Automation of Customization on TEXO’s FSX Weaving Loom Concept

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Automation of Customization of TEXO’s FSX Weaving Loom Concept

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(As a fulfillment of master’s degree in Production Engineering and Management)

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Abstract

The continuously increasing demand of the customer requires equivalent response from the industry. This phenomenon of lean supply chain has also been seen in the paper and textile industries.

TEXO AB produces customized weaving looms for the paper and textile industries. As every machine is redesigned to the customer requirements, TEXO needed to make the process efficient and effective. Once again the application of new computing technologies comes in handy.

The practice of parametric design is applied to the TEXO's FSX concept, which is one of the three weaving loom machine series supplied by TEXO. The frequent customization of FSX concept for each customer has created the need for faster redesign, better communication and quick order to suppliers.

The automation is done on Autodesk Inventor using its iLogic and Shrinkwrap features. The parametric model is complete where all components to be customized are included. An excel sheet with design calculations, parameters and possible machine modules is developed together with the model.

The feasibility of the automated design has been shown by the complete conformance of the model to the requirement. The excel sheet is very useful for improving the internal and external communications. After the completion of this project the redesign time is significantly reduced and the communication is simplified. It is also now possible to identify customization and module opportunities for future machines.

Key Words: customization, parameterization, weaving loom, mechanical design, Autodesk Inventor
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1. Introduction

1.1. The Company and operations

TEXO AB is one of the world’s leading manufacturers of weaving looms. Its main goal is to increase the value and profitability of its customers’ business with the help of customized products and a comprehensive service.

Since it’s founding in 1946, it has developed, designed and supplied over 1,000 weaving machines. This represents two-thirds of all the weaving machines on the world market in its category. It designs and produces looms for paper machine clothing. Today TEXO AB has around 70 employees in the head office in Älmhult, Sweden and in their subsidiaries TEXO INC. in Greenville, USA and TEXO PACIFIC Company Ltd. in Shanghai, China. The offices outside Sweden are placed to promote sales and provide technical assistance only.

TEXO makes paper production possible by supplying machines, which produce an essential input to the paper industry that are not known by most people outside the industry. The paper machine clothing, forming fabric and press felt are inputs to the paper mills, which are produced by the weaving looms from TEXO. The three machine series are the TransCent and the FormStar that produce the forming fabrics and the CompFelt that produces the press felt.

The customer is given the focus in the supply chain of these weaving looms. The looms are not mass-produced rather each is carefully customized to the needs of the specific customer.

TEXO does not produce the parts of the loom, but are bought from suppliers with an order from the design stage given in advance. It then assembles them after arrival to create the weaving loom.

The Lab-room at the plant in Älmhult, Sweden is used to test feasibility each design. TEXO wants to be a partner with its customers and have long-term relationship. Product development is done in order to increase the value, productivity and the profitability of its customers’ operations. The high-speed picking, variable speed control, automatic pirn changer inventions can be seen as examples of the dedication to customers. (Svensson, 2007) (Johansson, 1997) (Lindblom, 1996)

TEXO has also a service program in place for its customers. These are assembly, on-going maintenance, rebuilding, training and spare parts providing. The methods used for an automated module creation consider these services. TEXO documents every loom down to the very last detail of the 100,000 or so components it delivered over the years. Therefore it is able to provide the customer with exactly the part they need.
1.2. Operation process

Customer order is required to start production of a machine in TEXO. The marketing team will approach customers through advertisements or other means. When an interested customer notifies TEXO, the sales team coordinates the negotiations for an order. The operational process from order to supply is summarized in the diagram below and the table after. The design phase, part manufacturing and assembly phases can overlap.

Figure 1-1: Supply process

<table>
<thead>
<tr>
<th>Process</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Advertisement of the loom</td>
</tr>
<tr>
<td>2</td>
<td>Interest notification</td>
</tr>
<tr>
<td>3</td>
<td>Check feasibility of the machine with predesign</td>
</tr>
<tr>
<td>4</td>
<td>Feedback on feasibility (yes)</td>
</tr>
<tr>
<td>5</td>
<td>Information sent back to customer with quote</td>
</tr>
<tr>
<td>6</td>
<td>Feedback on the quote (approved)</td>
</tr>
<tr>
<td>7</td>
<td>Instructions to start the design</td>
</tr>
<tr>
<td>-</td>
<td>DESIGN PHASE</td>
</tr>
<tr>
<td>8</td>
<td>Order sent to manufacturer</td>
</tr>
<tr>
<td>-</td>
<td>PARTS MANUFACTURING</td>
</tr>
<tr>
<td>9</td>
<td>Manufactured part returned to TEXO</td>
</tr>
<tr>
<td>-</td>
<td>ASSEMBLING</td>
</tr>
<tr>
<td>10</td>
<td>Shipping of the loom to customer</td>
</tr>
<tr>
<td></td>
<td>Total processing time</td>
</tr>
</tbody>
</table>
1.3. The Problem

The customization of one loom takes around 7 months as shown in the figure and table above. TEXO will only be able to produce 5 looms annually with the current process assuming there will be overlaps between orders, design and assembly stages. TEXO can assemble three looms in parallel within the facility in Älmhult. The annual demand is expected to increase to 7-8 looms in few years time. Therefore, TEXO needs to adjust its process in order to fulfill the customers demand. There is also a problem because the sales department had to contact the design team in order to negotiate an order from the customer. This has taken unnecessary time and created frustration in the past that reduced the customer satisfaction.

From the current process that TEXO is performing the design phase is given the priority for improvement assuming the rest of the supply chain phases are fairly optimized. The design phase is also chosen because of the influence it has on the others processes. The improvement in the design stage is expected to give the sales department a better way to communicate with customers. It will enable the purchasing department to quickly order the parts needed for a new order.

1.4. Proposed Solution

The solution proposed for this problem is to automate the customization but still leave the possibility to manually design. In addition, finding out the future module opportunities was expected as possible outcome.

The automation of the customization shall be done on a CAD system to retrieve the 3D CAD model for graphical design feasibility evaluation. This automated model should be able to print the bill of materials to enable cost calculation. It will also need to update the drawings when there is a change of design. Parameterization of the construction is the most feasible option for accomplishing this mission.

If applied, the new process should reduce the design phase time by 70%. This will assure a significant improvement on the overall production process. The cost saving will be visible when it is implemented and will not be calculated here.

1.5. The FormStar and FSX Concept

A loom is a device used for weaving cloth. The method of any loom is to hold the warp threads with tension and enable interweaving the weft threads easily. There are different types of looms and TEXO produces the power loom type, which is driven by an electrical motor to move its dynamic components.

One of the three machine series produced by TEXO is the FormStar that produces the forming fabrics. The FSX concept has been derived from this FormStar machine and is used for the customization of the future FormStar looms. The focus of this thesis work will be on the FSX concept for the customization of the FormStar looms.
1.6. The Scope

This thesis is limited to the delivery of the parametric 3D CAD model, identification of module opportunities and organization of the design process. This is due to the time allowed and the amount of work that need to be done to go further into developing the bill of materials and cost calculations. All key parameters needed for the design of the FSX concept are considered in the automation system. The creation of 2D drafts can be easily added when the module creation from the last run of the system is done.

1.7. Report outline

The first part of this report describes the company and its market followed by the problem faced and solution proposed.

The next part shows the methodology used for progressing with the solution in great detail. This part allows the reader to apply the approach taken to any other similar situation.

The tests conducted and results approved are included in the third part. The evaluation of the model is done on the premises of TEXO.

At last there is a conclusion, discussion and recommendation part. Further extension on this work may follow from this part.
2. Methodology

2.1. Approach

In facing the problem, a work plan is laid out to apply the proposed solution. The first priority was to synchronize everyone involved to be on the same page. Literature review is done on the weaving technology, company specifications and the application to be used for this purpose. As mentioned before the proposed solution is to parameterize the construction of the FSX Concept deriving the models from the FormStar design document.

Parameterization is the process of deciding and defining the parameters necessary for a complete or relevant specification of a geometric object or model. In this project it only involves identifying certain parameters or variables. Most often, parameterization is a mathematical process involving the identification of a complete set of effective coordinates or degrees of freedom of the system, process or model, without regard to their utility in some design.

Parameterization of a line, surface or volume, for example, implies identification of a set of coordinates that allows one to uniquely identify any point (on the line, surface, or volume) with an ordered list of numbers. Each of the coordinates can be defined parametrically in the form of a parametric curve (one-dimensional) or a parametric equation (2+ dimensions).

Parameterizations are not generally unique. The ordinary three-dimensional object can be parameterized (or ‘coordinatized’) equally efficiently with Cartesian coordinates \((x,y,z)\), cylindrical polar coordinates \((\rho, \varphi, z)\), spherical coordinates \((r,\varphi,\theta)\) or other coordinate systems. Similarly, the color space of human trichromatic color vision can be parameterized in terms of the three colors red, green and blue, RGB, or alternatively with cyan, magenta and yellow, CMYK.

In this project, parameterization is defined as identifying and relating the key parameters that define the size, form or quantity of a model, component or feature according to the design procedures in TEXO. Therefore out of the many parameters that define the model only the main parameters, which will be affected by design changes, are relevant that will be identified and considered.

The proposed solution is tested on Autodesk Inventor’s iLogic feature with simpler parts and assemblies and was found to be feasible. Autodesk Inventor is chosen because of its capability and it is being currently used by TEXO. This will prevent any issues arising from using a different application. Microsoft Excel is chosen as the design software as it suited to the design calculation and iLogic has simplified codes for easily integrating and utilizing Excel files. There is only one Excel file imbedded in the whole system that is used for all design purposes.

To make it easier for understanding, what has been done in this project, the Inventor features used are discussed in the next section. The implementation and TEXO’s weaving technology will be discussed following the Inventor review.
2.2. Inventor Review

Here below is the explanation of important Inventor features used in this thesis work. (Shih, Tools for Design Using AutoCAD 2012, Autodesk Inventor 2012 and LEGO MINDSTORMS NXT & TETRIX, 2012)

A. Project file

Project files organize Inventor data. Project files determine the location of the working data, templates, styles, and libraries. The project type designates either a shared location called a workgroup or a personal editing location called a workspace. Many projects also specify one or more libraries, locations where files for reference but do not edit are stored. Only one project file is used to organize the files in this project.

B. iLogic

iLogic enables rules-driven design, providing a simple way to capture and reuse design work. It is used to standardize and automate design processes and configure virtual products. This feature is integrated in Inventor and has simplified codes for programming purposes. The iLogic Browser lists iLogic rules, forms, global forms and external rules.

C. Rules

A rule is a small Visual Basic (VB.NET) program that can monitor and control other Inventor parameters, features, or components. iLogic embeds rules as objects directly into part, assembly, and drawing documents. The rules determine and drive the design parameter and attribute values. By controlling these values, one can define the behavior of model attributes, features, and components. Knowledge is saved and stored directly in the documents, like the way in which geometric design elements are stored. Many rules are created in this project to enable the automated configuration of the CAD model.

D. Level of detail (LOD)

LOD representations improve capacity and performance. They suppress unneeded components or replace many parts with a single part representation to reduce memory consumption and to simplify the modeling environment. A simplified substitute LOD provides greater memory savings than suppression alone and is recommended in managing big assemblies such as the FormStar Model. Different levels of details were used in the CAD Model.

E. Part

A part in Inventor is a file with smallest detail, which is equivalent to real world part. A part is represented on disk with only one file type. However, there are many different types of part files. They can be simple to complex. The workflow used to create the part is what determines the part type.
F. Assembly

Assemblies are file that contain references of parts or other assemblies, which makes them equivalent to real world assemblies. Assembly modeling combines the strategies of placing existing components in an assembly, and creating other components in place within the context of the assembly. In a typical modeling process, some component designs are known and some standard components are used. Designs are created to meet specific objectives.

Parts and subassemblies are created in part files or created in place in assembly files. The features of components originate as sketches that can be fully or partially dimensioned. Feature volume is specified using feature-creation commands and supplying key values. Features can be resized by changing dimension values or redefined by specifying different angles or termination methods or relationships to other features.

G. Pack and go

Pack and Go packages an Autodesk Inventor file and all of its referenced files in a single location. All files that reference the selected Autodesk Inventor file from a selected project or folder can also be included in the package. Pack and Go is used to archive a file structure, copy a complete set of files while retaining links to referenced files, or isolate a group of files for design experimentation.

H. Components

Components are parts that make up an assembly. When editing an Autodesk Inventor component in an assembly, changes are made to all occurrences of the component in its source file and in other assemblies. To make a custom version of a component in only one assembly, the component needs to be saved in a part file with a new name.

In an assembly, components are positioned relative to one another with assembly constraints. To fit components together easily, work features can be included while creating components. Reference components are used in an assembly only as a reference but not listed in the bill of materials.

I. Constraints

Constraints are rules that determine the relative positions of geometric entities. Assembly constraints determine how components in the assembly fit together. As constraints applied, they remove degrees of freedom, restricting the ways components can move. A constraint can be assigned maximum, minimum, and resting position values to specify the allowable range of motion. Constraints are manipulated and created in part and assembly files of this project.
J. Suppression

Suppression is a way of removing components or features without deleting them from the model. Suppression of components in an assembly removes them from the bill of materials and the Modeling view. Suppression of features in parts removes the feature of the part in the modeling view but keeps it in the feature structure. Un-suppression will reverse the effects of suppression command. The use of suppression enabled the large system of assemblies created in this project to have minimum file size and faster processing.

K. Visibility

In a large assembly, you may need some components only for context, or the components you need may be obscured by other components. You can change components to not enabled or turn the visibility of components on and off as needed. Assembly files open and update faster when nonessential components are turned off. Visibility control has been done once in this project and can be adjusted as needed during the usage of the system.

L. Pattern

Part, surface, and assembly features can be arranged in a pattern to represent hole patterns or textures, slots, notches, or other symmetrical arrangements. In a multi-body part, a body can be patterned as multiple bodies. In an assembly, patterns are useful when creating weld preparation and machining features in Inventor. Patterns are automated in this project according to design procedures.

M. Parameters

Parameters define the size and shape of features in parts and control the relative positions of components within assemblies. Equation can be used to define parameters using standard formats. Inventor has a parameter window to enable the viewing of details of the parameters in a model. Parameters in this project are classified according to the influence they have on the rest of the parameters and the overall design.

N. iTrigger

iTrigger is an Inventor user parameter that can be included in the current document to fire rules manually. This parameter is frequently used to launch a dialog box from a rule. The dialog box provides a custom interface to define design parameters. This parameter is used in many iLogic rules in this project.

O. Update

Updating assemblies mean reflecting changes in design into the modeling view. An update for parts is done automatically when there is a change in the design parameters. The system created in this project updates when a run is completed.
P. Shrinkwrap

Shrinkwrap is a feature used to create a simplified single part representation of an assembly to improve capacity and performance in downstream assemblies or applications. Shrinkwrap uses the derived component command in the background to create a single part from an assembly. Shrinkwrap can use existing Design View or Level of Detail representations for maximum efficiency. Only visible components are calculated. This is applied to as many components as should be in this project. (Banach, Jones, & Kalameja, 2012)

Shrinkwrap provides the following benefits:
- Simple to use.
- Significant reduction in file size for large assemblies and complex parts.
- Reduced time to open an assembly using a Shrinkwrap assembly substitute LOD.
- Improved performance when viewing or working with large assemblies and complex parts.
- Protect intellectual property by removing holes and internal components.
- Simplify the component representation for BIM Exchange.

Q. Bottom up modeling

Bottom Up is the traditional way of building assemblies. The first step is to define the individual parts. Then put them into sub assemblies using assembly constraints. The sub assemblies are then placed into higher-level assemblies up to the top-level assembly. This assembly method will create assemblies with a lot of relationships between parts and assemblies. The assembly created in this project follows this approach because the parts have already been created.

R. Top down modeling

Top Down is unconventional way of creating assemblies. The first step is to start defining the end result and build in all of the known design criteria. This becomes the base for underlying sub assemblies and parts. This results in single conceptual file containing the overall information of the design with a single place for incorporating design changes. Working this way can provide faster updates, more available resources for handling larger data sets, an easier way of working in a collaborative environment and a better way of doing design work in general. The flow of rules follows this approach to enable faster processing.

There are many workflows used to design 3D models in Inventor. These workflows fit the top down or bottom up methods and sometimes both. (Shah & Mäntylä, 1995) (Shih, Learning Autodesk Inventor 2012, 2012)
2.3. Implementation

Starting the implementation of the proposed solution, the model files from the FormStar machine are assembled to the top assembly. The complete model is created and used as a platform for discussion on the design procedures of the components with specific functions in the loom. The construction of the parametric system is discussed in this section.

Four main variable parameters are found, which the customization of the whole machine will depend and values will be received from the customer. Three of these will be used at once together with four other parameters to enable the design of the FSX concept. All other variable parameters used for the construction depend on these parameters. The input of the parameters is done on the Excel file imbedded in the system.

The strength of beams is checked in the first sheet that will decide the placement of supports. Usually this design does not change if there is no major change in the design of the loom like a warp tension. The resulted values of the relevant parameters are sent to the second sheet where the calculation of main parameters is done with inputs from customer. The design result is then transferred to the model created in Autodesk Inventor for update of the 3D CAD Model.
The values of parameters extracted from the Excel file are stored in Inventor parameters. These values are used to decide how the update of the design will proceed in the Inventor 3D CAD model. They influence the change in suppression state, visibility, size or form of part or assembly.
The Excel file has additional two sheets with the same information but alternative view. These sheets list the possible customization opportunities with the current design constraints far wider than practical range of possible parameters. The calculation is automatic which depends on the constraint values. Any change to any of the constraints is considered in the listing of the possible machine modules.

The FormStar design in Inventor is discussed with designers and the models are stored in dispersed way. One way to continue with the solution is to take each assembly step by step and parameterize their construction. The other choice is to collect and make the main assembly and then parameterize the sub assemblies. The later step is chosen because of its simplicity to organize and plan the parameterization. This will also allow for faster processing times when updating the design in the model.

Some missing models are created from 2D drawings and few others adjusted from other models when available to complete the construction of the first FormStar module. Substitute models are inserted for unchanging parts just to keep the place. Complicated models are replaced with ShrinkWrap models to enable minimum file size and decrease the processing time.

After the highest-level assembly is completed, it is used as a center stage for communication. The highest-level assembly is the complete model of the FormStar loom. Twelve components are found in the highest-level assembly model, taken from the organization in the printed FormStar bill of materials. The design procedures for these components are discussed in detail and are
integrated in their respective models. The naming and organizing of new parts and assemblies follow the currently set standards for proper documentation, reference or retrieval purposes.

The following list summarizes the process of the parametric construction.

1. Find out the main parameters and key parameters
2. Design the Excel interface for the FSX concept
3. Create the whole assembly structure
4. Parameterize major component of the main assembly
5. Test each component for performance
6. Parameterize the main assembly
7. Test the whole system
8. Correct bugs found and go to step 7 (until no bugs are found)

In parameterizing the major components, the manipulation started from the part level. The parts, which make up the first assemblies in the components, are parameterized first. That is to say, the key parameters that are connected to the design changes are identified and considered in the upper level assembly. This is done through naming a new user parameter in the part or selecting the model parameter in the upper level assembly.

The dimensions that need to be changed are made to follow a variable that is changed when the design changes affect it. The quantity and other variables of patterns are edited to be dependent on the design procedure as they would manually. Other features like the holes are made to adapt their type and size with the current design. These are done through the named parameters or model parameters.

The next step is using these parameters in the design procedure of the assemblies that will make up the components of upper level assembly. This is done on assemblies that are between the lowest and 2nd level in the assembly structure. iLogic rules were used in creating the relation between design parameters in the assemblies and parts.

Every component has a rule included in it that will guide all updates of the design. These components in turn have subassemblies that have either have subassemblies or parts. The 3rd degree lower level subassembly is the last one with the presence of assembly files with the 4th level being an assembly of only parts.

The constraints of the subassemblies of the components are discussed to find out the design procedures. The logic of changing the parameters and passing values to lower level assembly are decided for each. In some cases there is also passing of orders through iLogic rules. The 3rd degree lower level assembly is the last with iLogic codes incorporated inside.

Even if the construction followed the top-down approach it is possible for any assembly or part to be used in another model because of the organization used. In other words, any assembly or part is by itself a parametric model. The
parameterizing of the model starts from the lowest level in the assembly structure and goes up until the main assembly.

Standard of naming and coding are used to simplify the organization and construction of the CAD Model. The coding followed the sequence from practice of manual design to make easier for planning. The sample codes below are taken from the constructed model.

Accepting values from Formstar Design Excel sheet called customize

Accepting values from Formstar Design Excel sheet called customize

Changing the suppression state of a component in an assembly

Changing the suppression state of a component in an assembly

Updating the value of the variable C2C depending on the number of sections

Updating the value of the variable C2C depending on the number of sections

Algorithm used to divide spacing between holes

Algorithm used to divide spacing between holes

Different algorithms are used to create logic for the update of the design. Symmetry is applied where suitable to create easier logics for manufacturing, assembly and maintenance. Other logics included the ease of transportation.

The following list summarizes the operation of the parametric system.

1. Accept the main parameters
2. Calculate key parameters in Microsoft Excel
3. Pass these values to the Inventor model parameters
4. Use and pass these values to components
5. Use the parameter values to update the design of the component
6. Update the main assembly
2.4. TEXO Weaving Technology

Brief description of the weaving technology used by TEXO machines is given below to allow for further explanation of the weaving loom, which this project was executed on.

A. Frame and foundation

The whole loom sits on an I-beam foundation, which dispenses with the need of any foundation work on the floor. The foundation is filled with concrete to make it very heavy and stable. Each frame module contains 2-3 loom sections. All are in order to speed up the installation time.

The logic for the design of the foundation has considered the simplicity for transportation, the number section per block and others. The calculation of the length and position of most features was decided in Inventor except the holes for the fixture of the frame.

The frame is fixed on top of the foundation. The distance between the sections blocks of the frame are decided by the designer on the excel sheet after the calculations result in suggested values. These values will be sent to the inventor, which will decide the position of the respective framework. The positions of the holes on the foundation for the fixing the section blocks also use these values.

Figure 2-5: sections blocks of the frame fixed on top of the foundation
**B. Warp Beam**

The warp beam/beams are driven by AC servo. The warp beam parts are carried on support rolls.

**C. Break (lead) Rolls**

The lead rolls are non-rotating and chromium plated with short distance between warp beam and beat-up. The lead rolls are designed to be easily dismounted at warp drawing in.

**D. Load Cell**

Warp tension measuring is carried out over a load cell arrangement, installed between the lead rolls. The warp yarns always maintain a constant angle against the load cell regardless of the warp diameter.

![Figure 2-6: The Warp Beam and The Break Roll Systems](image)

**E. Dobby**

The DISCO dobbay is a Direct Individual Servo Controlled dobbay with a modular build up in 12 mm pitch. Each frame has its own servo drive, which gives it close to endless possibilities, such as adjustable start time, adjustable stroke and “relax” pattern at stop.

The frames are operated from below and connected via quick connectors to allow quick warp changes. The build-up is very clear and easy to overview and since it is a modular system, additional frames can be added afterwards. The entire unit is designed for minimum maintenance.

![Figure 2-7: The Dobby](image)

The kinematics simulation is done for the Dobby using one frame to with the different positions of the motor to find the optimum arm length out of the scope of this thesis project.
F. Weft insertion

The AC-servo driven, double side middle transfer band rapier is used for up to 12 weft yarns from left hand side of the loom. Weft presentation is done through TEXOs’ patented Pozi-Grip function. The drive unit for the rapier bands is stationary mounted to the loom frame and is separated from the lay beam. Weft tension monitoring system is type TEXO TWTS, including Eltex ETM load cell and IRO TEC brakes. Electronic adjustment of the weft tension is done through recipe. Weft stop motion, average tension, peak tension and double weft protection are some of the built in supervisions.

Figure 2-8: Weft insertion mechanism

G. Hooks

Hooks are mounted on a separate cam driven beam that moves in position at time for the weft insertion.

Figure 2-9: The exchange of weft and application of hooks
H. Take-up System

A complete new thinking to operate the three take-up beams gives the possibility to compensate for different speed on top and bottom layer in the fabric. The upper- and bottom take-up beams are separately driven with AC servo. The intermediate beam is mechanically connected to the bottom beam. The intermediate beam is opened and closed by pneumatic cylinders. The logic for updating the design of the take-up beams is done in the same assembly. It enables it perform its function with the current production capacity.

Figure 2-10: Take-up System in process

I. Breast Beam

Fixed Breast beam structure holds the reed, lay beam and supports the take-up system. The Breast beam bar is of sword type. The logic is created for each of the components of the breast beam assembly.

J. Wind-up

The wind-up is the system for the collection of the finished fabric. The three-beam wind-up system is driven by a torque controlled motor in order to maintain a constant pull.

The logic created for the wind-up system enables it to adjust to the requirements of the current fabric length.

Figure 2-11: The Wind-up system
K. Edge cords

Complete set-up of edge yarns, including creel, brakes, twisters and roll up is placed on the left and right side of the loom.

Figure 2-12: Edge Cords being inserted

L. Main Drive

The variable main drive where the speed on the loom can be optimized during one revolution allows the right combination between speed and quality to be established. A double drive over separate gearboxes is placed inside the loom over a synchronizing shaft. This system was not included in the design of the system, as it does not change with the requirements of the customer.

M. Control System

Omron loom control with a touch screen is mounted on the handrail, on one side of the loom. The user interface is a WINDOWS based program made to be very easy to operate. Electrical cabinets are placed on the foundation on each side of the loom. This dispenses with the need of cable channels and so on in the floor. FormStar is built in compliance with EC-directives for machinery, low voltage and electromagnetic compatibility. This part is put in the model only as a reference.

(TEXO AB, 2005) (TEXO AB, 2003)
3. Results

The model is completed with all significant components parameterized. The system is complete with Excel file integrated and enabling the transfer of parameter values. The main assembly is able to transfer the values to the components and update the design accurately.

It is tested for confirmation to inquiries placed at the start of the thesis work. The whole range for which the machine is built is checked. The result is compared to two former practical design produced by TEXO. These tests confirmed the reliability of the system. No bugs are found in the system, which should have been visible during the test otherwise.

The time to initialize the system is 2 minutes on average although it depends on the design state, which it is saved in. The time to operate depends on the design update amount required is in the range of 5-10 minutes in TEXO’s current computing systems. The file size is also known to depend on the design state.

The operating simplicity is fairly optimal. A manual has been prepared for guiding the operation of the system. The system is presented to its users and is found to be easily manageable.

The Dobby system was simulated additionally to evaluate the applicability of the main model for kinematic simulation. The test verified the feasibility of the model to be used as a simulation framework for future machines.

The transfer of the whole system is not done under the Pack & Go feature of invertor rather a simple copying of the directory will do the job. Otherwise some components of the assembly will be left, which a design update might require in the future.

The flexibility included by allowing manual improvement of the design is beneficiary. This is because any design output can be redesigned to accommodate additional customer requirements outside the expectable range.

The reusability of the assemblies and parts in a stand-alone or any other parametric system increased the benefits of the system for the future. The parts and assemblies can be used in any other design similar to the FSX concept. It will make the making of parametric design shorter and easier.
Figure 3-1: The FSX Model in Inventor
4. Conclusions and Discussion

The result is seen as a complete success in the feasibility of the parametric design. It has confirmed the possibility of simplifying the design phase in a CAD system for as big and complex machines as the FormStar.

The process of construction took around 18 weeks, which is equivalent to the design time required for customization of one machine module and another half. This assures the time and cost efficiency of the construction of the model to be at better than acceptable level.

Although this project is done only on the FSX project, the approach followed and the tools used shows the practicability of the technology in any design project. Autodesk Inventor is an excellent tool for a parametric design and the integration of Microsoft Excel has even made it better. Microsoft Excel is known to be the best database and calculation application available on the market.

The system created will enable TEXO to reduce its design phase time by more than 70%. That is to 15-20 days from previously 60 to 80 days. This will give the designers more time to focus on important issues of the design than being consumed by the everyday tasks of creating design modules. The additional days required for the customization of the loom are need for preparation of the 2D drawings and bill of materials.

Improvements in communications following the implementation of the system are indisputable. The sales department now already knows the possible machine modules that can be produced under TEXO’s design procedures. This enables them to directly negotiate with customers on feasible machines. As previously stated, there was a problem because the sales department had to contact the design team in order to negotiate an order from the customer. This had taken unnecessary time and created frustration in the past that reduced the customer satisfaction. The internal communication is now given the same level of improvement as the external because of the simplicity of the operating system. The purchase department is also benefited because the availability of information will enable it to order quickly. It should be easier to imagine how much improved capacity this would give to the management and financial systems.

The cost savings might be difficult to calculate now but will be visible during and after the implementation stage of this project. It will have an environmental benefit by effectively reducing the consumables needed in doing the same job manually. This is typical shown by the reduction in usage of printed material and electricity.
5. Recommendations

Further work on this project would enable the automation of drafting and preparation of bill of materials. This has not been done in this project due the limitation in time and scope.

The framework for the job processes in TEXO will need an adjustment to integrate the new system available. The management should consider the implementation of its objectives in the perspective of its application.

Adaption of this project should also consider the wider features of Inventor or any other application. For example in Inventor the IMate future will enables to create copies of parts that might be used for wider range of a component. This would increase the capacity of the model and the whole system in general.

After pursuing with this project we have seen the feasibility of parametric design in automating design processes. It would be even better if the application of parametric design is considered from initial stage in order to decrease the time needed construction and eliminate the alterations in technical information.
Bibliography


