsequent cold forming. When a final cold forming step is added there will be an increase in hardness and strength while ductility at the same time is reduced. The mechanical properties of austenitic steels can thus vary significantly and cause unpleasant surprises in the machining processes if the delivery state is not clearly specified. The aim of his study is to investigate delivery state effects on two selected machinability criteria; cutting forces and chip breakability. Two different insert grades with the same chip breaker geometry are used, one with a thin physical vapor deposition (PVD) coating and the other one with a thicker chemical vapor deposition (CVD) coating. Both the annealed and the cold drawn delivery states are investigated, and it is shown that cold drawn material gives lower cutting forces for both tool types as well as better chip breakability when combined with the PVD coated tool.

WEDNESDAY 15:30 – 17:10

B. Flexible manufacturing processes and systems V

Location: Brevsorterarsalen 2

Session Chair: Bo Svensson (University West)

Improving Performance in Flexible Manufacturing by a P-SOP Approach

Authors: *Bo Svensson (University West), Fredrik Danielsson (University West)*

Abstract: This paper presents a Part oriented Sequence of Operation (P-SOP) approach that addresses flexibility, robustness and deployment in manufacturing cells up to plant level. A P-SOP description language has been formulated where the control strategy based on actual circumstances easily can be defined. Furthermore, a P-SOP multi-agent generator has been created that compiles the strategy description to multi-agents that control the manufacturing. Deadlock free IEC 61131-3 PLC code is directly generated from the description language. The code is not optimised for a specific scenario since the general description contains all possible routing paths and all resources available.

Business Support Agencies Introducing Lean Production in SMEs – Does it Make Any Difference?

Authors: *Anna-Lena Allert (Högskolan i Skövde), Kristina Säfsten (Jönköping University)*

Abstract: Many SMEs are implementing lean production in collaboration with a business support agency in order to improve their competitiveness. This research investigated whether improvement initiatives had the intended effect in some companies. A questionnaire was answered by employees in 26 SMEs. The result indicated experienced effect concerning leadership, communication and employee commitment, areas considered important for success in improvement initiatives, and also progress in areas that characterise development towards lean. The result also indicated differences in experienced effect between managerial and non-managerial functions and between companies.

Engineering Change Management in Engineering-to-Order Projects from a Manufacturing Perspective

Authors: *Peter Sjögren (Mälardalen University)*

Abstract: The purpose of this research was to investigate the engineering change management process in engineering-to-order projects while comparing the same process in traditional manufacturing. A single-case study at a engineering-to-order – engineering review office was performed and results were analysed in conjunction with literature covering the engineering change process in traditional manufacturing. Engineering-to-order projects and traditional manufacturing are different in many ways but share the need for a reliable engineering change process. This study found that engineering change management post-change analysis could benefit future projects in the form of quantifiable lessons learned from previous project's engineering change data.

Identification of Relationships between Operator Utilization and Real Process Capacity in Automated Manufacturing

Authors: *Richard Hedman (Chalmers University of Technology), Robin Sundkvist (Chalmers University of Technology), Peter Almström (Chalmers University of Technology)*

Abstract: In automated manufacturing there is continuous interaction between humans and machines. The utilization of those resources affects the capacity of manufacturing processes and consequently the performance of manufacturing systems. This paper presents an approach that incorporates productivity analysis tools and techniques to explain how manufacturing resource utilization relates to capacity and how the capacity can be improved. The findings are relevant for both academics and practitioners that are interested in understanding the effects of shop floor productivity improvements on capacity.

C. Virtual production development and simulation V

Location: Brevsorterarsalen 3

Session Chair: Björn Johansson (Chalmers University of Technology)

A Virtual Verification Approach Towards Evaluating a Multi-Product Assembly Systems

Authors: Erik Flores Garcia (*Mälardalen University*), Mats Jackson (*Volvo Construction Equipment*), Magnus Wiktorsson (*Mälardalen University*)

Abstract: Growing operational complexity and higher variety of products require flexibility in assembly. Despite its many benefits flexibility is a complex concept that requires evaluation to harness its full potential. This study uses virtual verification tools as enablers of the decision making process for production system design of a flexible multi-product assembly system. A case study approach analyses a flexible assembly concept for the earth moving equipment industry through a visual and a discrete event simulation model. The paper also discusses the challenges faced by virtual verification tools when applied to the evaluation of flexible assembly systems.

Function Block Design for Adaptive Machining of Thin-Walled Parts

Authors: Wei Wang (*KTH Royal Institute of Technology*), Lihui Wang (*KTH Royal Institute of Technology*), Yingguang Li (*Nanjing University of Aeronautics and Astronautics*)

Abstract: The thin-walled structures are widely existed in complex machined parts, such as aircraft structural parts. The thicknesses of the thin-walled structures are hard to achieve because their machining is subject to deformation. Therefore, the machining features of complex parts are usually manufactured by several machining operations. In order to adjust the tool path according to the feedback of in-process inspection, a function block-based approach is proposed for real-time operation planning. After process planning, the sequenced ideal machining status of a dynamic feature is embedded in a function block. The deviation between the actual intermediate status and the ideal intermediate status of the dynamic features are computed as the event to trigger the function blocks to adjust the unexecuted operations. How the function blocks are designed and how they can achieve the operation adjustments are described in this paper.

Process Planning Methodology Guide for Interactive Learning

Authors: *Magnus Lundgren (KTH Royal Institute of Technology), Mikael Hedlind (Scania CV AB), Torsten Kjellberg (KTH Royal Institute of Technology)*

Abstract: Process planning is a central, knowledge extensive and important activity in a manufacturing company. During process planning, countless decisions are made, many times based upon the process planner's tacit knowledge, based on years of experience. The knowledge gap between the expert and the novice is wide. Narrowing this gap, taking the novice towards becoming expert, is an objective of education. This paper presents a solution for model-based interactive learning of process planning, validated through application in master level production engineering courses.

Geometric Distortion Analysis Using CAD/CAM Based Manufacturing Simulation

Authors: *Mats Werke (Swerea IVF), Mikael Hedlind (Scania CV AB), Mihai Nicolescu (KTH Royal Institute of Technology)*

Abstract: Machining of components may cause geometric distortions and thereby quality issues and increased costs. This paper presents an engineering approach of CAD/CAM based manufacturing simulation in order to be in control of geometric distortions after machining. The method utilises STEP AP209 for communication of CAD/CAM simulation data. The method improves the ability to optimise process parameters, geometry, and material, in order to fulfil the design requirements. The method supports concurrent design and process planning using 3D models in CAD/CAM and FEM.

WEDNESDAY 15:30 – 17:10

C. Virtual production development and simulation VI

Location: Post 4

Session Chair: Mats Björkman (Linköping University)

Vision-Assisted Remote Robotic Assembly Guided by Sensor-driven 3D Models

Authors: *Abdullah Mohammed (KTH Royal Institute of Technology), Lihui Wang (KTH Royal Institute of Technology), Mauro Onori (KTH Royal Institute of Technology)*

Abstract: This paper proposes an approach to developing a cyber-physical model-driven system that performs robotic distant assembly operations in decentralised manufacturing environment. The system uses an industrial robot to assemble components unknown in advance. The system captures and analyses the components' silhouettes, and constructs the corresponding 3D models. By the help of the models, the system is able to guide a distant human operator to assemble the real components in the actual robot cell. The results show that the developed system can construct the 3D models and assemble them within a suitable total time, imitating the human behaviour in a similar situation.

A Theoretical Foundation for Resource Efficiency and Effectiveness in Production Systems

Authors: *Michael Lieder (KTH Royal Institute of Technology)*

Abstract: As a consequence of recently increased activities in the area of improved resource use a multiplicity of terminology and its interpretation has evolved. Phrases as resource efficiency or resource effectiveness have become quite popular. However their interpretations vary depending on the scope and perspective taken. In order to clarify the meaning and to found a theoretical basis for researchers and practitioners this review discusses various expressions found in literature focusing on improved resource use in industrial production. The description of relevant terminology provides researchers with a notion of how the perception of improved resource use in industrial production has evolved. The description finally results in a conceptual model for production system evaluation.

Benefits of Collaborative Robots in Assembly - An Evaluation Scheme

Authors: *Sten Grahn (Swerea IVF), Björn Langbeck (Swerea IVF)*

Abstract: Programming, safety measures and handling of inflexibility still hinder robot implementation for many applications. However, advancements in several fields such as programming, human-machine-interfaces and safety system technology are about to change this. These advancements could make it possible for operators to collaborate with robots that assist operators at close range, without compromising safety, often referred to as cobot installations. The aim of the project was to produce a picture of how potential economic advantages can be evaluated from installations of cobot cells, to be compared with manual assembly and standard robot installations.

What Does Multi-Objective Optimization Have to Do with Bottleneck Improvement of Production Systems?

Authors: *Amos H.C. Ng (University of Skövde), Jacob Bernedixen (University of Skövde), Leif Pehrsson (Volvo Car Corporation)*

Abstract: Bottleneck is a common term used to describe the process/operation/person that constrains the performance of the whole system. Since Goldratt introduced his theory of constraint, not many will argue about the importance of identifying and then improving the bottleneck, in order to improve the performance of the entire system. Nevertheless, there exist various definitions of bottleneck, which make bottleneck identification and improvement not a straightforward task in practice. The theory introduced by Production Systems Engineering (PSE) that the bottleneck of a production line is where the infinitesimal improvement can lead to the largest improvement of the average throughput, has provided an inspirational and rigorous way to understand the nature of bottleneck. This is because it conceptually puts bottleneck identification and improvement into a single task. Nevertheless, it is said that a procedure to evaluate how the efficiency increase of each machine would affect the total performance of a line is hardly possible in most practical situations. But is this true? In this paper, we argue how multi-objective optimization fits nicely into the theory introduced by PSE and hence how it can be developed into a practical bottleneck improvement methodology. Numerical results from a real-world application study on a highly complex machining line are provided to justify the practical applicability of this new methodology.

F. Integrated product and production development II

Location: Post 5

Session Chair: Magnus Wiktorsson (Mälardalen University)

Distortion Analysis in Laser Welding of Ultra High Strength Steel

Authors: *Karl Fahlström (Swerea KIMAB), Oscar Andersson (KTH Royal Institute of Technology), Urban Todal (Volvo Car Corporation), Arne Melander (Swerea KIMAB), Lars-Erik Svensson (University West), Leif Karlsson (University West)*

Abstract: Due to increased demands on reduced weight in automotive industries, the use of ultra high strength steels (UHSS) has increased. When laser welding UHSS sheets, heating and cooling of the material will cause geometrical distortions and may cause low joint quality. 700 mm long U-beam structures of 1 mm thick boron steel simulating structural pillars in body-in-white constructions have been laser welded along the flanges with different welding speeds to investigate distortions and weld quality. The results show that final distortions appear in the range of 0-8 mm. FE simulation methods have also been presented which generally predict the distribution of welding distortions.

Key Changes in the Welding of Fatigue Loaded Structures

Author: *Erik Åstrand (Volvo Construction Equipment)*

Abstract: This paper discusses welding problems of today and the possibilities for tomorrow for companies in the welding industry. By leaving old welding procedures based on traditions and applying new scientifically developed welding demands and procedures there is a vast potential to improve strength performance of the structures and increased competitiveness regarding weld work for the companies. Unfortunately, no changes are done easily and quickly and this paper gives proposals how changes can be done efficiently.

Supporting Tooling Design of Customized Products by Instant Access to Design Rationale

Authors: *Morteza Poorkiany (Jönköping University), Joel Johansson (Jönköping University), Fredrik Elgh (Jönköping University)*

Abstract: In an integrated product and production development environment, where changes in tooling design affect the product design and vice versa, access to design rationale of tooling would support concurrent development of new product variants and required tooling. This paper presents an information model that enables easy capture and access to the design rationale of toolings, moreover, supports tracing relevant information within different design software applications. A solution based on integrating SolidWorks, Microsoft Excel, and Microsoft Word has been developed and an industrial case study, where the system is introduced and evaluated is presented.

Effect of Austenitising Temperature and Cooling Rate on Microstructure in a Hot-Work Tool Steel

Authors: *Maria Teresa Coll Ferrari (Uddeholms AB), Amanda Forsberg (Uddeholms AB), Jörgen Andersson (The Swedish School of Mining and Metallurgy), Pavol Mikula (Nuclear Physics Institute ASCR), Premysl Beran (Nuclear Physics Institute ASCR)*

Abstract: The effects on microstructure of austenitising temperature and cooling rate during hardening were studied for a hot-work tool steel. Transformation temperatures were determined by dilatometry, scanning electron microscopy was used to characterise the microstructure and both retained austenite contents and their lattice parameters were measured by neutron diffraction. For lower cooling rates, lower austenitising temperatures produce larger amounts of both retained austenite and bainite. Retained austenite in bainitic structures is higher in carbon than in martensitic structures. Consequently, lowering the austenitising temperature will affect microstructure and properties.

THURSDAY 08:50 – 10:30

A. Resource efficient and sustainable production VIII

Location: Brevsorterarsalen 1

Session Chair: Carin Andersson (Lund University)

Cost Analysis for Crushing and Screening: Development of a Methodology for Determination of Production Cost for Product Fractions

Authors: Erik Rading Heyman (Lund University), Alexander Lindström (Lund University), Per Hedvall (Sandvik SRP AB), Fredrik Schultheiss (Lund University), Jan-Eric Ståhl (Lund University)

Abstract: The comminution processes are complex and there has thus far been no, previously published, efficient way to calculate the cost per product and metric ton. The proposed model has been adapted to fit the currently investigated process of crushing and screening (C&S). Deriving from the original model, the proposed new model is presenting the result in cost per metric ton of raw material. It has been indicated to be a useful approach for calculation of the production cost and deciding the profitability of a product on a more detailed scale, in the comminution industry.

An Evaluation of Economical and Energetic Savings Depending on the Arrangement of Quality Control Steps Within the Production

Authors: Sebastian Schoetz (Bayreuth University), Steffen Butzer (Fraunhofer Project Group Process Innovation), Rolf Steinhilper (Bayreuth University)

Abstract: In order to avoid that faulty units reach following production stages, and cause further costs and energy consumption, quality control steps need to be realised. Within the production, many different arrangements of quality control steps are possible. This paper describes an evaluation of costs and energy consumption depending on the arrangement of quality control steps based on a sample process sequence. The results of the evaluation show the different possible economical and energetic savings. Moreover the paper shows how far the cost optimal arrangements differ from the energy optimal arrangements.

Grinding or Shaving – Economic Decision Support in The Production Of Gears

Authors: *Carin Andersson (Lund University), Jan-Eric Ståhl (Lund University)*

Abstract: This paper describes a case study at an automotive company with the purpose of developing an economically based decision support tool, for strategic decision about whether to chose grinding or shaving as a finishing method in gear manufacturing. In the study different cost models are compared regarding input parameters in alignment with the required input data required to make a decision. With the performance driven cost model used during the analysis, shaving was shown to be the most cost efficient finishing method.

Differentiated Manufacturing Cost Allocation Approaches with Respect to Production Process Types

Authors: *Andreas Myrelid (GKN Aerospace), Jan Olhager (Lund University)*

Abstract: We investigate the problem of fitting appropriate cost allocation methods to different production process types. We analyse and compare the combinations of three product costing methods versus three process types using quantitative modelling. Real data from an advanced manufacturing technology firm are used to illustrate the effects of using different types of cost allocation schemes for different processes. We propose a hybrid approach that selects the right product costing approach for each production process type. Such a hybrid approach is particularly useful in plants with different types of production processes.

THURSDAY 08:50 – 10:30

B. Flexible manufacturing processes and systems VI

Location: Brevsorterarsalen 2

Session Chair: Jinming Zhou (Lund University)

High Performance Machining of High Chromium Wear Resistance Materials with pcBN and bcBN Tools

Authors: *Ling Chen (Lund University), Jinming Zhou (Lund University), Volodymyr Bushlya (Lund University), Oleksandr Gutnichenko (Lund University), Jan-Eric Ståhl (Lund University)*

Abstract: The presented paper is to experimentally evaluate the performance of the cBN tools in the machining of high chromium white cast iron. The performance in terms of the level of cutting forces, tool wear, surface roughness and process stability were evaluated during and after the cutting test. Two types of cBN tool material are evaluated in the tests, which include polycrystalline boron nitride (pcBN) and binder-less crystalline boron nitride (bcBN). The work materials used in the cutting tests have two groups of chemical composition with different levels of carbon silicon (C-Si) content in as-cast, annealed and hardened state respectively. Test results indicated that cutting tool materials, levels of C-Si contents and heat-treatment of the work materials have significant influence on the cutting performance. The study also reveals the mechanism of interaction between cBN tool and high chromium white cast iron under the range of machining parameters. Cutting tool materials exhibit clear differences in the wear rate and wear mechanisms during the machining test.

X-Ray Computed Tomography as a Tool in Joining Process Development

Authors: *Lars Pejryd (Örebro University), Rebecka Eriksson (Bofors Testcenter)*

Abstract: 3-D information on defects in joints are of great importance. Computed tomography is a method that holds the promise of generating this information. This work shows several examples of application of CT on joining or joining related processes. The detection of foreign material, cracks and porosity is shown as well as the ability to investigate much larger volumes than what is feasible with traditional cut-ups. Some limitations are also discussed.

Machinability of Lead-Free Brass – A comparative study

Authors: *Fredrik Schultheiss (Lund University), Erik Lundström (Lund University), Daniel Johansson (Lund University), Volodymyr Bushlya (Lund University), Jinming Zhou (Lund University), Kent Nilsson (AB Markaryds Metallarmatur), Jan-Eric Ståhl (Lund University)*

Abstract: Conventional brass is still allowed to contain up to 3.5 wt.% lead even though lead is a hazardous metal. However, due to environmental concerns lead-free brasses are becoming increasingly available. The aim of this paper is to evaluate the machinability of a lead-free brass alloy, CuZn21Si3P, as compared to a conventionally used, lead-alloyed alternative, CuZn39Pb3. The attained results show that CuZn21Si3P has a considerably higher strength than the lead-alloyed material resulting in significantly higher cutting forces. This increase in cutting forces was found to result in more rapid deterioration of the cutting tool, raising concerns for higher manufacturing cost if not properly addressed.

Identification of Theoretical Shear Strength and Onset of Yielding in Cubic Boron Nitrides via Nanoindentation

Authors: *Sergey Dub (Institute for Superhard Materials), Igor Petrusha (Institute for Superhard Materials), Volodymyr Bushlya (Lund University), Galina Tolmachova (Kharkov Institute of Physics and Technology), Aleksey Andreev (Institute for Superhard Materials)*

Abstract: The onset of plasticity in cubic boron nitride (cBN) was studied by nanoindentation with continuous stiffness measurement (CSM) option. CSM option allows us to observe elastic-plastic transition in the contact and to measure the yield strength of cBN at nanoscale. In single crystals with low dislocations density sharp elastic-plastic transition (pop-in) was observed in result of homogeneous dislocations nucleation at shear stress close to theoretical shear strength ($G/2\pi$). For near nanocrystalline cBN sample the smooth elastic-plastic transition was observed in results of propagation of already existed dislocations in the region of contact.

THURSDAY 08:50 – 10:30

C. Virtual production development and simulation VII

Location: Brevsorterarsalen 3

Session Chair: Anders Skoogh (Chalmers University of Technology)

Production Cost Case Generation by a Recursive Monte-Carlo Method in Electrical Machine Production

Authors: Pontus Fyhr (Lund University), Jan-Eric Ståhl (Lund University), Mats Andersson (Lund University)

Abstract: Electrical machine production is a multi-disciplinary area, comprising traditional mechanical processes such as sheet metal cutting, chemical processes for insulation and electrical for the working principles. In manufacturing, high throughput automation of coilwinding and sheet-cutting is combined with complex assembly, such as slotting the coils, often performed manually, but with increasing interest in automation. Followed by inherently slow processes such as the curing of resins for insulation, this poses a very difficult challenge for production system designers. Selecting the most efficient combination of low and high cycle time processes, appropriate levels of automation and sufficient buffer levels, while minimizing investments and work in progress costs.

Quantifying the Effects of Production Maintenance Decisions Using Discrete Event Simulation

Authors: Maheshwaran Gopalakrishnan (Chalmers University of Technology), Camilla Lundgren (Chalmers University of Technology), Nadine Karlsson (Chalmers University of Technology), Anders Skoogh (Chalmers University of Technology)

Abstract: Use of simulation to analyze and plan maintenance activities is still limited compared to planning production activities. The paper discusses a simulation based approach to quantify the effects of maintenance decision making by identifying the related performance indicators. The aim of the paper is to quantify the production maintenance related decisions, in terms of Key Performance Indicators (KPIs) determined through interviews and simulation. The approach is exemplified in a manufacturing case-study. The results show that use of simulation tool has the potential to be a strategic decision support tool for production maintenance in the production system.

Towards Applying the Boothroyd, Dewhurst and Knight Methodology for Cost Estimation on Carbon Fiber Composite Manufacturing – A Theoretical Approach

Authors: *Fredrik Henriksson (Linköping University), Kerstin Johansen (Linköping University)*

Abstract: Increased usage of carbon fibre composite poses challenges for the automotive industry; one is to manage carbon fibre composites within the product development process. This paper combines knowledge in design engineering, material science and production technology, aiming to bridge these domains. The study indicates that mass production methods suitable for carbon fibre have several factors in common with traditional polymer production methods. Thus, it is possible that DfMA methods for traditional polymer production can be adjusted for carbon fibre composite production. The result is summarised in a table aiming to facilitate engineering decisions related to cost estimations for composite moulding.

THURSDAY 08:50 – 10:30

D. Human-centred production systems IV

Location: Post 4

Session Chair: Carin Rösiö (Mälardalen University)

Quality Problems in Materials Kit Preparation

Authors: Patrik Fager (Chalmers University of Technology), Mats Johansson (Chalmers University of Technology), Lars Medbo (Chalmers University of Technology)

Abstract: Increasing customisation, together with a focus on assemblers' value added time, inflates the number of component variants required in assembly, and drives implementation of kitting processes. Practice indicates that current kitting process designs exhibit quality problems, but research is scarce concerning which problems arise and why. Therefore, this paper provides a decomposition of quality in kitting processes by establishing a framework consisting of types, causes and determinants of quality problems in kitting processes. Through a multiple case study, several underlying mechanisms of quality problems and why they arise were revealed, thereby extending the current frame of knowledge.

Meetings – The Innovative Glue Between the Organisation System and Information System

Authors: Per Gullander (Swerea IVF), Åsa Fasth Berglund (Chalmers University of Technology), Ulrika Harlin (Swerea IVF), Sandra Mattsson (Chalmers University of Technology), Cecilia Groth (Swerea IVF), Magnus Åkerman (Chalmers University of Technology), Johan Stahre (Chalmers University of Technology)

Abstract: The research presented aims for enhanced utilization of human skills, collaboration, and information sharing. This paper concerns the production context, and the needs and challenges of people striving for high-quality, innovative, and efficient work. The paper presents a model of the information system (IS) and organisations system (OS) and their integration. Main conclusions are that these systems overlap, and create an innovative working arena for the different working processes. People with knowledge gather into meetings held for different purposes supported by technical systems. These meetings provide a core element for efficient and innovative collaboration, requiring parallel development of IS and OS.

Creating a structured MEETing arena for knowledge-sharing

Authors: Åsa Fasth Berglund (*Chalmers University of Technology*), Magnus Åkerman (*Chalmers University of Technology*), Cecilia Groth (*Swerea IVF*), Per Gullander (*Swerea IVF*), Ulrika Harlin (*Swerea IVF*), Sandra Mattsson (*Chalmers University of Technology*)

Abstract: This paper aims to describe how to create and structure a meeting arena by combining organisation structure and information structure; this will be used in order to create an innovative and creative arena for knowledge sharing and problem solving within the company. The model is exemplified by four industrial case-studies. Results reveal that most of the companies do not have any standards for information- or knowledge sharing, most improvement potentials are seen in structuring and storing the right information (IS), aiming from tacit towards explicit knowledge (OS) and this could be done by structuring the questions in the OS-M-IS model and by creating innovative and creative meeting arenas.

Knowledge in Production: Towards a Quantifying Model

Authors: Magnus Åkerman (*Chalmers University of Technology*), Åsa Fasth Berglund (*Chalmers University of Technology*)

Abstract: Many concepts related to knowledge sharing and knowledge creation impact to the overall efficiency and competitiveness of production systems. From a socio-technical system perspective a model is presented combining focus concepts derived from the three areas: efficiency, empowerment and automation. The contribution is a first step towards a quantifying model of the overall production system in relation to knowledge.

F. Integrated product and production development III

Location: Post 5

Session Chair: Kristina Wärnefjord (Chalmers University of Technology)

Tolerance Cost in Relation to Surface Finish during Longitudinal Turning Operations

Authors: Jan-Eric Ståhl (*Lund University*), Fredrik Schultheiss (*Lund University*), Sören Hägglund (*Seco Tools*)

Abstract: Tolerances are an important part of production where the desire to produce quality products have to be weighed against the increased production costs. The desired tolerance will influence the choice of both production method as well as the machine used. Given that machining is an adequate production method, variation of the required surface roughness will imply a variation of the part cost which needs to be taken into account during production planning. This paper presents a method for evaluating the tolerance cost in regards to surface roughness during longitudinal turning operations, thus enabling a better comparison between different production situations.

Piston Ring Topography Variation and Robust Characterization

Authors: Olena Flys (*Halmstad University*), Zlate Dimkovski (*Halmstad University*), Bengt Olsson (*Volvo Truck AB*), Bengt-Göran Rosén (*Halmstad University*), Lars Bååth (*Halmstad University*)

Abstract: In this paper, the surfaces of the two lands of twin oil control ring were investigated, since they play the key role in controlling the desired low emission and fuel levels designed for modern internal combustion engines. The goal is to map the variation in surface roughness of piston rings that appear at different scales from form and waviness to micro and nano roughness. Areal topography measurements were made by white light interferometer designed at the Halmstad University able to measure and scan the total functional area of the set of commercial piston rings. The results show both the variation and uncertainty of ring topography. The most stable parameters were found and recommended for an effective quality control.

Nano Graphite Flakes as Lubricant Additive

Authors: Lanny Kirkhorn (*Lund University*), Oleksandr Gutnichenko (*Lund University*), Oleksandr Melnyk (*Zhytomyr State Technological University*)

Abstract: The fundamental method of reducing friction and wear in metal to metal contact manufacturing processes like forging, extrusion, sheet metal forming etc. is based upon surface separation. The separation is usually obtained by adding different types of lubricants to the process. In this work, graphite nano platelets (GNp) powder has been used as a lubrication additive to explore and evaluate the influence on the frictional outcome. The experiments have been performed utilizing laboratory test equipment based on strip drawing. Three different lubricant systems are tested 'oil', 'oil-GNp' and GNp only. The result clearly shows that the specific type of nano-graphite used has a favorable effect of reducing the frictional forces both in mixture with a base oil and as a standalone coating.

A Training Consortium to Explore and Exploit Surface Metrology

Authors: Sabina Rebeggiani (*Halmstad University*), Bengt-Göran Rosén (*Halmstad University*), Leigh Flemming (*Huddersfield University*), Liam Blunt (*Huddersfield University*)

Abstract: The importance of surface finish in all aspects of manufacturing influences economic considerations as well as environmental aspects and functionality. The ability to effectively and efficiently characterise surface topography is an important tool in the manufacturers arsenal which is often overlooked or underutilised. By providing a comprehensive, affordable training package, a gap in the industrial knowledge is filled giving manufacturers the ability to increase their competitive edge.

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