IDENTIFY CUSTOMIZATION, MODULE OPPORTUNITIES FOR MACHINES AND PARAMETRIZE THE CONSTRUCTION

Case of the

TransCent TCR loom

MASTER THESIS REPORT

By:

ABEL BAJAY

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TransCent TCR loom

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Abel Bajay
Royal Institute of Technology (KTH)

Mentor: Mr. MARTIN GOVERDE
Technical Manager
TEXO AB
design.goverde@teixo.se

Advisor: Dr. OVE BAYARD
Department of Production Engineering
Royal Institute of Technology (KTH)
oveb@iip.kth.se

Kungliga Tekniska Högskolan (KTH)
School of Industrial Engineering and Management
Department of Production Engineering
S-100 44 Stockholm, Sweden
I declare that, apart from properly referenced quotations, this report is my own work and contains no plagiarism; it has not been submitted previously for any other assessed unit on this or other degree courses

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To my parents
Abstract

Paper is one of the elements used in our everyday life under its different forms; from the office use, newspapers, books, post-it, different packaging… it is ever present. The mass production of paper is made possible today by the industrial paper mill. One of a key component affecting the quality of the paper is the forming fabric used as a filter in the preliminary stages of paper manufacturing. The TCR Transcent is such machine used to produce the forming fabric and TEXO-AB assures two third of the world production of the machine. Given the ever increasing customer demand, machine variants and technological need, it is imperial for TEXO-AB to implement a time-efficient and responsive design system. This is made possible by shifting from traditional design to a logic based parametric design. The TCR loom model provided by the method followed in this report allows among other benefit a reduction of up to 28% in the time taken to design a new machine while still attending to the customization element providing a unique machine for every customer. The use of the model will afford designers more time to focus on other essential tasks, schemes and strive toward continuous improvement in terms of quality and technology.

Keywords: loom, parametric design, logic design, customization
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I. Introduction

1.1. Company description

TEXO is one of the world’s leading manufacturers of weaving looms for the production of paper machine clothing. More than two thirds of all the looms for the paper industry have been supplied by TEXO. TEXO was founded in 1946 and have developed and supplied over 1000 weaving machines the years.

With more than 50 years in the business, since 1984 – TEXO Inc. was established in Greenville, USA, to promote sales and provide support in both North and South America and from 1991 – Streamlined development and production modern industrial looms started.

TEXO’s headquarter and manufacturing facilities are located in Älmhult-Sweden. TEXO Inc. a subsidiary of TEXO AB in Greenville USA is responsible for sales and support in the North and South America. TEXO Pacific Company Ltd is responsible for service and support in the Pacific corridor.

TEXO makes paper production possible by producing machines that help manufacture critical parts for the paper mills, namely the forming fabric and the press felt.

With customer in focus TEXO does not mass produce looms. Every machine is carefully customized at the Lab-loom at the plant in Älmhult, Sweden.

TEXO Service program include assemblies, on-going maintenance, rebuilds, spare parts listings and training at the customer site, in Älmhult-Sweden or in Greenville, USA. TEXO documents every loom down to the very last detail of the 100,000 or so components that have been delivered over the years.

1.2. Operation process

The following diagram summarize the process from a customer order till the delivery of a weaving loom.
**Table 1 The process time**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Advertisement of the loom</td>
<td>-</td>
</tr>
<tr>
<td>2 Order placing</td>
<td>+/- 1 week</td>
</tr>
<tr>
<td>3 Checking manufacturability with design</td>
<td>+/- 2 weeks</td>
</tr>
<tr>
<td>PRE DESIGN. Main/Key parameters check</td>
<td></td>
</tr>
<tr>
<td>4 Feedback on manufacturability (Yes)</td>
<td></td>
</tr>
<tr>
<td>5 Information sent back to customer with quote</td>
<td></td>
</tr>
<tr>
<td>6 Feedback on the quote (approved)</td>
<td>+/- 2 weeks</td>
</tr>
<tr>
<td>7 Instructions to start the design</td>
<td></td>
</tr>
<tr>
<td>DESIGN PHASE</td>
<td>6 – 8 weeks</td>
</tr>
<tr>
<td>8 Order sent to manufacturer</td>
<td></td>
</tr>
<tr>
<td>PARTS MANUFACTURING</td>
<td>8 – 12 weeks</td>
</tr>
<tr>
<td>9 Manufactured part returned to TEXO</td>
<td></td>
</tr>
<tr>
<td>ASSEMBLING</td>
<td>5 - 7 weeks</td>
</tr>
<tr>
<td>10 Shipping of the loom to customer</td>
<td>3 - 4 weeks</td>
</tr>
<tr>
<td></td>
<td>+/- 28 weeks</td>
</tr>
</tbody>
</table>

Note that the design phase, parts manufacturing and assembly can overlap.
1.3. The problem

From the figure and the table above we can see that it takes roughly 7 months from the order placing to the delivery of a machine. Unless machines are identical (case of which will have a single design phase for more than 2 machines) it is nearly impossible for TEXO AB to adjust to an increase in demand. The actual setting, given overlaps in orders and design phases will only allow for a maximum of 5 machines per year.

In order increase the productivity and responsiveness to peaks in demand, something need to be done to reduce the overall lead time.

The areas taking too much time that are under the control of TEXO AB are the design phase and the assembly. The assembly is dependent of the availability of parts from suppliers which are in turn dependent on suppliers’ internal processes and the timing at which design drawing where given for manufacturing.

Assuming that the assembly process is nearly optimal, the area that needs some revision is the design phase. An improvement here will lead to the overall decrease of the total time but also that of the manufacturing.

TEXO AB can influence the manufacturing time if its orders are standards, have less part variability and are placed in time. This is where our work comes into production.

IDENTIFY CUSTOMIZATION, MODULE OPPORTUNITIES AND PARAMETERIZE THE CONSTRUCTION OF MACHINES

Identify customization and module opportunity: consist of developing standards in term of machine component and at the same time keep the window open for flexibility.

Parameterizing the construction will allow for a top-down design approach, which permits within a reduced time, just the time for the computer to update the model (experienced at approximately 7 minutes), to know if a design and manufacturability is possible, deliver a 3D version and drawing view of the whole machine, generate a bill of material for manufacturing and costing and deliver updated drawings for that particular machine within.

If completely implemented, the predesign and design phases of a loom would go from the actual 8-10 weeks to just about 2-3 weeks and also minimize and nullify the
time variation necessary to go from one machine to another with significant difference in design parameters and characteristics.

1.4. **The product**

A LOOM is a frame or machine for interlacing at right angles two or more sets of threads or yarns to form a fabric/cloth.

The basic purpose of any loom is to hold the warp threads under tension to facilitate the interweaving of the weft threads. The precise shape of the loom and its mechanics may vary, but the basic function is the same.

1.5. **Scope and limitation**

Despite the multiple opportunities and advantages that can be exploited and achieved with the full implementation of the of the method, the limited time imparted to us forces the thesis to focus only at delivering the key parameters with custom relationship among them and a functional 3D parametric model of the TCR Transcent loom. Further work will make possible the generation of an automated bill of material and ready to be used 2D drawings of each and every single component of the machine.

1.6. **Thesis’s outline**

The first part of this thesis comprises a brief background of the company and the industry in which it is competing, the product that we deal with throughout the thesis and objectives of the thesis.

The second parts explain the method used in order to achieve the desired results along with the possibility to export the solution to any other machine or product.

We later give results and a brief discussion from which we will pull a conclusion and give recommendations by opening door for future continuation work and further innovations.
1.7. The TEXO TCR Transcent loom

Transcent, by its name “Trans”: Beyond and “Cent”: Hundred means beyond hundred and indicates a machine able to exceed 100 picks per minute. Transcent is a high speed loom used for the weaving of paper machine clothing.

Dimensions
Total machine width: weaving width plus 9.0m (weaving width: from 7 to 18 meters)
Total machine height: 2.5m including foundation
Total machine depth: 6.8m including weaver’s bridge, wind-up and two warp-beams
Maximum warp tension: 1500kg/m
Maximum beat-up tension: 3000 kg/m
a) Frame and foundations

TEXO’s idea of a smooth and easy installation consist of having the whole loom pre mounted on a concrete filled I-beam foundation designed for installation on “flat” floor. The concrete filling makes it very stable. Each frame module is adapted to fit in to a standard freight carrier in order to give customers a cost effective investment.

b) Drive and lay movement

Transcent is driven by a patented Texo Dynamic Drive, TDD main drive. Each intermediate section is driven by synchronized AC servo motors via direct connected gearbox. Lay motion is achieved via shaft actuation of lay sword. Lay beam steel supported on each lay sword section. TDD Drive gives a virtual maintenance free, less power consumption and a very quiet loom main drive.

c) Take-up system

The TEXO three roll take up system gives the possibility to, compensate for different speeds of top and bottom layer in the fabric via separately driven AC servo upper roll.

Upper roll is supported with caterpillar belts for one solid roll surface to achieve better friction and by that higher quality to the fabric.
Intermediate and lower rolls are driven together via separate AC-servo drive. Intermediate beam is pneumatically operated for opening and closing.

Breast beam is fixed and breast beam bar of sword type.

d)      Warp beam arrangement

Warp beams of steel in machined execution in 1 piece. Warp beams carried on support rolls. The warp beam/beams are individually driven by AC-servo motor and reduction gearbox at one end of the between the non-rotating lead rolls and gives the warp yarn a constant angle regardless of warp diameter. TransCent from TEXO has warp beam handling system for easier canister change as standard.

e)    Control system

The entire TransCent is controlled by TEXO LoCoMo control system with Omron PLC. The loom frame located cabinets and the loom is pre-wired at delivery. User interface is a Windows based program made to be very easy to operate on an industrial PC with touch screen, including WinTexo software LAN connectable. Fully integrated water-cooling system for electrical cabinets and rapier AC-servos. TransCent is built in compliance with EC-directives for machinery, low voltage and electromagnetic compatibility.
f) Weft insertion
AC-servo driven double side middle transfer band rapier for up to 12 weft yarns from left hand side of the loom. Drive unit is stationary mounted to the frame and is separated from the lay beam movement. Hooks mounted on a separate beam, which moves in position at time of the weft insertion. Weft presentation trough Texo’s patented PoziGrip weft positioning system is controlled by weft tension monitoring and regulation system type TEXO TWTS, including Eltex ETM unit. Electronic adjustment of tension is through recipe. Weft stop motion, average tension, peak tension and weft protection are some of the built in supervisions as standard on a TransCent.

Fig.8b Weft insertion system

g) Dobby
TEXO’s DISCO is a Direct Individual Servo Controlled doby with modular build up in 12 mm pitch. Each frame is driven by AC servomotor, which gives it close to endless possibilities such as

Fig.9 Disco Dobby system
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 DISCO Dobby build-up is very clear and easy to overview and since it is a modular system, additional frames up to a total of 56 frames, can be added afterwards. The entire unit is designed for a minimum of maintenance. Frame position is controlled and visualized at operations menu on screen.

h) **Edge cords**
Complete set-up of edge yarns, including creel, brakes, twisters, temple and roll up

Fig.10 Edge cords system

i) **Wind-up**
Three-beam wind-up system driven by a torque controlled motor in order to maintain a constant pull. Polished beams under walkway for low friction against fabric.

Fig.11 Windup system

j) **Weaver's bridge**
TransCent is built to be user friendly, accessible all around the loom. Personnel can walk around the entire loom without using weaving room floor. Walkway is covered with non-slip carpet and secured with hand rail.
1.8. **Weaving process**

Weaving is a method of fabric production in which two distinct sets of yarns or threads are interlaced at right angles to form a fabric or cloth. The longitudinal threads are called the warp and the lateral threads are the weft or filling. The method in which these threads are interwoven affects the characteristics of the cloth.

Weaving is done by intersecting the longitudinal threads, the warp, i.e. "that which is thrown across", with the transverse threads, the weft, i.e. "that which is woven". (Collier 1974, p. 92)

![Fig.13 Weaving](image)

The major components of the loom are the warp beam, heddles, harnesses or shafts (as few as two, four is common, sixteen not unheard of), shuttle, reed and take-up roll. In the loom, yarn processing includes shedding, picking, battening and taking-up operations. These are the principal motions. (Collier 1974, p. 104)

**Shedding.** Shedding is the raising of part of the warp yarn to form a shed (the vertical space between the raised and unraised warp yarns), through which the filling yarn, carried by the shuttle, can be inserted. On the modern loom, simple and intricate shedding operations are performed automatically by the heddle or heald frame, also known as a harness. This is a rectangular frame to which a series of wires, called heddles or healds, are attached. The yarns are passed through the eye...
holes of the heddles, which hang vertically from the harnesses. The weave pattern determines which harness controls which warp yarns, and the number of harnesses used depends on the complexity of the weave. Two common methods of controlling the heddles are dobbies and a Jacquard Head.

**Picking.** As the harnesses raise the heddles or healds, which raise the warp yarns, the shed is created. The filling yarn in inserted through the shed by a small carrier device called a shuttle. The shuttle is normally pointed at each end to allow passage through the shed. In a traditional shuttle loom, the filling yarn is wound onto a quill, which in turn is mounted in the shuttle. The filling yarn emerges through a hole in the shuttle as it moves across the loom. A single crossing of the shuttle from one side of the loom to the other is known as a pick. As the shuttle moves back and forth across the shed, it weaves an edge, or selvage, on each side of the fabric to prevent the fabric from raveling.

**Battening.** As the shuttle moves across the loom laying down the fill yarn, it also passes through openings in another frame called a reed (which resembles a comb). With each picking operation, the reed presses or battens each filling yarn against the portion of the fabric that has already been formed. The point where the fabric is formed is called the fell. Conventional shuttle looms can operate at speeds of about 150 to 160 picks per minute. (*Collier 1974, p. 104*)

There are two secondary motions, because with each weaving operation the newly constructed fabric must be wound on a cloth beam. This process is called taking up. At the same time, the warp yarns must be let off or released from the warp beams. To become fully automatic, a loom needs a tertiary motion, the filling stop motion. This will brake the loom, if the weft thread breaks. (*Collier 1974, p. 104*) An automatic loom requires 0.125 hp to 0.5 hp to operate.
II. Methods

As highlighted earlier, the traditional design approach is bottom-up whereas the parametric design should be top-down. The difference comes from the fact that the traditional approach plugs information into sub-assemblies first and then those information and parameters individually will make up for the top assembly which doesn’t have information of its own.

The top-down approach work with parameters from the top assembly and trickled them down to the subassemblies.

To realize this, two conditions are necessary.

1. The pre-knowledge of main parameters of the loom at the top assembly level.
2. Parts that are expected to change in either quantity or size/form and all subassemblies should be flexibly built and parameterized.

2.1. **Software used**

*Microsoft Excel 2010*: used for tabulation of identified main parameters and for advanced beam deflection and other calculus.

*Autodesk Inventor 2012*: Used for the construction of the 3D model and advanced stress and strain analysis.

The software are at first used independently and later combined. The combination is done by attaching the excel spreadsheet containing figures to the inventor model.

Inventor is chosen for two reasons:

1. It is the design software that has been in use for years at the TEXO, and to reduce the compatibility problems that may arise during conversions between different software for previously designed parts we had to stick to it.
2. Inventor 2012 have a built-in module called iLogic. iLogic is a rule driven design solution add-in that allow for programming of case scenario directly on a 2D and/or 3D model.
iLogic software allows designers and engineers to capture and embed engineering and product knowledge directly into virtual models. It introduces a design for reuse and automation methodology that is the next logical step in parametric modeling. Whereas parametric design allows the capturing of design intent, Logimetric design allows one to capture design intelligence.

*iLogic Highlights*

- Uses the power of Autodesk Inventor™ to capture initial parametric design intent. iLogic™ is used to define the product behaviors, using logimetric rules, that result from changing the design input values.
- Provides easy access to powerful design automation functions through a simple, user-friendly interface designed for users with little or no programming experience.
- Lets users add knowledge to existing designs with full support for iparts and iassemblies. Rules can be added to any Inventor™ part or assembly model transforming it into a reusable knowledge asset.
- Extends Inventor's™ parameter types to include Boolean, string and multi-value lists.
- Defines product behavior based on true or false input or property values, such as Material type, Mass or even custom properties.
- Allows design and engineering knowledge to be defined and stored as iLogic™ Rule objects that are embedded directly into the models. With iLogic there are no new documents to manage!
- Introduces a new way of capturing design intent that goes far beyond what can be achieved with only parametric design capability. Capture design Intent with Parametrics. Capture design Intelligence with Logimetrics.

(Logimetric the thinking software accessed december 2011 http://www.logimetrixinc.com/iLogic.htm

An alternate approach to achieve the same results would be to use any other design software in conjunction with programming software of choice (C++, java…). Note here that a good base in programming skills will be required.

This modeling approach is similar to the skeleton approach available in other commercial design software (Pro-engineering, Catia, Solidwork and even Inventor)
with the difference being on the flexibility that free programing of parts at subassembly and top assembly yields.

2.2. **Steps**

To be able to construct a parametric model of the TCR Transcent Loom, a few steps are necessary.

1. Identify the loom main parameters and define the relation between them.
2. Design the parts and construct subassemblies
3. Program different case scenario within the selected range of variation
4. Assimilate subassemblies into the top assembly
5. Test and fix bug if necessary

1. **Identify loom parameters and define the relation between them.**
   At this stage parameters were identified using data from previously designed machines/loom and pre-calculated charts on how main parameters interact with each other. Data are set in an excel spreadsheet and relationship on how they affect each other for different machine sizes is established with formulae on the spreadsheet.

   Parameters here should be separated into two categories. Those that the customers dictate and the constants in the design form the first group and the rest which are calculated and variable from one machine to another form the second.

   At this stage it is possible to know the number of certain components such as supports, length of key parts such as beams and therefore we decided that it was necessary to add and run the beams deflection calculation, stress and strain, sheer stress, torque and other key mechanical design parameters.
When this phase is complete, it is already possible to know and judge if a particular customer-requested machine design and manufacturing is possible by meeting all the mechanical design and manufacturing parameters. Parameters and conditions that are not met are highlighted and if necessary and possible, adjustments can be made in order for all conditions to be met or else the request machine is declared a non-manufacturing possibility.

Fig. 14 Main Parameters Excel Snapshot
2. **Design the parts and construct subassemblies**

This is where machine components are designed in 3D and subassembly formed in a structure both agreed by the design and the sale department; a structure that facilitate both design and bill material extraction used for machine costing.

It is here necessary to note that the design of parts should be robust and designed in such a way that necessary changes and mathematical parameters integrated and easily modified for part that vary from one machine to another. Effort should be made to have a single or at most three user-parameters that control all necessary changes within a part and within a subassembly. This is achieved by the use of formulae that connect different parameters used in the construction of a part and/or a subassembly.

3. **Programming**

The programing is done at the subassembly level. The programming is used to make the subassembly flexible within itself in order to accommodate different case scenario for different machine requirements.
User-parameters that control the subassembly are created and let loose for connection on the top assembly.

![Programming Parameters ILogic Snapshot](image)

4. **Assimilate subassemblies into the top assembly**

This stage consists of bringing together all subassemblies to form the top assembly. Here the traditional align-mate-insert is used along with the coordinate system. Further programming take place at this stage in order to generate relationship between subassemblies. The created excel spreadsheet is then embedded in the inventor model and parameters are connected so that values pre-calculated from the spreadsheet are transferred to the top assembly which in turn will transfer those values to the let-loose parameters from the subassemblies which in turn will affect the individual parts in the desired and programmed way.
5. *Test and fix bug if necessary*

The last stage is to test how the model behaves, observe the changes, check for any collision or bugs in the way the model is updated. Customer defined parameters are entered in the excel spreadsheet and a model update is run in inventor in order to almost instantly have the 3D version of the model on the screen and from which 2D drawings can be generated, treated and sent for manufacturing after validation.

In order to avoid the navigation between two software interfaces, we can create a user interface in inventor in which customer defined machine parameters are typed, this data is automatically sent in excel which in turn will return the rest of calculated parameters to inventor, therefor creating a loop between the software.

*Fig. 17 Complete Loom Model Inventor Snapshot*
III. Results

3.1. Main parameters
After analysis of previously designed looms, 14 keys parameters were identified to be necessary in order to have a general representation of the loom in the top assembly.

The table below gives a summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bobbin type</td>
<td>Designate the widths of the bobbins used for the loom</td>
</tr>
<tr>
<td>Number of bobbins</td>
<td>Designate the number of bobbin necessary for a loom</td>
</tr>
<tr>
<td>Temple sword type</td>
<td>Designate the type of trim used for the loom.</td>
</tr>
<tr>
<td>Supports required</td>
<td>Designate the number of supports required for the warp beam</td>
</tr>
<tr>
<td>Number of intermediate sections</td>
<td>Designate the number of main building blocks and pair of AC servo motor needed for the loom</td>
</tr>
<tr>
<td>Cut Weaving width Length</td>
<td>Designate the final/trimmed width of the fabric</td>
</tr>
<tr>
<td>Weaving width ( nominal)</td>
<td>Designate the width of the untrimmed fabric the loom produce</td>
</tr>
<tr>
<td>Edges sections distance</td>
<td>Designate the distance between the first and last intermediate sections</td>
</tr>
<tr>
<td>Breast beam table</td>
<td>Designate the length of the breast beam table</td>
</tr>
<tr>
<td>Laybeam</td>
<td>Designate the total length of the beam used for battening</td>
</tr>
<tr>
<td>Rapier guide hooks</td>
<td>Designate the total length of rapier band rail</td>
</tr>
<tr>
<td>Take up beam</td>
<td>Designate the length of the three-level beam used for</td>
</tr>
<tr>
<td>Harness frame</td>
<td>Designate the length of the harness frame</td>
</tr>
<tr>
<td>Main reed width</td>
<td>Designate the width of the main reed</td>
</tr>
</tbody>
</table>

*Table 2 Main Parameters Summary*

The gray scaled parameters are those that are/can be influenced by the customer.

a) Bobbin type
Different bobbin design for looms are used in the industry today but in the effort to standardize TEXO design machines and gives customers the choice to pick between a 200mm and 280mm. Those are the two bobbins types available for the TCR transcent.

b) Number of bobbins
The number of bobbins is a critical element in the design of the loom. The bobbin contain the yarn and knowing the type of bobbin in term of width and the total of lateral number permits an approximation of the width of the final fabric.

The number of bobbins on a TCR loom should always be an even number and at best symmetrically distributed along the warp beam between the supports.
c) Temple sword type
A temple sword is the device that determines and controls the amount of fabric trimmed on a loom. TEXO avails 3 types of temple swords, a single temple sword 125mm, a double temple sword 240mm and a double wide temple sword 375mm.

d) Support required
The number of support required designates the number of necessary units required to avoid out of range deflection of the warp beam. TEXO has different type of supports but in order to increase the quality, a thinner support is required and therefore a 20mm support between bobbins is being dubbed as a new standard.

e) Intermediate sections
Intermediate sections are the core of the TCR loom. They are the steel structure that support the patented Texo Dynamic Drive TDD in charge of the drive and lay movement. Each individual intermediate section is driven by synchronized AC servo motors via direct connected gearbox.
On the TCR translucent loom the minimum distance between two intermediate section is 1570 mm and the maximum at 1700mm. Therefore the knowledge of the distance between the first and the last intermediate sections becomes valuable to calculate the number required and the distance between them.

f) Weaving width and cut weaving width
The weaving width is not a part of the machine, but it is the goal of the machine. The weaving width is the width of the woven material which is the final product of a machine and key parameters among what the customer expect. The cut weaving width is the trimmed to ulterior specification of the final fabric as produced by the TCR loom. The model we provide is meant to cover fabric of width between 7m and 18 meters width.

g) Laybeam
The laybeam as its name indicates, is the beam responsible for the lay motion of the loom. It length is directly related to the fabric width plus a safety of 30mm.

h) Take-up beam
It is a set of three stacked beams to guide the fabric to the windup and higher its quality. The take up beams total length is equal of that of the desired weaving g with
+ 160mm. given that the fabric have different speed from top to bottom, the takeup beams are driven by different and separate AC servo motors.

i) Harness frame

The harness frame is the frame that holds the heedless on the loom, the TCR transient use a harness frame of length nominal weaving width + 300mm. The harness frame determines the number of patterns that can be woven on the loom.

j) Main reed width

The reed resembles a giant hair comb used to push the weft yarn in position and to separates the threads and keep them untangled. The length of the reed is function of the temple sword type and the weaving width

3.2. Model testing

The model has been tested for responsiveness and accuracy over 50 times and counting. Testing consists of simulating various scenario of what type of loom a customer would request. This data is recorded and input in the Excel Spreadsheet which is linked to Inventor.

The feedback on feasibility is instantly available and the construction of the 3D model with the given parameters takes an average of 25 minutes. This time is directly influenced by the hardware on which the program is run.

90% of time, 45 out of 50 instances, the model responded well. We experienced some software unresponsiveness and freezing at the other instances.

Over 15000 mechanical components were parametrically and automatically adjusted by the input of 3 ms-excel cells.

3.3. Model Impact

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Advertisement of the loom</td>
<td>-</td>
</tr>
<tr>
<td>2 Order placing</td>
<td>+/- 1 week</td>
</tr>
<tr>
<td>3 Checking manufacturability with design</td>
<td></td>
</tr>
<tr>
<td>PRE DESIGN Main/Key parameters check</td>
<td>-</td>
</tr>
<tr>
<td>4 Feedback on manufacturability (Yes)</td>
<td></td>
</tr>
<tr>
<td>5 Information sent back to customer with quote</td>
<td></td>
</tr>
<tr>
<td>6 Feedback on the quote (approved)</td>
<td>+/- 2 weeks</td>
</tr>
<tr>
<td>7 Instructions to start the design</td>
<td></td>
</tr>
<tr>
<td>DESIGN PHASE</td>
<td>3 – 4 weeks</td>
</tr>
<tr>
<td>8 Order sent to manufacturer</td>
<td></td>
</tr>
<tr>
<td>PARTS MANUFACTURING</td>
<td>7-8 weeks</td>
</tr>
<tr>
<td>9 Manufactured part returned to TEXO ASSEMBLING</td>
<td>5 - 6 weeks</td>
</tr>
<tr>
<td>10 Shipping of the loom to customer</td>
<td>3 - 4 weeks</td>
</tr>
</tbody>
</table>

*Table 3 The new process time*

The impact of the project and model have made the Predesign phase irrelevant and reduce the Design phase by 50% - and the Overall time by 28% - Resulting in an improved designer focus, an efficient use of resources and better customer relation.
IV. Discussions and Conclusions

The identification of building parameters and the construction of the model was successful. We faced some difficulties at the beginning of the project in terms of scope limitation and structuring the data. Given that the task was never attempted before and that the expectations of it were not clear. This situation quickly led to scope creeping but as we progressed, it became clear on what to expect from the project and structure the approach.

4 weeks were spent in collecting and arranging the data from previously constructed model, and trying to find and/or develop a mathematical relations and logic to link the models. The construction and programming of the model itself took a further 12 weeks.

On its largest setting, largest machine, the model contains over 17,000 parts. This could have taken an enormous amount of time to build from scratch, but we were fortunate enough to have most of the CAD parts already developed in previous versions of Inventor. Work was done to convert them, modify those that could be modified but also reconstruct from scratch were it was necessary.

The most visible benefit of the model is that it allowed the purchasing department to give a quick instantaneous feedback to customers on whether what the customers asked was readily feasible. If declared not feasible, the model will propose the closest feasible machine, a size bigger and a size smaller.

We have to add here, that even if the model declares a machine not feasible, it still possible to modify certain parameters and make it possible to give the customer what they want. However this will be risky as venturing outside safety parameters and mechanical and mathematical tolerances will be the compromise to take.

An overall estimated 28% time saved on the development of every new loom is expected. That will afford designer more time for research and development and the responsiveness and quicker feedback will help improve customer relations and accelerate the reaching out to new customers.
V. Recommendations

- Redesign and/or modify all existing parts in order to increase the flexibility of the parametric-logimetric model.

- Increase specification/performance of the computers running the model in order to make the program faster and smoother during the update and allow quick generation of the full model 2D views.

- Integrate the Microsoft excel function directly into Autodesk inventor parameters by creating a separate part program that will handle main parameters.

- Develop a file storage system that will permit to keep history and data of previously designed machines using the parametric-logimetric model.

- Add data such as cost on major parts and enable the model to automatically generate a bill of material of the complete loom.

- Integrate mechanism for motion in order to identify collision that may occur when dynamic parts of the machine are moving during a functioning simulation.
VI. Acknowledgements

I would like to take time here to acknowledge and give thanks to:

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Abel Bajay
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