Product Enhancement with a systems approach, utilising Time Compression Technologies

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ABSTRACT

In the current competitive market of introducing new products and processes it is absolutely vital to reduce lead times, produce a prototype which is right first time and produce design specifications which will ensure that the products are eventually produced to a quality requirement at a competitive price. In order to achieve this the Centre For rapid Product Development at Northumbria University has undertaken a number of assignments to assist SME's in the region using a traditional systems approach combining modern engineering technologies such as Rapid Prototyping , Reverse Engineering , Computer Aided Design , Computer Aided manufacturing and Surface engineering.

Key Words: - Rapid Prototyping, Surface Engineering, Reverse Engineering, CAD, CAE, Time Compression Technologies

1.0 REGIONAL ECONOMIC STRUCTURE

In the past the North East region was economically strong built on a legacy of primary industry that formed the backbone of the region; these industries were namely ship building and coal mining. The Economy of the North East has been transformed dramatically in the last 25 years.
During 1981 – 1986 over 55 000 jobs in primary industry and 80 000 jobs in the manufacturing industry were lost. Many of the lost jobs were due to the decline of the ship building industry and decommissioning of working coal mines *[1]*. Due to this enforced change in the economy the region experienced an increase in the number of small companies that were trading in the area. Many people with skills from the primary industries had moved into secondary and tertiary industries such as precision engineering and, component wholesaling.
A detailed local economic study carried out by the Centre for Regional Development Studies (CURDS) showed that the over 99 % of the regions companies are Small Medium Sized Enterprises (SME's), with 95% being small (less than 50 people) *[2]*.

Small Medium Enterprises (SME'S) can be categorized by the following defining factors,

- Less than 250 employees
- Turnover of less than 40 million Euros

Due to the structure of the region, majority of the collaborating companies that are SME's.

The region has received substantial assistance from both the European Social Fund (ESF) and the European Regional Development Fund (ERDF).European money has been allocated to areas that have been classified as economically deprived due to recent social changes. Money has been allocated by the objective 2 programme, which will bring over £500 million to the region from 2000 – 2006.

Objective 2 funds are allocated to areas that are adjusting to industrial and service sector changes, which the North East complies with due to the decline of industries like coal mining, steel industry and recently the loss of major employers in the manufacturing industry *[3]*.

2.0 THE CENTRE FOR RAPID PRODUCT DEVELOPEMNT (CRPD)

The Centre for Rapid Product Development (CRPD) was set up in 1996 with the aim of helping to support the Regional Economic Strategy (RES).The key factors now driving the economy are knowledge and technology, creating what is termed a knowledge driven economy *[4]*.The CRPD has been pivotal in helping the region make the transformation to having a knowledge driven economy.
The CRPD has assisted over 600 companies with products and process developments and have been crucial to assisting companies to deliver on time and ensure that both design and manufacturing lead times have been streamlined thus resulting in a financially successful product reaching the commercial market. A recent study by the Regional Technology Centre North, of a structured sample of over 350 Regional companies, found that those companies reporting an increase in turnover in the past three years were the companies who were more involved in product and process improvement and the use of Information Communication Technologies [*5]*.

The CRPD has introduced companies to the application of a Systems approach in conjunction with Time Compression Technologies to reduce the product design lead time and help companies to get their products 'right first time'.

In a recent survey, senior managers placed 'time to market' in the top three criteria driving their business *[6]*. This survey proves how the service offered by the CRPD is at the heart of the driving force for local companies to meet their targets.

3.0 A SYSTEMS APPROACH

A Systems Approach to Product Development consists of viewing each stage off the product development cycle as one complete entity and moving away from the traditional approach of viewing each section of the development cycle as separate entities. In the past a culture of 'over the wall' product development has been practiced with companies using different companies or departments to complete each section for example,

Design Office, Machine Shop, Quality Department – each of these departments would do their job only with minimal collaboration and information input throughout different stages of the product development. It can be seen from Figure 1 that all of these department have an input into the core drawing/development office at some stage in the product development cycle.

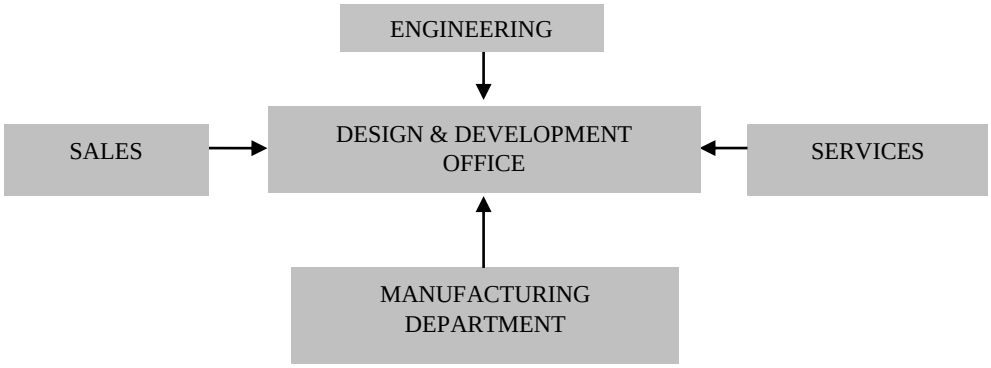

Figure 1: Information Paths Between Departments involved in Product Development

Using the Systems approach we optimise the product deign process by linking together each of the stages that make up the product development cycle as shown in figure 2.

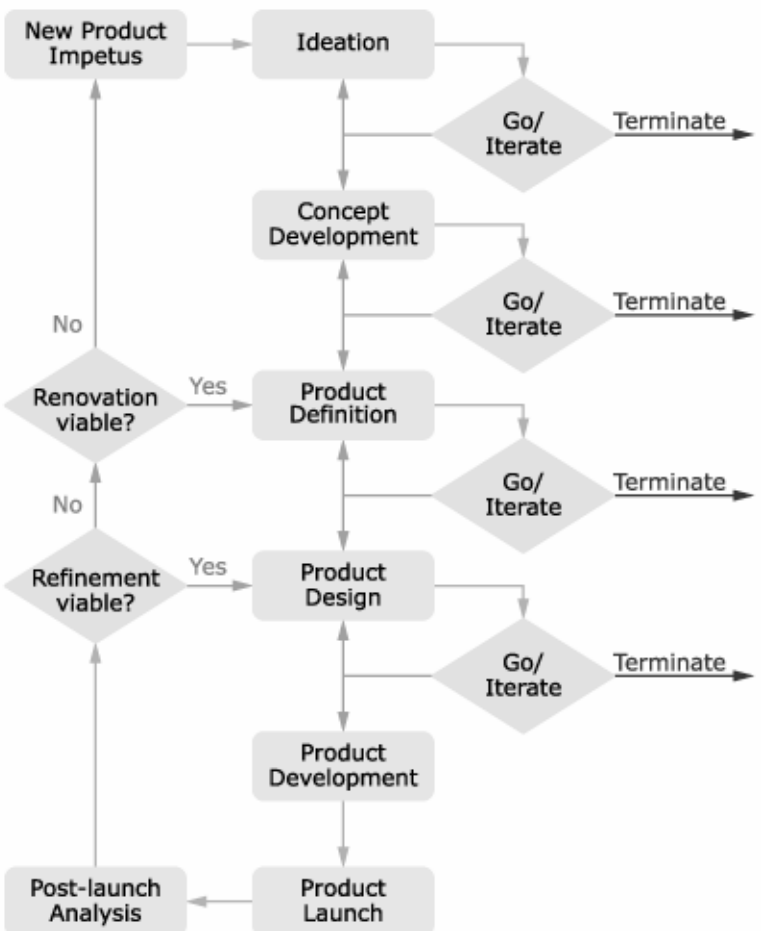

Figure 2: Product Development Stages from Concept to Commercial Product *[7]*

Using the systems approach each stage is completed whilst working concurrently with the next stage and viewing the effect that design for manufacture and design for assembly can have on reducing the manufacturing cost and manufacturing lead times. It is important to understand that each stage in the design and development process have great effects upon all other stages in the system. Each department in the organisation can integrate with the design office to offer a full systems approach to the product, which eliminates the over the wall mentality.

4.0 TIME COMPRESSION TECHNOLOGIES

Time Compression Technologies (TCT) is a collection of software and hardware solutions that can help to reduce the design and development cycle to traditional manufacturing technologies. Some of the software and hardware that make up the Time Compression Technology service offered by the CRPD are outlined in the following subsections.

4.1 COMPUTER AIDED DESIGN (CAD)

CAD is much more than using a computer to draw lines and shapes, CAD systems are tools of the design engineer as a hammer can be classed as the tool of a builder. All the design decisions still have to be made by the designer. The CRPD uses both 2D & 3D CAD systems and have implemented both of these systems to assist SME's.
The 3D CAD system used is SolidWorks™ which is a market leader in the CAD software arena. The files created in the 3D CAD software are used as the basis for the analysis and simulations as well as being an output in a file

format that is directly used for Rapid prototyping. Figure 3 shows a 3D CAD model of a pneumatic machine guard designed for a local SME.

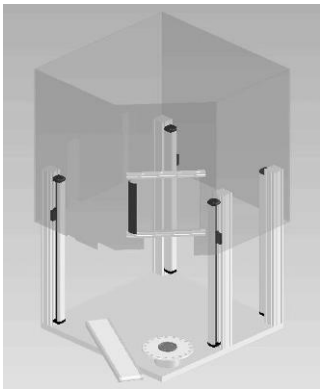

Figure 3: 3D CAD Model Produced by CRPD for a SME

Figure 4 : Finite Element Stress Analysis Result Plot

4.2 ANALYSIS & SIMULATION SOFTWARE

Both mechanical and thermal situations can be applied to 3D CAD models of components and assemblies of components using Finite Element Analysis software.
This software allows calculations to be carried out to look at the heat loss in a process or the stress experienced at any point through out the component.
Full kinetic motion can also be simulated to look for part interference and also to examine dynamic forces experience in components .This process can be can be successfully achieved in a matter of minutes rather than the hours of work it would take to manually verify all calculations .

The use of these technologies allow critical design decision to be made confidently at an early stage in the product development cycle thus helping to enforce the importance and ease of getting it right first time.
The implementation of this technology as part of a systems approach can allow components to be manufacture more competitively and also to be functionally superior , .These software's can cut out the old method of making sure components don't fail by over engineering them. Figure 4 shows a typical stress analysis plot for a component show the area of greatest stress.
The flow of fluids can also be incorporated in the systems approach through the use of Computational Fluid dynamics software which allows flow paths to be analysed. This is a very useful tool when trying to look at a situation of fluid heat transfer. It also allows dead pools to be identified .Through the use of this software much more efficient system and flow paths can be achieved which can result in products that are market leaders.

4.3 REVERSE ENGINEERING

Reverse Engineering is the process of gathering data from undefined 3D surfaces, and is used in fields such as tool, die and mould making. *[8]*

The CRPD has two Reverse Engineering Systems that have been used in collaboration with other Time Compression Technologies to assist SME's.The two systems allow a range of different size and complexity of components to be reverse engineered with different levels of accuracy and data capture speeds.

Contact Reverse Engineering System: - A Renishaw Cyclone, allows very accurate data capture to be achieved up to eight microns. The System uses a ruby tipped probe that is force sensitive to trace over a defined area constantly recording positional points, when the probe comes into contact with a surface it rides over the part following the contours always remaining in contact. This process allows for 3D data to be captured as well as 2D profiles that can be an output for use in CAD systems. The Renishaw Cyclone is shown in figure 5.

Figure 5: Renishaw Cyclone Contact Digitising Machine

Figure 6 : Roland Picza Non Contact Reverse Engineering System

Non Contact Reverse Engineering System: - A Roland Picza laser scanner allows data to be captured without any contact being made with the part. This system allows for very quick collection of data and allows complete data to be collected for a part in one single scan .This machine is ideal for free form and organic shapes. The Roland Picza is shown in Figure 6.

4.4 RAPID PROTOTYPING (RP)

Rapid prototyping allows digital media to be realised in a physical model in a matter of ours .Rapid prototyping uses the principle of building a part in a series of layers in a laminating fashion, the process is an additive when material is added to the part rather than being subtractive like milling a part when material is removed from a stock to leave the required geometry.

There are many different rapid prototyping processes available today which allow parts to be manufactured in materials including polymers and metals. The CRPD has three rapid prototyping techniques that are outline below.

LOM: - A process that uses a laser to cut out model cross sections from a paper coated with a heart sensitive adhesive. The model is built up using a heated pressure roller which sets the adhesive on the paper. This process is ideal for large components as separate modules can be easily joined. The LOM process allows parts that can be directly used for investment casting to be manufactured eliminating the long pattern manufacturing process that would usually be required. Figure 7 shows examples of prototypes using the LOM process.

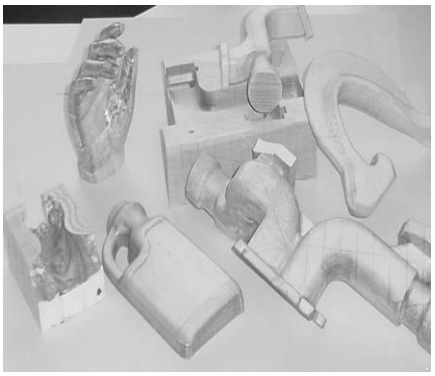

Figure 7: Parts Manufacfured on LOM machine in the CRPD

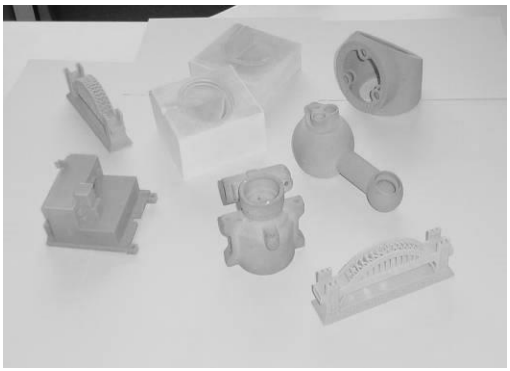

Figure 8 : Parts Manufactured on Z Corps 3D Printing Machine

3D Printing: - This process works very similar to an inkjet printer that is used to print on paper, but differs in the fact that instead of paper a bed of starch powder is used and the ink is replaced by an adhesive resin. The part prints a cross sectional layer with the resin hardening the starch powder into a solid in the printed area, this area then lowers and a new bed of starch is laid for the next layer to be printed onto .The Z Corps 3D printer allows parts to be manufactured very quickly and cheaply down to the low material costs associated with the process. This process is perfect for concept models. Figure 8 shows a sample of prototypes using the 3D Printing process.

Digital Light Manufacturing (DLM): - The EnvisionTec machine uses digital Light manufacturing to produce parts. Light is projected onto a photo reactive resin using a Digital Light Manufacturing chip which uses millions of mirrors to shine the light in the areas that are required to produce solidified cross sectional layer from the acrylic resin. This process allows for accurate parts to be manufacture and also the parts can be used for photoelectric stress analysis. Figure 9 shows an example of a part manufactured using the Envisiontec machine.

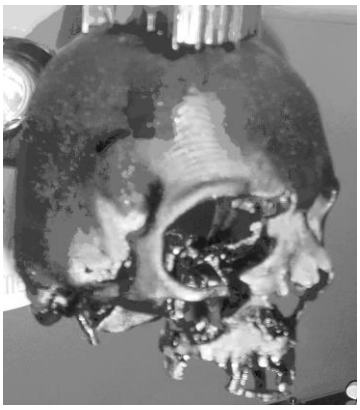

Figure 9: Skull manufactured using the DLM EnvisionTec process

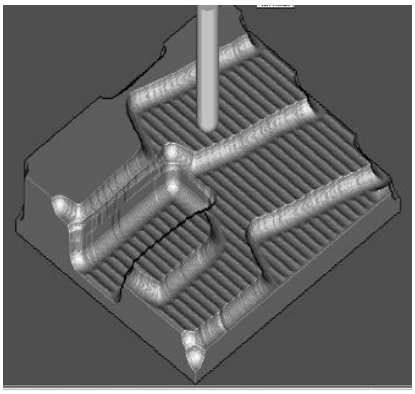

Figure 10: Snap shot of CAM simulation

4.5 COMPUTER AIDED MANUFACTURE (CAM)

This is the process of using computers to programme how a machine moves and operates to create a part, the CAM software that is used at the CRPD is Delcam PowerMILL ™. This process allows NC codes to be produced to drive a milling machine to manufacture parts. The machining programme can be downloaded to a Computer Numerically Controlled milling machine for part manufacturing. A full milling simulation can be created allowing the process to be analysed giving accurate machining times. Figure 10 shows a snap shot of a simulation. CAM allows for very accurate parts to be manufactured with perfect repeatability. It also drastically reduces manufacturing times and can reduce the number of skilled machinists required as a machine operator is only required to load the stock material and start the programme the rest of the machine movement has been defined using the Cam software.

5.0 CASE STUDY

Case studies give a brief summary of project activity demonstrating direct assistance that SME'S have received resulting in product and process improvements, lead time reduction, increased profitability and improvements in quality.

5.1 NEW IMPELLER DESIGN & PRODUCT DEVELOPMENT

Background – A local company had a long standing product development problem which required assistance.

Enquiry – In order to compete with market competitors it was essential for the well being of the company that a new product be introduced to the market. This new product required an impeller that was a special size .The Company required a small number of impellers for tests using hot and cold water.

Actions - The staff in the Centre for Rapid Product Development in the School of Computing, Engineering & Information sciences at Northumbria University worked with the company and utilised the following Computer Aided Engineering (CAE) technologies and expertise to meet the companies' requirements

- **Reverse Engineering -** Using the Renishaw Cyclone™ contact scanner profiles of the current impeller vanes were captured and transferred into a CAD system
- **Computer Aided Design –** The new impeller was modelled using the profiles captured using reverse engineering and new design features were added to allow accurate location of the parts.

- **Rapid Prototyping –** A Prototype impeller was produced as a single component to allow cold water testing to be carried out. This prototype was produced in Acrylic using the DLM EnvisionTec machine.

- **Computer Aided Manufacture (CAM) -** A impeller was produced using Computer Aided Manufacturing & CNC machining in Acetyl for hot water testing. Figure 11

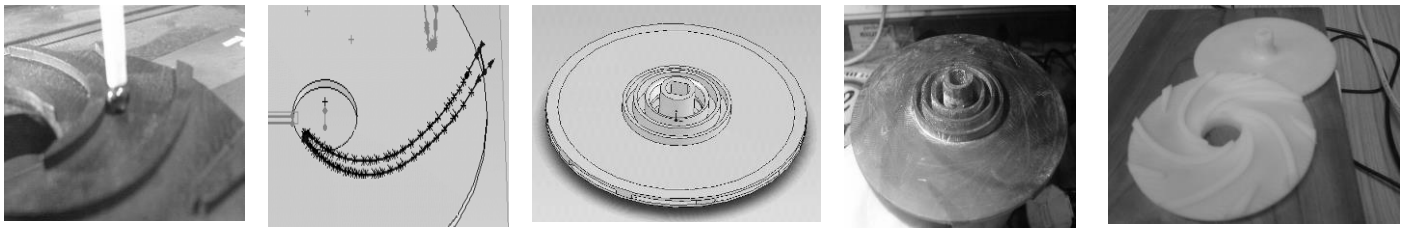

Figure 11 : Reverse Engineeering, Digitising, 3D CAD, RP Impeller, CNC machined

Benefits:

- Long standing Problem solved
- Cost effective solution reached
- Enhanced ICT application
- Un rivalled lead time gained through implementation of CAE technologies
- Large financial commitment to tooling can be done with confidence
- Product was right first time and is now in the commercial market

6.0 DISCUSSION

The benefits of applying the systems approach using Time Compression Technologies can be summaries as,

6.1 Benefits to the North East Region

- Direct Assistance and advice provided for the implementation of CAE systems and product development solutions with SME's within the North East region.
- Provision of a regional impartial Resource for CAE related information, advice and guidance.
- Company case studies generated via company based student placements
- Dissemination of Literature
- Network opportunities for Companies and project organisations

6.2 Benefits to University of Northumbria

- Regional exposure of University of Northumbria and raising its profile.
- Networking with SME'S and hence spin-offs for student placement, part time courses, consultancy.
- Teaching material generated as a direct result of systems approach activity with companies.
- Financial income achieved for commercial work completed

6.3 Benefits to the School of Computing Engineering and Information Sciences

University and regional exposure of the School of Computing Engineering and Information Sciences

- Introducing SME'S and their employees to the activities of The School of Engineering and Technology.
- University and regional exposure of the School of Computing Engineering and Information Sciences
- Assisting with future industrial placements via the contacts made with SME'S.
- Possibility of future Knowledge Transfer Partnerships (KTPs)

- Undergraduate student projects.
- Enhancing student experience.
- Possible future students for undergraduate and postgraduate UNN courses.
- Opportunity for staff development at no additional cost.
- Production of learning material
    - CAD/CAM
    - Business Integration
    - Solid Modelling

  (A substantial output, which can be used as short course material/undergraduate students).

7.0 Conclusions

The clear conclusions that can be provided from the assistance given to SME's to assist with product and process developments in the North East region are,

- Delivered 'company specific' solutions to CAE-related particular technical problems in SME'S
- Developed and embedded improved and increased CAE technical capacity and capability within SME'S.
- Provided an additional, technically CAE focused, resource for SME'S through the supply, and placement, of highly skilled and motivated young people.
- Facilitated and promoted graduate recruitment by SME'S, thereby increasing and improving engineering graduate retention within the region.
- Developed effective working relationships between Project partner development staff, university academic staff, and manufacturing SME'S in the selection and application of CAE tools and technologies.
- Established the use and application of CAE as the basis for the on-going development of a continuous improvement and innovative culture within the North East of England Region.
- Established the Systems approach ethos in local SME's assisted

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