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A generic simulator for continuous flow manufacturing

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ABSTRACT

The incorporation of concepts such as flexible manufacturing (FMS), computer-integrated manufacturing (CIM), just-in-time (JIT), and total quality control (TQC) in modern manufacturing environments render simulation modeling of such systems a complex and time consuming task. Continous flow manufacturing (CFM) is a manufacturing strategy that employs the above concepts. This paper describes a generic simulator for modeling CFM systems. The simulator allows the details of the system to be represented parametrically, following a "core" modeling approach to represent the manufacturing logic. The focus in developing the simulator has been to represent the complex phsical and operational characteristics of CFM systems in a realistic manner. In addition, quick and easy model development without involving repetitive programming for similar CFM systems has been an important consideration.

1. INTRODUCTION

Modern manufacturing systems possess a highly dynamic character and undergo continual changes in their structure and composition due to the impact of new technology, new products, new product mixes, and processing of multiple products at work centers. The pressures of enhanced productivity, quality, and global competition have forced managements to change their operating philosophies and adopt strategies like flexible manufacturing (FMS), total quality control (TQC), and continuous flow manufacturing (CFM).

Particularly during facility design, weekly changes can occur in the selection of process technologies, material handling, product routings, and workplace configurations. For large facilities, each modification can mean a significant programming effort in a traditional simulation language, which in turn means that analysis of system performance can never keep up with changes in the proposed system design.

This paper describes a parametric simulator, called SIM-CFM, developed at the University of Massachusetts that allows for the rapid development of simulations for large-scale continuous flow manufacturing facilities. One goal in developing this simulator has been to allow manufacturing engineers to readily describe changes in system configuration, including large-scale changes such as changes in layout, tooling, and product flow. This is accomplished by combining a user-friendly front-end with what we have called a "core modeling" approach to manufacturing simulation.

A number of researchers have developed parametric models and program generators for FMS [Mathewson, 1975; Lenz, 1980; Jain, 1986; Warnecke, et al., 1986; Watford and Greene, 1986], and Ketcham and Watt have earlier applied a core modeling approach to FMS [1987a, 1987b]. CFM systems, however, involve a different control logic than FMS with complex design issues of their own. These can be represented in a simulation by a common logic for the entire class of CFM systems. To illustrate these design issues, this paper first discusses issues in CFM system design and then discusses the simulation techniques developed to efficiently represent large-scale CFM systems.

2. THE PROTOTYPE MANUFACTURING SYSTEM

This simulator was initially developed for an electronic chip manufacturing line currently being installed. This is a complex large scale manufacturing line that adopts a CFM strategy. Although originally developed to model a specific system, SIM-CFM can be applied to a large class of systems of a similar type.

CFM incorporates the concepts of just-in-time (JIT), FMS, TQC, and computer integrated manufacturing (CIM). The size of CFM systems can be gauged from the line for which SIM-CFM was developed. In its current form, the line includes approximately 200 operations, organized into 30 sectors. There are nearly 50 batch machines and 10 continuous machines, such as ovens, with many inspection points along the line. Process controls, similar to kanbans in a JIT system, manage the level of work-in-process (WIP) in each sector, including rework. JIT principles are employed in a coarse manner by regulating the flow the flow of products betwen groups of operations designated as sectors rather than between individual operations. Kanbans are used for each sector to represent the maximum allowable WIP in the sector.

FMS aspects of the system include the allocation of alternatie machines for operations and sharign of machines by multiple operations. Sharing machines results in lesser flor space area. Providing alternate machines for an operation by clustering similar machines ensures continous operation of the line in spite of machine breakdowns.

Quality control policies mean that each product is inspected at several points in each sector. The duration of minor inspections ranges from 5 to 15 minutes. Major inspections, though few in number, range from one to four hours. There may be several complex rework loops within a sector and between sectors, with up to four alternate rework routes from certain operations.

The system processes two types of jobs, namely rush and regular jobs. Rush type jobs have priority over regular jobs in process and batching activities. Both job types follow the same routing.

3. AN EXAMPLE SYSTEM

The working of a CFM system in terms of its components and their inter-relationships will be described with the help of an example system that represents a scaled down version of typical CFM systems. The structure of the system and the routing for the product can be seen in Figure 1. We will refer to this example throughout the paper when individual aspects of the simulator are discussed.

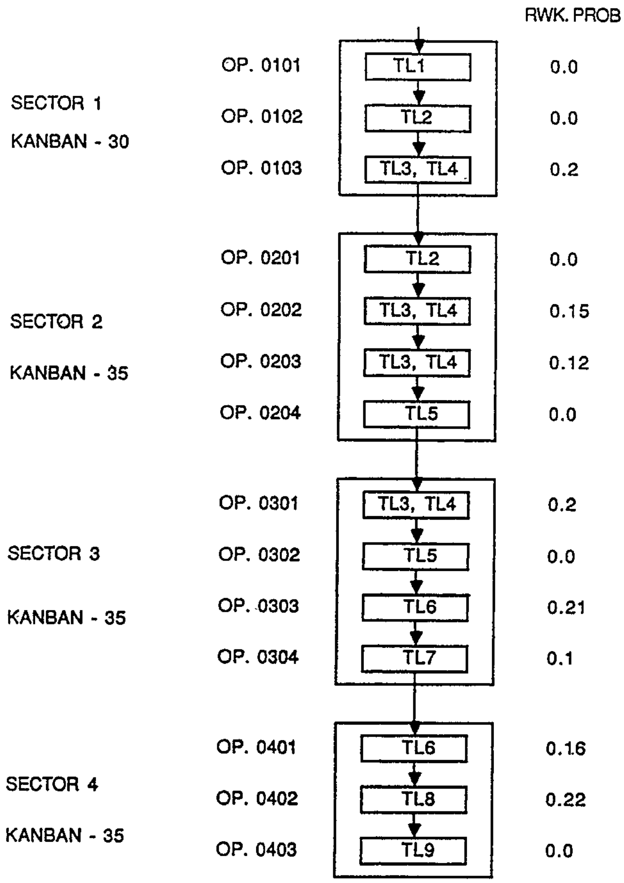

Figure 1. Flow diagram of the example problem

The example system has 14 operations which are grouped into 4 sectors. Sectors 1 and 4 have 3 operations, and sectors 2 and 3 have 4 operations each. The operations are served by 9 machines. The products are processed on these machines either individually or as a batch.

Machines are classified into two types namely, batch and continuous. Batch machines are those that operate on a single product batch at a time. The product batch size can be 1 or more than 1. When the machine is busy, product batches arriving to the machine must wait until processing is completed on the batch presently on the machine. On the other hand, continuous machines can process more than 1 product batch at the same time. Like the batch machine, batch sizes can be 1 or more than 1. The number of batches that can be handled at any time depends upon the physical capacity of the machine. The batch and continuous machines are subjected to fixed downtime such as breaks and preventive maintenance and also random breakdowns.

It can be seen from Figure 1. that more than 1 machine is available for some operation. For example operation 0202 in sector 2 can either be processed on TL3 or TL4. Also, a single machine can serve many operations. Machine TL2 serves operations 0102 and 0201.

Due to inspections at certain operations, product defects are detected and sent for rework. The rework operation could be any operation within the same sector as the operation where the defect was detected or in any other sector. The probabilities of the occurrence of rework is also given in Figure 1. The product after rework can either come back to operation where the defect was detected or it can proceed in sequence from the rework operation. At certain rework operations, the product may have to undergo purge or strip-off operations before the actual rework operation is performed. This is essentially a cleaning operation to undo the effects of the defective operation.

The WIP in each sector is regulated by kanbans. The WIP in each sector is not allowed to exceed the limit imposed by the kanban.

Raw materials are introduced into the line in batches at regular time intervals.

4. OPERATIONAL POLICY DECISIONS

In contrast to FMS, where a principal concern is job scheduling, the major issues in CFM are the tooling layout, differences in tooling characteristics, product rework and WIP regulation. Some of the important characteristics of the system are:

- Grouping of operations by function into sectors
- Implementation of WIP regulators or kanbans for sectors
- Existence of batch and continuous tools
- Extensive product rework
- Multiple operations on the same tool
- Batching of products

Due to the evolutionary nature of the product and technological advancements, changes in the product and process design occur frequently. Changes can take the form of addition or deletion of operations or machines, changes in machine layout, and changes in the organization of the system.

System performance is affected not only by changes in the structure of the system affect, but also by its control policies. These policies dictate the interactions between the physical objects in the system. Some of the critical policy issues are discussed below:

(1) Machine layout: The presence of alternate machines at an operation and the sharing of machines by multiple operations poses many machine layout problems. In the example system, machines TL3 and TL4 are shared by operations 0202, 0203 and 0301. Products from all the three operations can be processed on either TL3 or TL4. Such a layout is called a "farm" layout wherein machines of similar function can be clustered. If machine TL3 had been dedicated to one operation, say 0202, and TL4 to operations 0203 and 0301, then this layout would be a "dedicated" layout. This kind of a layout is typical of the traditional flow line where machines are dedicated to operations. The "farm" layout is the result of including FMS characteristics into the flow line as part of the CFM strategy.

Both types of layouts have their advantages and disadvantages. The "farm" layout ensures continuous processing of products without stoppage. In the example, if TL3 goes down due to a random breakdown, then all the three operations could still proceed as TL4 can handle them. But in a "dedicated" setup, it would mean stoppage of operation 0202. This would in turn result in the build-up of WIP in sector 2 and the starvation of machines downstream. Due to the presence of kanban, the WIP build-up could prevent the entering of products into the sector from sector 1.

The "farm" layout suffers from a major drawback by imposing a higher demand on the material handling equipment. If the cluster is located close to operation 0202 and if travel distances are long for operations 0203 and 0301, then this would mean a high portion of utilization of the material handling equipment. An optimal location for the cluster maybe a complex problem by itself as there maybe other physical and control variables which may constrain the situation. As a result, the CFM line is flexible enough to accommodate both types of layout to exist within the same line. However, analysis must precede any decision in selecting either type of layout.

(2) Machine specification: At a cluster, the particular machine on which the product has to be processed has to be decided. The natural policy in such cases is to choose the first available machine. But in some cases where there are individual queues or input buffers to machines, alternate courses exist. The machine with the shortest queue or the machine with the shortest total processing time can be selected.

(3) Product batching: Because multiple operations can share the same machine and the machines can process multiple products as a batch, the batching rules assume a special importance. Batching can occur either among products from the same operation or products going to the same tool from different operations. Batching of products from different operations can occur only if they can be identified individually after processing so that they can proceed to their corresponding successor operation.

(4) Maximum and minimum batch sizes: Situations may exist where a free machine may be available and wait for a product batch to be formed. Machine under-utilization coupled with products waiting to be batched is uneconomical and will result in higher product cycle time. In such cases, to lessen the idle time, the batch sizes could be reduced so that the batch is formed faster leading to improved usage of the machine. The extent to which the batch sizes can be reduced can be addressed effectively by monitoring machine idleness and the product batching activity.

(5) Rework and kanban: When a product is sent to rework in a different sector, as any other product it has to obey the kanban to enter the sector. We know that any rework operation adds to the cycle time of the product. Hence, in rework situations, it maybe argued that the rework product maybe treated as special cases and be allowed to break the kanban. Moreover, rework products have more value added on to them as they would have been in the system longer than the regular products. Breaking the kanban limit however contradicts the principle of CFM to strictly regulate WIP in sectors. Thus the decisions mean a trade-off between excess WIP in the sector and increases in the product cycle time.

(6) Queue discipline: Products wait in a queue in front of the machine for processing. The general discipline followed is first-in, first-out. But for the same reasons discussed before, rework products could be prioritized in these queues. The impact of such a preference upon system behavior and performance has to be studied before implementation.

The impact of design and policy decisions need to be analyzed in detail to study their impact on key system performance measures like product cycle time, line throughput, sector WIP, and machine utilization.

5. MODELING APPROACH

So far, we have discussed the characteristics of the system. We shall now focus on the modeling technique adopted for the simulator.

From the description of the prototype CFM line under development, the number of system description parameters can be gauged. Since developing systems have to be evaluated frequently due to design changes, model construction or changes in the model are not easy to perform. Moreover, it is advantageous to make use of the generic logic common to all CFM systems. This can be done by separating the simulation into a model that describes the system logic frame and a set of parameters that describe the system configuration and performance characteristics. The system logic frame can be construed as a skeleton or a "core" model of CFM systems. The "core" model will not contain any specific data or configuration but just the manufacturing logic. Developing a simulation then involves building individual models from the "core" model using the data from different parameter sets. By permanently retaining the common logic, the "core" modeling approach eliminates the need for programming when developing models of new systems or changing parameters for existing systems. The user now can define different configurations by entering the respective parameters.

5.1. Structure of the Core Model

The "core" module is a set of modules representing both the physical construction of the system and the controlling functions. The modules and their links with one another can be seen in Figure 2.

Sector module: The sector module acts as a gate for jobs entering a sector. Products can enter the next sector from the previous sector only if the WIP in the next sector is below its kanban level. This module also keeps track of the WIP and the associated statistical measures like the sector cycle times for the product, the time interval between products coming out of the sector, the queue length for products waiting to enter the next sector due to kanban, and the corresponding waiting time in these queues.

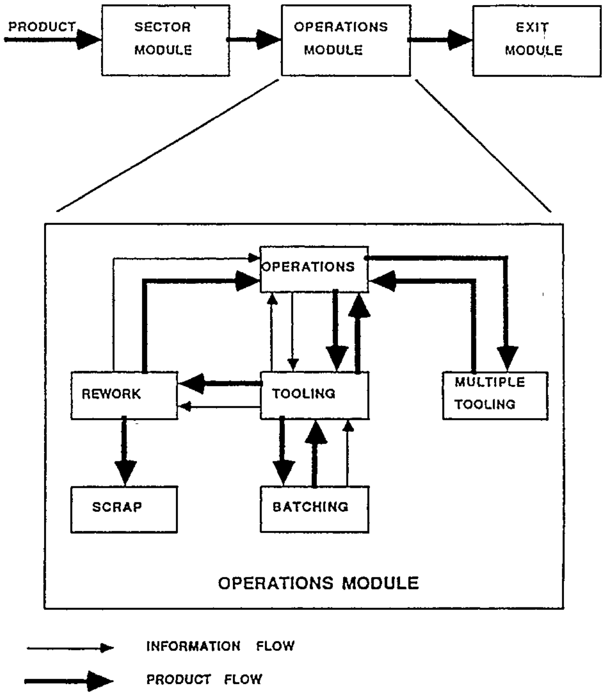

Figure 2. Structure of the "Core" Model

Operations module: This module is divided into 6 sub-modules. They are:

(1) Operation sub-module
(2) Multiple tooling sub-module
(3) Batching sub-module
(4) Tooling sub-module
(5) Rework-sub-module
(6) Scrap sub-module

Operation sub-module: The operation sub-module is a controlling module for the 5 other sub-modules. It coordinates the movement of the product within these sub-modules. Decision-making here is dependent upon many factors like job type, tool type, layout, and dynamic characteristics like the loading on the tool, WIP, batch sizes, etc. Among these characteristics, the batch size forms the key aspect handled in the operation sub-module.

The method of choosing between the maximum and the minimum batch sizes is given below in the form of an algorithm:

Step-1: Choose the tool for the operation.
Step-2: Assign the batch size to be the maximum batch size for the chosen tool.
Step-3: Check tool status.
If tool is free then go to step-4.
Else go to step-6.
Step-4: Check batching queue length for the operation.
If there are no other products in the batching queue go to step-5.
Else go to step-6.
Step-5: Assign the batch size to be the minimum batch size.
Step-6: Batch the products according to the assigned batch size.

Multiple tooling sub-module: This module comes into play only when there is more than 1 tool for a particular operation and reflects the existence of a "farm" layout. The rule used here is that the product selects the first tool that is free. If none of the tools is free, then the tool with the shortest queue length of waiting products in front of it is selected. Ties are broken arbitrarily.

Batching sub-module: The actual batching of the products takes place in the batching module and is done by means of batching queues for each operation. Statistics for the waiting time to form a batch are also collected in this module.

Tooling sub-module: The actual processing of the product is done in this module, after the tool for the operation has been selected. Priority for processing is given at two levels. First, rework products have a higher priority than non-rework products. Second, among rework and non- rework products, rush products have a higher priority than regular products. After processing finishes, it is decided whether the product has to be reworked or not based on rework information that resides in the parameter frame.

Tool breakdowns and maintenance also take place in this module in accordance with the specified mean-time-to-fail (MTTF) and the mean-time- to-repair (MTTR).

Rework sub-module: Products that have to be reworked after processing come to the rework module. Reworked products also return to this module. In this module the product status is changed from rework to non-rework or vice versa depending on whether the product is going to be reworked or has finished being reworked. For a product going into rework, any additional strip-off operation is performed in this module.

Two types of rework routings can be handled after the rework operation. The product can either be sent back to the source operation where the rework was detected or it can continue in sequence from the rework operation. Depending upon the sectors for the source and rework operations, WIP increases and reductions are handled appropriately.

Due to the special nature of the rework products, they are allowed to enter the sector even if the WIP levels are at the kanban limit.

Scrap sub-module: As part of the rework routings, a product can be scrapped from any operation. When it scrapped, the product comes to this module where it is disposed off and the relevant statistics are collected.

Exit module: All products after total processing leave the system via this module. The statistical measures recorded here are the overall cycle time in the system and total line throughput.

5.2. *Modeling Parameters*

The parameter frame possesses the actual details of each system to be simulated. The following are the key characteristics of the system that are represented in each parameter frame.

(1) Sector information
(2) Operation information
(3) Rework information
(4) Tooling information
(5) Product information
(6) Modeling information

Model Capacities

The capacities of the "core" model are given below:

Maximum number of sectors: 45
Maximum number of operations: 250
Maximum number of batch machines: 80
Maximum number of continuous machines: 20
Maximum number of rework routes from an operation: 4
Maximum number of alternate machines at an operation
- Batch machines: Any #
- Cont. machines: 4

6. SIMULATION OUTPUT

The following are the output measures are obtained from the simulation:

(1) The sector cycle times
(2) The overall cycle time
(3) The sector WIP levels
(4) The line throughput
(5) The machine utilization
(6) The queue time for machines
(7) The batching time for operations
(8) The machine queue length
(9) The kanban waiting time
(10) The kanban queue length
(11) The time between products coming out of each sector

A portion of the output for the example problem is given in Figure 3.

SIMAN RUN PROCESSOR RELEASE 3.0
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SIMAN SUMMARY REPORT

RUN NUMBER 1 OF 1

PROJECT: CHIP PROBLEM6
ANALYST: SHEKAR
DATE : 6/12/1988

RUN ENDED AT TIME : 0.2500E+04

TALLY VARIABLES

NUMBER	IDENTIFIER	AVERAGE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBS.
1	REG SEC 1 CT	129.99422	52.21672	59.84036	351.14832	342
2	RUSH SEC 1 CT	113.96909	58.69228	63.84009	509.08472	117
3	REG SEC 2 CT	197.71399	48.91254	126.86407	533.36401	278
4	RUSH SEC 2 CT	183.23541	36.85294	119.86429	326.43506	91
5	REG SEC 3 CT	191.38940	79.47878	29.25720	651.84155	282
6	RUSH SEC 3 CT	171.37636	64.76559	75.22821	427.24475	83
7	REG SEC 4 CT	108.82949	57.47629	34.74634	401.13470	233
8	RUSH SEC 4 CT	102.85915	51.21770	36.96497	272.12164	73
9	REG OVERALL CT	674.56	153.10	416.03	1346.54	233
10	RUSH OVERALL CT	604.89	145.95	386.91	1205.24	73
11	OP 0101 BATCH	10.00251	19.12877	0.00000	98.71188	128
12	OP 0102 BATCH	3.22627	8.61096	0.00000	66.18091	154
13	OP 0103 BATCH	6.16073	8.47171	0.00000	45.30115	147
14	OP 0201 BATCH	3.92469	8.47598	0.00000	39.63306	120
15	OP 0202 BATCH	7.31395	10.65509	0.00000	48.84363	131
16	OP 0203 BATCH	8.28083	10.25165	0.00000	44.55994	134
17	OP 0204 BATCH	30.72219	24.75401	0.00000	90.76746	39
18	OP 0301 BATCH	6.57021	10.61391	0.00000	45.22876	121
19	OP 0302 BATCH	38.15905	28.54137	0.01285	105.49646	40
20	OP 0303 BATCH	21.15481	26.13212	0.00000	96.14990	47
21	OP 0304 BATCH	31.53618	30.90160	0.00000	105.12354	39
22	OP 0401 BATCH	39.72985	30.23183	0.00928	119.98804	38
23	OP 0402 BATCH	12.77287	20.31872	0.00000	72.76086	76
24	OP 0403 BATCH	4.59523	14.32984	0.00000	115.32983	155
25	OP 0101 QUEUE	10.42757	13.79697	0.00000	67.93286	128
26	OP 0102 QUEUE	0.77081	3.02495	0.00000	35.97034	357
27	OP 0103 QUEUE	1.29376	6.33981	0.00000	47.41443	147
28	OP 0201 QUEUE	1.99003	6.12997	0.00000	42.94177	371
29	OP 0202 QUEUE	2.08497	7.68279	0.00000	47.97485	131
30	OP 0203 QUEUE	1.35627	5.87143	0.00000	35.75598	134
31	OP 0204 QUEUE	0.78371	4.89427	0.00000	30.56470	39

DISCRETE CHANGE VARIABLES

NUMBER	IDENTIFIER	AVERAGE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	TIME PERIOD
1	KANBAN 1 QUE LEN	2.73980	4.32047	0.00000	17.00000	2500.00
2	KANBAN 2 QUE LEN	3.26935	4.27507	0.00000	21.00000	2500.00
3	KANBAN 3 QUE LEN	1.41084	2.83216	0.00000	12.00000	2500.00
4	KANBAN 4 QUE LEN	0.00000	0.00000	0.00000	0.00000	2500.00
5	SECTOR 1 WIP	23.80088	7.98210	0.00000	35.00000	2500.00
6	SECTOR 2 WIP	31.91668	7.34944	0.00000	40.00000	2500.00
7	SECTOR 3 WIP	27.70055	10.60814	0.00000	41.00000	2500.00
8	SECTOR 4 WIP	13.43779	8.04443	0.00000	30.00000	2500.00
9	TL1 UTIL	0.29796	0.45736	0.00000	1.00000	2500.00
10	TL2 UTIL	2.58283	1.91459	0.00000	5.00000	2500.00
11	TL5 UTIL	1.85248	0.90673	0.00000	5.00000	2500.00
12	TL6 UTIL	0.31751	0.51680	0.00000	2.00000	2500.00
13	TL9 UTIL	0.78700	0.90631	0.00000	2.00000	2500.00
14	TL3 UTIL	3.16559	3.84053	0.00000	20.00000	2500.00
15	TL4 UTIL	2.02722	4.52816	0.00000	20.00000	2500.00
16	TL7 UTIL	0.45774	1.42070	0.00000	7.00000	2500.00
17	TL8 UTIL	0.43292	1.19643	0.00000	5.00000	2500.00

Figure 3. Simulation Output

7. IMPLEMENTATION OF THE SIMULATOR

7.1. Selection of the Simulation Language

The SIMAN simulation language was chosen for implementing the simulation. Its inherent structure of model separation from experiment data made it the best candidate language. The "core" model is the SIMAN model frame and each individual set of parameters is represented by its respective SIMAN experiment frame.

7.2. The User Interface

Since every detail of operations, machines, rework, etc. has to be represented to the core model, manually constructing a SIMAN experimental frame would be a time consuming and laborious task. This defeats the goal of quick and easy model construction. Hence the need exists for a user-interface where the user need not be concerned with the requirements of the simulation language but, instead, can enter the model data in a simplified format into a data base. The information in the data base can then be used to automatically generate the SIMAN experiment frame.

The interface consists of a series of screens that are constructed in a manner similar to that of a spread-sheet. There are eight basic types of screens. They are:

(1) Project screen
(2) System screen
(3) Sector screens
(4) Kanban screen

(5) Tooling screens
(6) Tool schedules screens
(7) Rework screens
(8) Simulation specification screen

The user-interface is adaptable to the size of the model as screens can be added or deleted depending upon the size of the CFM system. Selected screens for the example problem are given in the Appendix.

The data from the interface is stored in a model data base. A translator program uses this data base to generate the SIMAN experiment frame. The translator is modularly constructed where each module generates a SIMAN experiment element.

All the model development activities till the generation of the SIMAN experiment frame have to be done on the IBM PC-AT microcomputer and compatibles. The compilation and linking of the SIMAN files, and the execution of the simulation can be done on the DEC VAX series of minicomputers of the IBM 9370 series mainframe computers.

The overall structure of the simulator is shown in Figure 4.

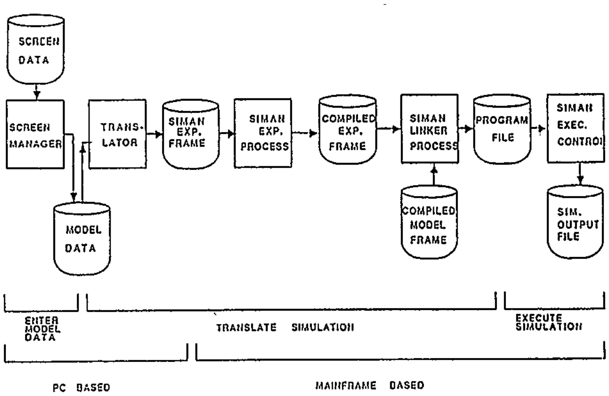

Figure 4. SIM-CFM Structure

8. CONCLUSION

The focus in developing SIM-CFM has been on the simplicity of model generation and simulation execution of large scale CFM models. The "core" modeling approach has eliminated the effort of reprogramming of models using the same operating logic. The success of the simulator has been demonstrated by the acceptance, implementation and usage by the firm for which it was developed. Manufacturing engineers have been able to develop and run large scale CFM models and evaluate the impact of changes in the physical structure and operational policies. The time factor has been crucial, for it now takes usually a week to develop models which have taken more than 2 months by conventional modeling techniques.

REFERENCES

Jain, S. and W. J. Foley. 1986. "Basis for Development of a Generic Simulator." In *Proceedings of the Second ORSA/TIMS Conference on Flexible Manufacturing Systems: Operations Research Models and Applications.*

Ketcham, M. G. and J. Watt. 1987a. "SIMBED: A Parametric Program for Simulation Flexible Manufacturing and Assembly Systems." In *Proceeding of the IX International Conference on Production Research.*

Ketcham, M. G. and J. Watt. 1987b. "A Parametric Simulation for Flexible Assembly Systems." In Review.

Lenz, J. E. 1980. "Manufacturing System Tool--MAST--An Introduction." In *Proceedings of the 1980 Winter Simulation Conference.* Pp. 299-303.

Mathewson, S. C. 1975. "Simulation Program Generators," *Simulation,* 23, 181-189.

Warnecke, H. J., R. Steinhilper, and K. P. Zeh. 1986. "Simulation as an Integral Part of an Effective Planning of Flexible Manufacturing Systems (FMS)." In *Proceedings of the 2nd International Conference on Simulation in Manufacturing.*

Watford, B. A. and T. J. Greene. 1986. "Simulation Software for Bulk Material Transportation Systems: A Case Study." In *Proceedings of the 19th Annual Simulation Symposium.*

APPENDIX

SECTOR SCREEN

OP.NO	#TOOLS	TOOL1	TOOL2	TOOL3	TOOL4	RWK.PR	OPERATION TIME	RTE.TIME
0101	1	TL1	-----	-----	-----	0.0	RN(5,0.02)	UN(2,1)
0102	1	TL2	-----	-----	-----	0.0	UN(6,9)	CO(5)
0103	2	TL3	TL4	-----	-----	0.0	RN(40,2.5)	RN(3,0.06)
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
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-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------

SCREEN NAME: SECTOR1 SCREEN NUMBER: 3

COMMAND: 0101

SECTOR SCREEN

OP.NO	#TOOLS	TOOL1	TOOL2	TOOL3	TOOL4	RWK.PR	OPERATION TIME	RTE.TIME
0201	1	TL2	-----	-----	-----	0.0	CO(10)	UN(5,6)
0202	2	TL3	TL4	-----	-----	0.0	RN(5,0.01)	TR(1,2,3)
0203	2	TL3	TL4	-----	-----	0.0	CO(7)	UN(4,6)
0204	1	TL5	-----	-----	-----	0.0	UN(70,100)	CO(10)
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
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-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------
-----	0	-----	-----	-----	-----	0.0	--------------	------------

SCREEN NAME: SECTOR2 SCREEN NUMBER: 4

COMMAND: 0201

KANBAN SCREEN

SECTOR-1 : 9999	SECTOR-16 : 9999	SECTOR-31 : 9999
SECTOR-2 : 9999	SECTOR-17 : 9999	SECTOR-32 : 9999
SECTOR-3 : 9999	SECTOR-18 : 9999	SECTOR-33 : 9999
SECTOR-4 : 9999	SECTOR-19 : 9999	SECTOR-34 : 9999
SECTOR-5 : 9999	SECTOR-20 : 9999	SECTOR-35 : 9999
SECTOR-6 : 9999	SECTOR-21 : 9999	SECTOR-36 : 9999
SECTOR-7 : 9999	SECTOR-22 : 9999	SECTOR-37 : 9999
SECTOR-8 : 9999	SECTOR-23 : 9999	SECTOR-38 : 9999
SECTOR-9 : 9999	SECTOR-24 : 9999	SECTOR-39 : 9999
SECTOR-10 : 9999	SECTOR-25 : 9999	SECTOR-40 : 9999
SECTOR-11 : 9999	SECTOR-26 : 9999	SECTOR-41 : 9999
SECTOR-12 : 9999	SECTOR-27 : 9999	SECTOR-42 : 9999
SECTOR-13 : 9999	SECTOR-28 : 9999	SECTOR-43 : 9999
SECTOR-14 : 9999	SECTOR-29 : 9999	SECTOR-44 : 9999
SECTOR-15 : 9999	SECTOR-30 : 9999	SECTOR-45 : 9999

SCREEN NAME: KANBAN1 SCREEN NUMBER: 7

COMMAND: 9999

TOOLING SCREEN

TOOL	TYPE	MIN.BATCH	MAX.BATCH	MEAN TIME TO FAIL	MEAN TIME TO REPAIR
TL1	B	4	4	----------------	----------------
TL2	B	2	2	----------------	----------------
TL3	C	4	4	----------------	----------------
TL4	C	4	4	----------------	----------------
TL5	B	10	10	----------------	----------------
TL6	B	10	10	----------------	----------------
TL7	C	10	10	----------------	----------------
TL8	C	5	5	----------------	----------------
TL9	B	2	2	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------
-----	-	0	0	----------------	----------------

SCREEN NAME: TOOL1 SCREEN NUMBER: 8

COMMAND: TL1