Synthesis Report

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Abstract

Shop floor and process control in plastic processing companies is a complex issue. The injection moulding process both has characteristics form continuous production like in chemical plants and discrete manufacturing like in mechanical engineering. The change of “flow goods” to single identifiable parts is performed in the injection moulding machine. For an effective control, the complete chain from conveying the raw material to injection moulding has to be controlled.
The plastic processing industry can be subdivided into several branches which have different requirements on the technologies used for shop floor and process control. The CIMBAPP project has developed a classification scheme which maps the type of a company to the module: of an ideal shop floor control (SFC) system.
Existing systems for shop floor control, factory data acquisition (FDA), material supply (MSS) and material data management (MDM) have been enhanced and partly been integrated at the pilot plant which produces supply parts for the automotive industry and technical parts. The SFC systems has been linked to the production planning& control system (PPC) of the pilot plant.

Introduction

As markets are getting more and more global, the European companies are facing an accelerating competition with East-Europe and Asian companies. Loan costs are often much lower so that European companies can only compete by designing the manufacturing process more effective and supplying best quality goods. As plastic material are getting more and more important in many application like in the automotive industry where they substitute metal parts because they are cheaper and lighter, it is important to support this branch be developing effective technologies which help to produce more economically. In former years, especially the basic process of injection moulding and the automatic removal of parts at the machine by handling devices and robots have been areas of research and development ([2]).
Plastic processing companies in Europe mostly belong to the small and medium sized companies (SME) and often do not have the potential to perform industrial research on their own. The project CIMBAPP therefore developed a modular structure applicable for a wide range of companies.
In an economic design of the manufacturing process, attention should be paid on the several control systems within the process chain. Shop floor control (SFC) systems which have applied successfully in other branches, have a slightly different structure in plastic processing companies. Quality assurance aspects and automated collection of quality data are important issues especially for

suppliers of the automotive and electro-technical industries ([1], [2]). The raw material preparation and transport can often be centralised and automated where the amount of raw material is high enough but this needs a separate process control system (material supply system - MSS). The data handled by SFC and MSS are different. The SFC system mainly handles shop floor orders in terms of parts to be produced, the MSS follows a different paradigm and mainly handles raw materials, mixtures and recipes measured in KG. For reducing the setup and still-stand times it is important that SFC and MSS are working synchronous. The project CIMBAPP intended to reach such a synchronisation by developing a Cell Controller (CC) with interfaces to the main subsystems FDA, PDA, MSS and MDM (see also [5]). Figure 1 shows a typical structure consisting of a shop floor control and a process control system. Besides the technical control aspects, the qualification of staff has to be respected in a factory with more and more complex control system [3]. The user interfaces of the applications have to be designed comprehensible and easy.

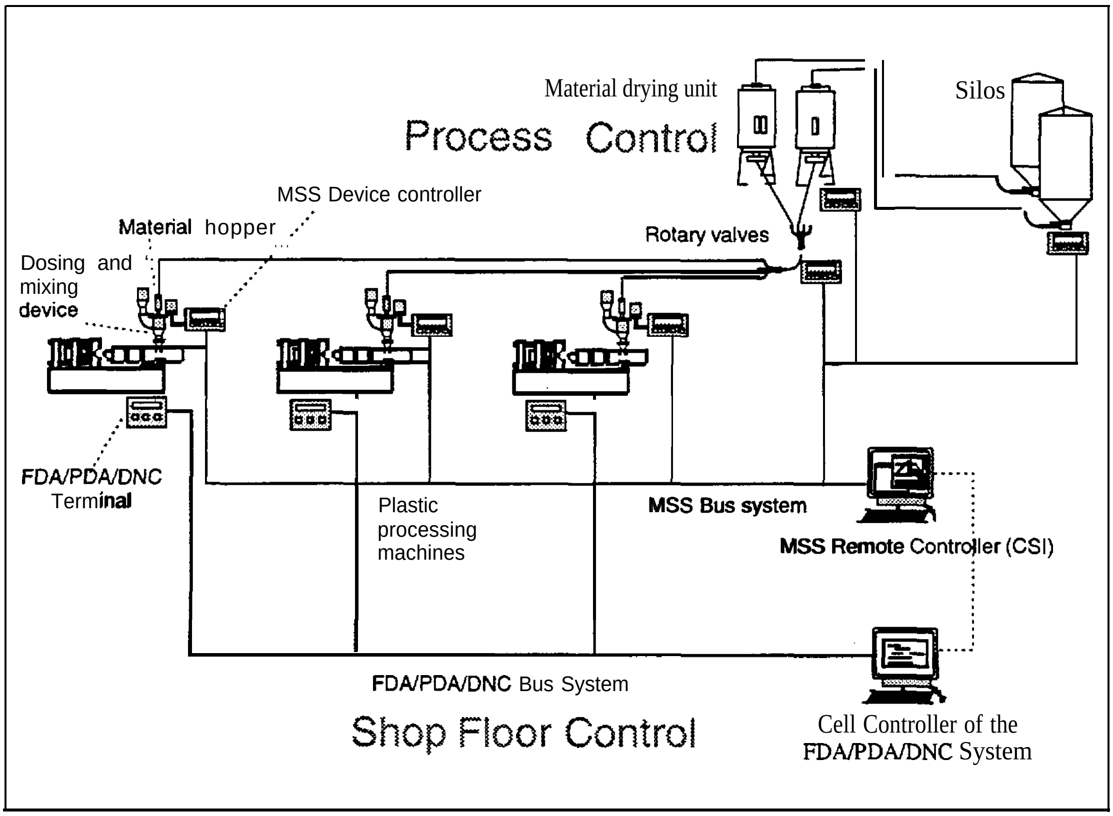

Figure I: Typical structure of combined shop floor and process control in plastic processing

Technical Description

Structure of the project

The project can be divided into the 2 main phases user *requirements analysis* and *design & implementation.* User requirements analysis contains tasks 1-4 and design & implementation contains tasks 5-10 as shown in Figure 2. Dividing the project in this way was very helpful as it sets common goals for the project team members.

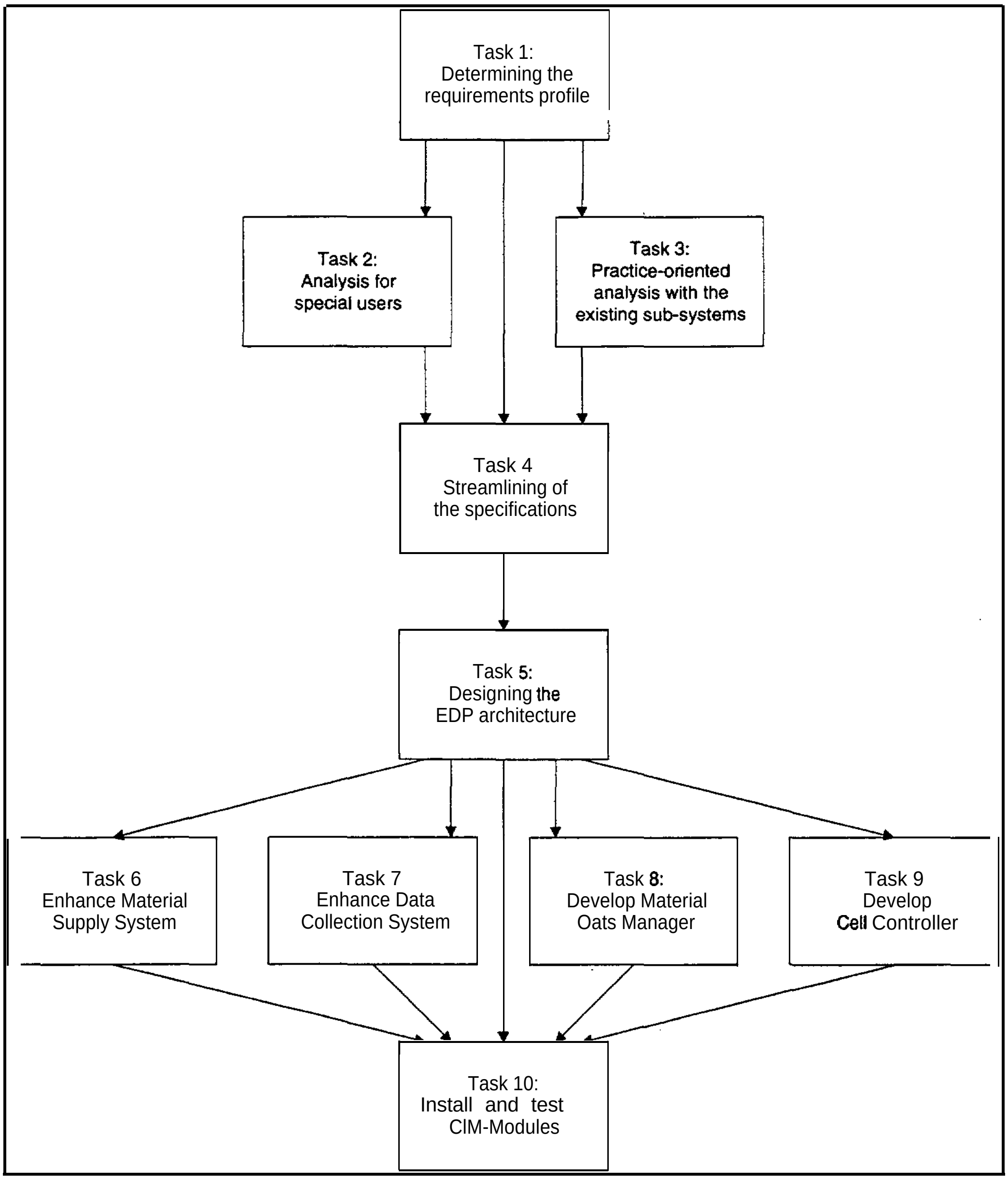

Figure 2:Structure of the project

User Requirements analysis phase

Research topics

During the user requirements analysis phase, the following questions should be answered:

1. What is the state-of-the art in plastic processing companies concerning shop floor control and automated raw material supply?
2. Do they already have SFC and/or MSS systems or are they planning to introduce them?
3. How important is quality control for the companies?
4. Which technical components have to be controlled besides injection moulding machines. and automated material supply systems?
5. How can the plastic processing industry be classified into classes with different needs on shop floor control / process control?
6. How can savings in energy, material and loan costs be quantified?
7. What are the requirements of the pilot user concerning shop floor control/ process control?

Different methods of research have been applied to copy with these questions. The first five questions have been handled by performing interviews in 33 companies mostly in Germany and by evaluating a graphical questionnaire sent out to several thousand companies in Europe.

Results from the questionnaire

The following presents shortly some results from the graphical questionaire. The complete evaluation is contained in [4]. The graphical questionnaire aimed at getting information about relations between company size and installation of CIM components and was mainly focussed on injection moulding. More than 82 % of the companies had injection moulding machines followed by 28 % of the companies having extrusion lines installed.

The percentage of companies having a Cell Controller or Leitstand system installed does not depend on the size of the company in terms of machines. Between 25 and 27 % of the companies having responded to the questionnaire answered that they still have a Leitstand, which is a little bit to optimistic from the experience of one of the partners who has the experience that about 1070 have already such a system.

The percentage of companies having a centralised Material Supply System installed varies on the size of the companies because economic effects in using an MSS depend on the amount of material being consumed for plastic processing. Only 37 % of companies with less than 15 machines but 67 % of companies with more than 50 machines have an MSS installed.

Classification of companies and modular structure for shop floor control

From the results of applying these methods a ideal modular structure for shop floor control has been developed which is shown in Figure 3. The structure is restricted to the injection moulding process although some companies with extrusion lines have been visited. Extrusion is not a discrete manufacturing process and therefore the factory data acquisition and material supply system work different as in injection moulding.

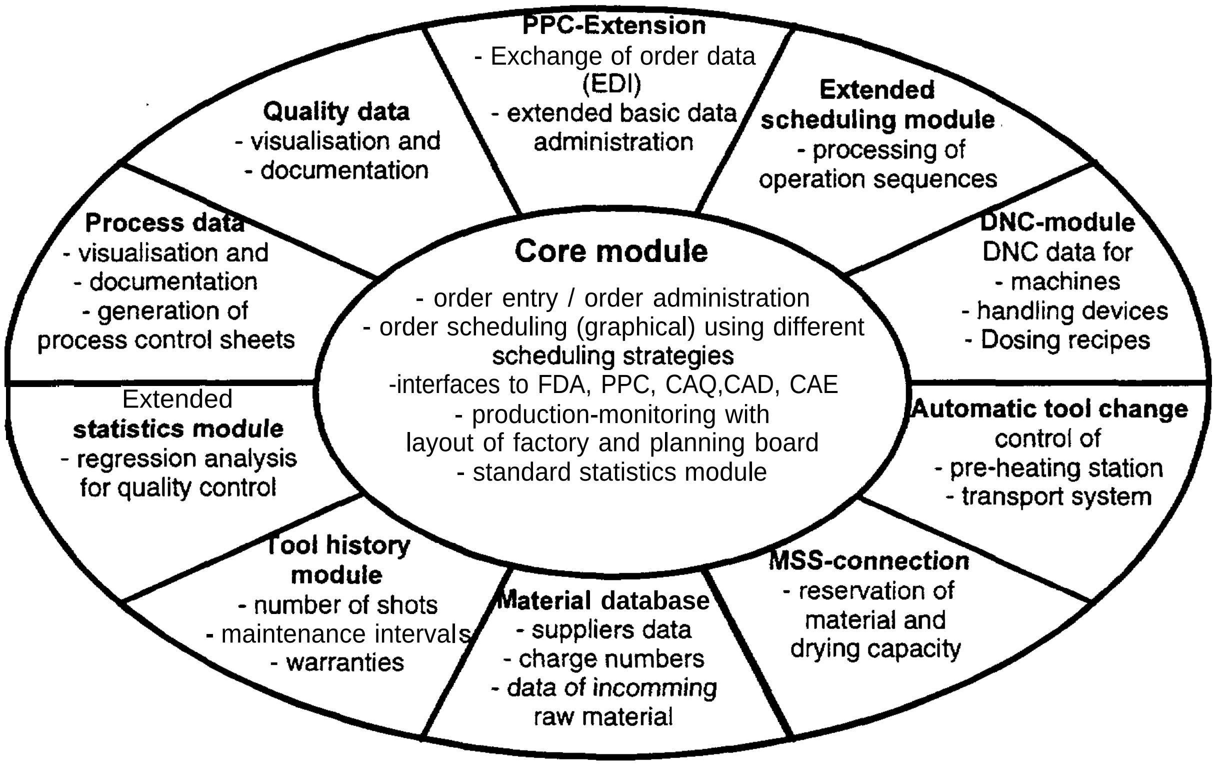

Figure 3: Ideal structure of shop floor control in plastic processing companies

One can determine the modules necessary for shop floor and process control by determining the company type according to the classification scheme developed and looking up the table shown in Figure 2. The core module, for instance, is needed in every company. The PPC Extension Module is only necessary in small companies (both suppliers and manufacturers of technical parts) who normally will not have an own PPC system.

		Core module	PPC-Extension	Extended Planning m	Material Database	Tool history module	Quality data module	DNC module	Tool change module	MSS interface	Process data module	Extended statistics m
Suppliers	Small companies	●	●	●				●	●	●	●	
	Many production steps	●		●			●	●	●	●	●	●
	Many different raw materials	●		●	●			●	●	●	●	
	Own tool shop	●		●			●	●	●	●	●	
Manufacturers of technical parts	Small companies	●	●					●	●	●		
	Many production steps	●		●				●	●	●		
	Many different raw materials	●			●			●	●	●		
	Own tool shop	●				●	●	●	●	●		
	Manufacturer of consumer goods	●										

Figure 4: Classification of plastic processing companies

Calculation scheme for estimating savings of material, energy and loan costs

For handling question No. 6, a calculation scheme has been developed based on a spreadsheet program which allows to evaluate the expected savings in energy, material and loan costs based on estimations of the company. It has to be specified how often data is collected from the machines, how many persons are employed in raw material storage and transportation by handling the material and several other components. Figure 5 shows the calculation scheme for estimating the economic effects of the IBN-BDE factory data acquisition and Leitstand system which is part of the CIMBAPP architecture. Given the hourly wages of staff, the result is calculated in teems of money which can be saved per year in the company.

No.	Evaluation of Economy	01.09.95	rm_30	No	Example	Company
		dates of experience		UK		
	working weeks per year		week	>	45	
	working days par week		day	>	5	
	working hours per day		h	>	24	
	no. of machines		no	>	30	
1.	**Time for data collection and evaluation**					
.1	time for manual collection per machine per day	5-12	min	>	5	
	e. g. no. of pieces/bad pieces					
	stops, reasons for stops					
	time for ways					
.2	total time for all machines		min		150	
.3	time for manual evaluation all machines per day	10-80	min	>	30	
	e. g. input					
	reports/analysis					
	determination of degree of utilisation					
	time per day		h		3	
	hourly wage per employee		P/h	>	18	
1.4	**Total time for collection and evaluation**		P		**12.150**	
2.	**Loss in utilisation due to problems recognized too late or not at all**					
2.1	due to stops recognized too late	0,3-3,0	%	>	0,3	
2.2	due to weak points not recognized	0,2-3,0	%	>	0,2	
	turnover per year		P	>	3.500.000	
2.3	**Total loss in utilisation**		P		**17.500**	
3.	**Expenditures for manual planning**					
3.1	Preparation per machine per week		no	>	?	
	plus necessary planification for all machines per week		no		90	
3.2	Expenditures for one special planification	5-15	min	>	10	
	working time (preparation, cycle, cavity, working days)					
	evaluation of different planning alternatives					
	including tools to be disposed of					
	avoiding unfavourable consequences of preparation (colour, tools)					
	total time per year		h		675	
	hourly wage per person planning		P/h	>	20	
3.3	***Expenditures for planning in total***		P		**13.500**	
4.	**Reduction of bad pieces**					
4.1	process control — percent of turnover	0,4-2,0	%	>	0,4	
4.2	analysis of bad pieces — percent of turnover	0,1-5,0	%	>	0,2	
4.3	**Avoidable cost for bad pieces in total**		P		**21.000**	
5.	**Summary per year**		P			
5.1	**Total time for collection and evaluation (Pkt.1.4)**		P		**12.150**	
5.2	**Total loss in utilisation (Pkt.2.3)**		P		**17.500**	
5.3	**Expenditures for planning in total (Pkt.3.3)**		P		**13.500**	
5.4	**Avoidable cost for bad pieces in total (Pkt.4.3)**		P		**21.000**	
5.5	Cost saving per year by **IBN-BDE**		P		**64.150**	

5.6 additional possibilities for cost saving which are difficult to express in numbers
..by more transparency
..by a better information system for team work

5.7 **ISO 9000**
.. modules by **IBN-BDE** are taking over tasks
that are demanded by these **standards**

Figure S: Calculation scheme for evaluting economy of production

Design & implementation phase

The results of the user requirements analysis phase could directly be used in the design & implementation phase for writing the specifications of the components which had to be newly developed.

The subsystems of CIMBAPP have been developed decentrally by the responsible partners. Bilateral meetings have been held where the interface between two systems had to be defined. Due to the fast development on the personal computer and operating system market, all partners had to cope with the migration of their software onto a new (or new generation of the already used) OS platform.

Results

The following general results have been reached:

- A modular structure for shop floor control in plastic processing companies
- A classification of companies according to different needs on shop floor control
- An scheme for calculating the material, energy and loan savings that could be reached by introducing shop floor / process control.

The following results have been reached during the project concerning the pilot plant installation:

- Based on a detailed user requirements analysis, the Cell controller of the FDA/PDA/DNC system has been reimplemented for the UNIX and MS Windows NT operating system platforms.
- The reimplementation of the Remote Controller of the MSS system has been started using a SCADA development tool on MS Windows NT. Two new drivers have been implemented for the Remote Controller.
- The Material Database Manager and an application database for the pilot user have been developed for MS Windows.
- The Cell Controller, the FDA/PDA/DNC system and the Material Database Manager have been installed at the pilot plant. The installation and integration of the MSS Remote Controller still has to be performed.
- The Cell Controller at the pilot plant has been linked to the existing PPC system

The link of the Cell Controller to the MSS Remote Controller still has to be performed.

Conclusions

There are still some topics remaining where research and development is needed to gain full benefit of the technologies applied. At first, the final integration of shop floor and process control system has to be performed to assure a consistent database for all production level systems. A deeper integration of shop floor and process control could also mean that the Cell Controller of the shop floor control system could be used for planning the material consumption. This currently cannot be performed by the MSS Remote Controller because it does not have any information on planned shop floor orders and it cannot be performed by the Cell Controller alone because this system does not have enough material related information like drying time and temperature to perform the necessary calculations. The benefit of having access to detailed information concerning material consumption, silo content etc. within the SFC system could be that its planning algorithms could detect bottlenecks in material supply possibly earlier.

Acknowledgements

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References

[I] Michaeli,W.;Eversheim, W.: "CIM im Spritzgie13betrieb'',Hanser Verlag, München,Wien 1993

[2]Warnecke,H.J.;Volkholz,V.: "Modeme Spritzgießfertigung", Hanser Verlag München,Wien 1990

[3] Greif,M.: "Technikentwicklung und Qualifikationsstruktur in der kunststoffverarbeitenden Industries", VDI-Verlag Reihe 16: Technik und Wirtschaft, 1992

[4] Schallock,B.;Arlt,R.: "Evaluation of the graphical questionnaire'',BRITE Project Nr.5319 CIMBAPP;Technical Report forTask 1, IPK Berlin 1994

[5] Nonnenmann,W. : "Integration von BDE, Leitstand und PPS", Kunststoffe 85 (1995), Hanser Verlag München, Wien 1995