Graphic Model of the Processes Involved in the Production of Casegood Furniture

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Abstract

Imports from foreign furniture manufacturers are on the rise and American manufacturers must take advantage of recent technological advances to regain their lost market share. To facilitate implementation of technologies for improving productivity and quality, a graphic model of the wood furniture production process has been developed using the IDEF (ICAM—Integrated Computer Aided Manufacturing—DEFinition) modeling process and is presented. IDEF modeling provides a graphic representation of the production process by presenting the information in easy-to-grasp chunks. A description of the modeling process explains how the model represents the data that flows through the plant, the activities in the plant, and their interaction. Analysis of the model may result in improved communication, recognition of specific points for implementing new technologies, evidence of bottlenecks and problem areas, simplified inventory control, or reduction of paperwork.

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Introduction

As imports from foreign manufacturers increase, American wood furniture producers are searching for reasons for this loss of market share. Foreign competition in the furniture industry has increased significantly since 1972, and the greatest competition has been in the wood furniture category (U.S. Department of Commerce 1985). To regain market share, U.S. wood furniture manufacturers need to use new technologies. To better communicate and analyze manufacturing for applying the new technologies and improving productivity, a graphic model of the wood furniture production process has been developed. The model represents the functions of the wood furniture production system and the information and objects that interrelate with those functions.

Reasons for Loss of Market Share

The Myth of Labor Costs

The most common perception among American manufacturers for the cause of this increased competition is reduced labor costs associated with many foreign countries, especially those in the Pacific Rim. While this may have been true in the past, it is no longer true today. For example, Taiwan, for many years, has enjoyed the advantage of lower wage rates than the U.S. However, today Taiwanese firms faced with labor shortages operate below capacity. The factory workers that are available are demanding higher wages and improved working conditions (Smith and West 1991). Since this trend occurs as countries become more industrialized, it is reasonable to expect wage rates to climb in other Pacific Rim countries, also.

European manufacturers have no advantage in labor costs since wages in European countries are nearly the same as, or higher than, American wages. Aggregate figures for the 16 European countries for which 1988 data is available (Fig. 1) show that in 1986 European countries paid an average hourly rate at 83 percent of the United States average, 101 percent in 1987, and 105 percent in 1988 (U.S. Department of Commerce 1989).

The Reality of Quality

One reason for the U.S. loss of market share is the resistance of American manufacturers to design products with customer expectations in mind. In a recent international quality study conducted by the American Quality Foundation and Ernst & Young, it was discovered that Japanese companies are three times as likely as American and Canadian businesses to incorporate customer expectations into the design of new products and services. Furthermore, German businesses are twice as likely as North American businesses to translate customer expectations into the design of new products and services (Bemowski 1991).

Strategy for Improvement

By educating the workforce on the complete manufacturing process and the tools and techniques used to evaluate productivity and quality, America can regain its competitive status. The 1988 ASQC/Gallup survey reported that employee education is one of the most important ways to improve quality in American business (Ryan 1989). A practice common to recent winners of the Malcolm Baldridge National Quality Award is the implementation of training courses in managing for quality, making improvements, and using the tools and techniques available (Juran 1991). Before improvements in quality can be realized, managers must recognize the points where quality problems are likely to arise, where improvements are needed, and at which new techniques may be applied effectively.

Once expertise on managing for quality is acquired, new tools and techniques must be applied to gain control of the manufacturing process. "Gaining total control of the process requires a system applied uniformly across the operation, from raw materials to finished product, so that communication barriers come down via a common language and common format." (Slater 1991). A graphic model can be used to explain the manufacturing process to individuals not familiar with the furniture industry, as well as to pinpoint areas where quality might be a problem before final assembly.
Description of Model

This paper presents the graphic model of a typical casegood furniture plant. The model (Appendix A) was developed using the IDEF (Integrated Computer Aided Manufacturing—DEFinition) modeling process developed by the U.S. Air Force program for Integrated Computer Aided Manufacturing (ICAM) (Softech, Inc. 1981). The basic premise behind the process is that the human mind has the ability to accommodate any amount of complexity if it is presented in easy-to-grasp chunks that fit together to make the whole. To impose the restriction that only related information is shown on any single chart, the IDEF method limits a function to six or fewer subfunctions; thus a consistent level of detail for each function within a chart is maintained and decision points become apparent.

In using the IDEF method, each box in the model represents a function. Figure 2 contains six boxes, each representing a major stage in the production of wood furniture. Each arrow entering a box from the left represents an input and each arrow exiting a box from the right represents an output of the function. As shown in Figure 2, the order preparation stage (prepare order box) produces the supplies (including lumber, hardware, fasteners, adhesives), due date, and work center schedule. However, to see all the intermittent steps, it is necessary to explode the box into several smaller boxes. This decomposition is shown in Figure 3. Each of these boxes, prepare cutting order and procure supplies, in turn, can be decomposed further, hence Figures 4 and 5.

Arrows entering from the top represent constraints. For example, in Figure 2, the moisture content of the lumber is considered a constraint since moisture will affect how long it will take to prepare the lumber for processing. Arrows entering from the bottom represent mechanisms or devices needed to execute the function which that box represents. In Figure 6, the stickers placed in between the lumber to facilitate air flow are considered devices.

In addition, the IDEF method associates a node index with the entire set of charts. The node index, an outline of the process, is generated by assigning a number to each box within a single chart. If a box is exploded into another chart, each box within this chart is numbered and that number is appended to that of the "parent" box. The process continues recursively until entirely catalogued. The node index provides a listing of all the functions and is formatted to show "parent" functions and their "offspring." For example, Figure 2 is the overview of the process and is assigned the number 1A. Prepare order, a decomposition of the first function, is designated 1A1; prepare lumber, 1A2; dimension pieces, 1A3, and so on. Figure 3 generates 1A11, prepare cutting order, and 1A12, procure supplies.

If no greater level of detail is required for a particular function, then it is not imperative to generate additional boxes even though other functions that follow may require further decomposition. The complete node index for the entire process is presented immediately following the model in Appendix B.

The model describes the manufacturing processes of a dresser, bureau, or nightstand. It may be customized easily to show specific production lines for additional parts such as doors, or different procedures such as a gang-rip-first cutup operation.

Previous Applications

The IDEF modeling process improves problem analysis, requirements definition, and functional specifications through the rigorous expression of complex ideas that had seemed too abstract and obscure to treat technically. The process does not solve problems; it is a tool that allows people to express, understand, manipulate, and check problem areas.

The U.S. Air Force provides the showpiece of this technology in their ICAM program. Thousands of people from hundreds of organizations working on more than one hundred major projects used the methodology not only for the technical work of system definition and design, but for project management and integration as well.

Additional applications of this tool include system design, package design, documentation organization, curriculum design for teaching, and project estimation and management. Some specific examples are separation of function and design in environment control systems; uncovering overlooked tasks in the structure of a software development project; and assessment of the impact of factory modernization on engineering, purchasing, quality assurance, and shipping. Furthermore, one large corporation applied the IDEF product specification and design diagrams to meeting control; participants addressed specific issues and made decisions with less effort and time than before using IDEF (Ross 1985). These examples demonstrate the breadth of problems addressed using the IDEF modeling procedure.

Future Applications

Within the wood furniture industry, the possible benefits of applying the IDEF modeling process are vast. As furniture manufacturers move to respond to customers more quickly and take advantage of new technologies, they must analyze their product and current production system to determine which technologies are applicable and feasible. The analysis must also uncover points where the new technologies may be integrated with the current system. By modeling the production process with IDEF, such an analysis would be greatly facilitated.

Inventory control may be improved by diagram analysis to pinpoint areas where excess inventory is generated.
Figure 2.-1A Overview.

* Machine.
Figure 3.—Decomposition of prepare order.
Figure 4.—Decomposition of prepare cutting order.
Figure 5.—Decomposition of procure supplies.
Similarly, production flow may be streamlined as bottlenecks become obvious. Diagramming of the entire production system reveals work-in-process accumulation. Once such problems are identified, steps can be taken to resolve the congestion, such as adding another machine or rerouting work to a different machine.

Paperwork may be reduced and information flow improved. When all inputs to a function are identified, they may be checked, one by one, to see if that information is necessary to the function. If it is not necessary, that transaction can be eliminated and the information provided only when it is necessary. Conversely, by analyzing the IDEF model, it may become apparent that information required for a particular function may not be carried through formal communication channels. In this instance, a direct line of communication may be opened, thus eliminating the need for a production employee or expeditor to trace the information.

Decision making should improve. The IDEF model allows managers to analyze a specific subsystem while considering its interrelations with the system as a whole. Previously overlooked factors that influence decision making are revealed. In addition, downstream factors may have more bearing on decisions than previously realized, forcing decisions to be made too soon.

Setup time may be reduced once production employees become familiar with the entire manufacturing system. Also, when design engineers are acquainted with the complete process, design for manufacture can be implemented. An additional operation early in the production process may eliminate two or more operations later on. In addition, the change may be accomplished more easily earlier in the process. The IDEF model shows the most frequent changeover occurrences and which changeovers constrain the system.

The IDEF model of the wood furniture production process may be analyzed to shed light on a wide range of problems, not just those listed here. Only after these problems are defined, can they be addressed.

Literature Cited


Appendix A — IDEF Model

Figure 6.—Decomposition of prepare lumber.
Figure 7. - 1A Overview.
Figure 8.—1A1 Prepare order.
DETERMINE WHERE ON SCHEDULE ORDER IS TO BE PLACED

DETERMINE BILL OF MATERIALS (BOM)

ESTABLISH WORK CENTER SCHEDULE

guidelines for process times

due date

order dates for receipt of supplies if in feedback loop

due date

BOM

due date

work center schedule

Figure 9.—1A11 Prepare cutting order.
On hand inventory

Bill of materials

Due date

Work center schedule

Deduct on hand from BOM and update on hand inventory records

Need-to-buy list

Due date

Work center schedule

Cut purchase orders

Purchase order

Desired delivery date

Vendor's production schedule and on hand inventory

Place order w/vendor

Supplies

On-time delivery dates

Delayed delivery dates

Due date

Work center schedule

Figure 10.—1A12 Procure supplies.
Figure 11.—1A2 Prepare lumber.
Figure 12.—1A22 Kiln dry boards.
Figure 13. - 1A3 Dimension pieces.
Figure 14. – 1A32 Crosscut boards.
Figure 15.—1A33 Rip boards.
SELECT PIECES SUCH THAT THE TOTAL WIDTH APPLIES COMES CLOSEST TO DESIRED WIDTH WITHOUT GOING UNDER due date work center schedule

SUPPLIES selected pieces due date work center schedule

GLUE PIECES glue roller ball due date work center schedule

PUT TOGETHER AND CURE rough pieces of size due date work center schedule

Figure 16.—1A35 Glue boards together.
Figure 17.—1A36 Trim pieces.
Figure 18.—1A4 Shape pieces.

* Work center schedule with actual work done marked off.
** Ready to Assemble.
core pieces
supplies
due date
work center schedule

SET UP M/C's

supplies
due date
work center schedule

CUT EXTERIOR SHAPE*

shaped pieces
supplies
due date
work center schedule

machines*
sawdust

tenacity of lumber

CARVE INTERIOR DESIGNS**

shaped and carved basic pieces
flawed pieces
sawdust

machines**

PLACE IN WASTE BINS

* machines for this operation would include routers, lathes, tenoners, planers, and shapers.

** profiling m/c's, drills, carving m/c's, and boring m/c's.

Figure 19. - 1A41 Cut out basic shams
supplies
due date
work center
schedule

SET UP MACHINES

shaped pieces
supplies
due date
work center
schedule

RUN PIECES
THROUGH
M/C's TO
SHAPE EDGES

saw speeds
for type of
lumber

completed pieces
flawed pieces
sawdust

machines*

PLACE IN
WASTE BINS

* machines may include moulders, dovetailers, mitering machines.

Figure 20.—1A42 Shape edges.
Figure 21.—1A43 Sand pieces.
Figure 22. - 1A44 Inspect pieces.

- **Sanded pieces**
  - Supplies
  - Due date
  - Work center schedule
- **Flawed pieces**
  - Supplies
  - Due date
  - Work center schedule
- **Human operator**
- **SCAN SURFACES**
- **MARK FLAWS**
  - Pieces with minor flaws
  - Pieces with major flaws
- **REWORK FLAWED PIECES**
- **RTA which do not require pre-assembly staining**
- **RTA which require pre-assembly staining**
  - **COUNT NUMBER PASSED INSPECTION**
    - Count of number passed
    - (Work center schedule with actual work done marked off)
  - **PLACE IN SCRAP LUMBER PILE**
  - **Ready-to-assemble (RTA) pieces**
flawed pieces (minor) → FILL IN FLAWS → filled pieces → SMOOTH OUT FILLING → repaired pieces

PLACE IN WASTE BINS

paint brush

iron

Figure 23.—1A45 Rework flawed pieces.
Figure 24.—1A5 Assemble parts.
Figure 25.—1A51 Assemble frame.
Figure 26.—1A52 Assemble drawers.
Figure 27. - 1A53 Put frames and drawers together.
Figure 28.—1A54 inspect.
SPECIAL texture of wood
Supplies

+/
FILL AND STAIN

treated furniture

7 I
stained furniture

STAIN
supplies

TREAT WITH SPECIAL EFFECTS

okayed barewood furniture

PERFORM HIGH GLOSS RUBDOWN

stained furniture (glossy)

Figure 29.—1A55 Stain and finish.
Figure 30: 1A552 Fill and stain.
Figure 31.—1A553 Seal and stain.
Figure 32. 1A56 Attach hardware.
Figure 33.-1A565 Inspect furniture.
Figure 34.—1A6 Pack and ship.
Appendix B — Node Index

1A. Overview

1A1. Prepare order
1A11. Prepare cutting order
   1A111. Determine where on master schedule order is to be placed
   1A112. Determine bill of materials
   1A113. Establish workcenter schedules
1A12. Procure supplies
   1A121. Deduct on hand inventory from bill of materials and update on hand inventory records
   1A122. Cut purchase orders
   1A123. Place order with vendor

1A2. Prepare lumber
1A21. Stack boards of one kind of lumber
1A22. Kiln dry boards
   1A221. Get stack(s) of boards of type of lumber specified on work center schedule
   1A222. Move and put in kiln and adjust controls
1A23. Test moisture content
1A24. Unstack boards

1A3. Dimension pieces
1A31. Plane boards
1A32. Crosscut boards
   1A321. Scan board for defect information
   1A322. Determine where crosscuts should go to get largest clear area of desired length
   1A323. Crosscut boards
   1A324. Place in waste bins
1A33. Separate boards by length
1A34. Rip boards
   1A341. Set saw blades for desired widths
   1A342. Feed boards through rip saw
   1A343. Place in waste bins
1A35. Glue boards together
   1A351. Load selector
   1A352. Scan pieces
   1A353. Select pieces such that the total width when glued together comes closest to desired width without being under desired width
   1A354. Apply glue
   1A355. Put boards together and cure
1A36. Trim pieces
   1A361. Resurface pieces
   1A362. Trim pieces to uniform length
   1A363. Apply veneer or vinyl coating

1A4. Shape pieces
1A41. Cut out basic shapes
   1A411. Set up machines
   1A412. Cut exterior shape
   1A413. Carve interior designs
   1A414. Place (flawed pieces and sawdust) in waste bins
1A42. Shape edges
   1A421. Set up machines
   1A422. Run pieces through machines to shape edges
   1A423. Place flawed pieces and sawdust in waste bins
1A43. Sand pieces
   1A431. Set up sanding machines
   1A432. Run pieces through sanders
   1A433. Touch up intricate work by sanding by hand
   1A434. Place sawdust in waste bins
1A44. Inspect pieces
   1A441. Scan surfaces
   1A442. Mark flaws
   1A443. Place in scrap lumber pile
   1A444. Count number passed inspection
1A45. Rework flawed pieces
   1A451. Fill in flaws
   1A452. Smooth out filling
1A46. Stain pieces which will be visible only part of the time

1A5. Assemble parts
1A51. Assemble frame
   1A511. Attach sides to top
   1A512. Attach shelves
   1A513. Attach runners
   1A514. Attach to pallet
1A52. Assemble drawers
   1A521. Join sides to back
   1A522. Attach bottom
   1A523. Attach drawer fronts
   1A524. Attach slides (and blocks)
1A53. Put frames and drawers together
   1A531. Insert drawers into frames
   1A532. Affix stops
1A54. Inspect
   1A541. Visually scan pieces
   1A542. Mark flaws
   1A543. Pull off assembly line
   1A544. Put in buffer area
1A55. Stain and finish
   1A551. Treat with special effects (highlight, fly speck)
   1A552. Fill and stain
      1A5521. Spray stain on bare wood
      1A5522. Rub off runs
      1A5523. Dry furniture
   1A553. Seal and stain (top coat)
      1A5531. Apply finish (glaze)
      1A5532. Rub off runs
      1A5533. Dry furniture
   1A554. High gloss rubdown
1A56. Attach hardware
   1A561. Kit hardware
   1A562. Assign kit to piece
   1A563. Attach hardware to piece
   1A564. Wipe off furniture
   1A565. Inspect furniture
      1A5651. Thoroughly inspect piece visually
      1A5652. Increment count of finished goods by one
   1A5653. Mark flaws
      1A5654. Pull off line
      1A5655. Place in buffer area
1A6. Pack and ship
   1A61. Wrap in packing material
1A62. Fit box around piece
1A63. Seal top of box
1A64. Remove furniture from pallet
1A65. Seal bottom of box
1A66. Transport to warehouse or waiting truck

Imports from foreign furniture manufacturers are on the rise, and American manufacturers must take advantage of recent technological advances to regain their lost market share. To facilitate the implementation of these technologies for improving productivity and quality, a graphic model of the wood furniture production process is presented using the IDEF modeling process. Description explains the data that flows and the activities that occur in the plant, and their interaction. By analyzing the model, communication may be improved, specific points for implementing new technologies may occur, bottlenecks and problem areas may become evident, inventory control may be simplified, and paperwork may be reduced.

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