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M. S. Dimitrov

Technical University – Sofia, Sofia, Bulgaria

MODELLING AND STUDY OF EVENT-DRIVEN FLOW MOVEMENTS IN THE MANUFACTURING OF WIRE HARNESSES USING ULTRASONIC WELDING FOR WIRES CONNECTION

The development of the common control theory, organization and management of production systems and processes, computer information systems and technology, instrumental environments and development systems require development of new models, structures and management systems of different types of production systems and processes. The purpose of this work is to study production system in order to increase efficiency by developing new models and structures for the management of production system. This work focuses on modeling and development of new information - control over the production structures for connecting wires through the method of ultrasonic welding with a view to the so-occurring trends. It is using Event-Drive flow (stream) models in Matlab. Furthermore it develops and implements study and validation of the information system and event model with Matlab and SimEvents. **Simulation results.** In accordance with the principle examined functional stream in P2 at an application time -0,5h and operation time - 0,6h as well as at obtained simulation results from Fig. 4, 5, 6, 7 and 8 follows that we have a valid realization of EVENT flow model. Since implementation of ultrasonic welding is 0,1h longer than the time of forming application in the internal buffer storage at USW workplace within one shift there will be an asynchronous accumulation of small amounts of cable bundles. Except this, synchronization of produced cable connections gets also disturbed.

Keywords: flow movements; event flow model; ultrasonic welding; production systems.

Introduction

Modeling, i.e. production models of production systems, aims on the one hand to enable their study and determine optimal parameters and structure of the system and other development of efficient algorithms management. When designing the model, all buffer warehouses, material circuits and their characteristics are taken into consideration. Accepted typification, i.e. the use of model elements in description of production processes allows and creates a unified approach to build their patterns of base modules and their study using computer information system technologies, tools and development environment systems. Here is some general considerations about learning of the models. One option is based on process simulation, i.e. the study of its models in order to obtain additional information about the actual process.

In simulation studies using the model production is mimic. Here the impact of basic control values is estimated that defines the rational functioning of the system. The purpose of this work is to study production system in order to increase efficiency by developing new models and structures for the management of production system. The work investigates technological characteristics of manufacturing process for cable components production and represents event flow model of manufacturing process. Furthermore it develops and implements study and validation of the information system and event model with Matlab and SimEvents. Implementation and validation of modules are achieved with Paradox by instrumental environment Database Desktop.

Summary

1. Features of the production process for manufacturing of cable connections

Connecting parts with ultrasound. For inseparable connecting the structural parts through welding various methods are used. They differ according to the principle of energy import in the welding zone.

In ultrasound-welding energy is imported through elastic UW - vibrations. The materials to be bonded are pressed by external force (welding pressure). Under influence of ultrasound vibrations, contact surfaces are rubbing and the temperature in the welding zone increases. It comes to plastic deformation, diffusion, re-crystallization, melting and other phenomena, thanks to which the parts are connected inseparably. As a result of this operating principle actions can be connected to each other as conducting as well as non-conductive or heterogeneous materials. Order is issued with a certain S number.

Transporter of production 3 (P3) where the cable forms are assembled issue an order. This is realized when transporter from P3 goes to P2 and writes on the whiteboard S-number of cable forms which needs for corresponding wire harness reference number which will be produced. In printed order there are two bar codes: FULL and EMPTY. When P2 transporter supplies cables to corresponding working position, it scans FULL bar code. When P3 transporter supplies corresponding line with required cable forms, it scans EMPTY bar code.

Receiving a request. Once P3 transporter writes a request on the whiteboard, P2 transporter reads the order on the computer and prints it. In the order all S-numbers of cables included into the cable form is reflected. Once the order is printed, P2 transporter checks which cables are needed for the welding joint. P2 transporter reads a request, where it’s written which cables needs to be supplied to working station.

Cable supply. After P2 transporter goes to the wires storing area(warehouse). In this area there are the structures which are identified by a number (the number corresponds to the quantity of connected wire harnesses). Transporter takes necessary wires for cable form in accordance with the order and comes back to P2 to supply the necessary wires to respecting working stations where is producing the cables forms through ultrasonic welding. Cable according to request form and return to P2 to deliver the necessary cables of the working position, wherein the produced cable shapes such as are associated cables at one point by ultrasonic welding. Where cables are attached is called weld.

When transporter of P2 charging cables appropriate working position, scan the label of each bundle cable. Since each bundle cable has S number. This is done to the system to show that this Cable is low, so that in turn automatically be stated (generated) in order Production 1 (P1) and cutting and crimping expended cables in P2. After working load place with cables, conveyor scan ordering FULL bar code, which means that the charging work position and filled the order. It started working operator for production cable forms. The operator takes the cables on the left and right of worktable remove insulation, puts the leads(wire strands) of the jaws of the machine, position the wires with the jaws of the machine, start the welding process by pressing the button / pedal for welding. Proceeds welding process connection of copper conductors (creep, diffusion, re-crystallization), which are connect the wires. It follows visual assessment by operator.

If the criteria for visual assessment are covered, operator isolate the welding joint (splice) with adhesive tape or heat shrink tube with glue. If the welding joint(splice) does not cover required standards for visual assessment, then the operator removes the welding joint with whole cable form from the total batch with cable forms and records the defect.

Winding and attaching the manufactured cable forms the designated temporary stay place.

Transporter of P2 takes the cable and forms them transported to a warehouse in batches cable forms that It is located in the storage area of various types Cable forms. In the storage depot of the cable forms having a plurality of structures which are numbered. Cable conveyor puts shaped structure which is identified with the same S number as is cable form. To bundle cable forms is attached printed order.

Transporter of P3 goes into storage of cable forms checked structures, if no compounds goes and S record order number if there are structures cable form.

Production 3 (P3), which are mounted cable forms. After loading the line scan order, which is attached to the bundle cable forms bar code EMPTY. This is done in order to take account of the system that the line is loaded with the necessary cable form and generate new orders for P2. In P2 there where printer automatically after scanning a bar code EMPTY by transporter in P3 print order in P2. After prints contract follows the same procedure charging cables, and the production of cable forms.

2. Development of the event - streaming model of manufacturing process

Defining the information and functional objects of manufacture. Information objects - orders, materials, ..., submit and process of accumulation associated with different types of flows. Information objects (Fig. 1):

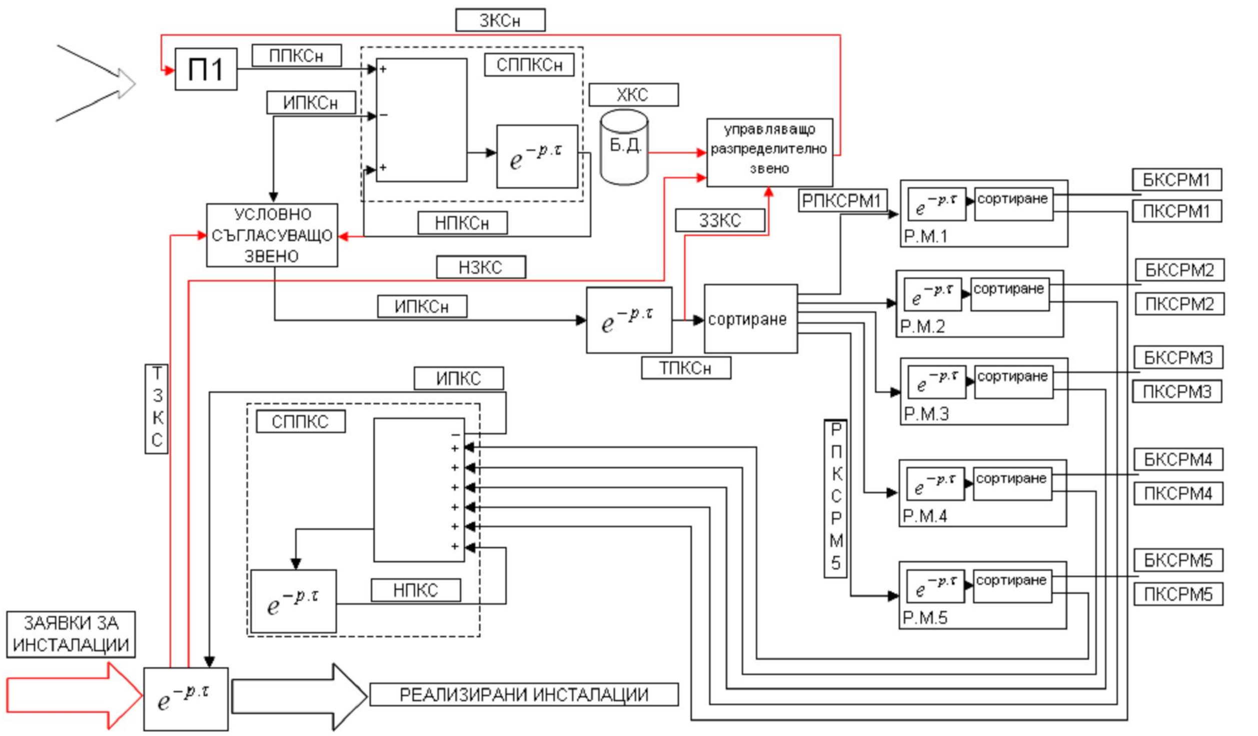

Fig. 1. Event flow model of production process in P2 area (pre-assembly - ultrasonic wire welding)

IBCB - incoming batch of cable bundle;
DBCB - derived batch of cable bundle;
ABCB - accumulated batches of cable bundles;
TBCB - transported batch of cable bundles;

DBCBWP1 - distributed(delivered) batch of cable bundles in working position(workplace with machine) 1;

PBCFWP1 - produced(manufactured) batch cable forms(ultrasonically joined wires) of Working position 1;

SCFWP1 - scrapped cable forms of Working position 1;

ABCF - accumulated batches cable forms (ultrasonically joined wires);

CRCF - current request for cable forms (welding joint);

IQCF - initial query(request, order) for cable forms (welding joint);

LQCF- loaded query(request, order) for cable forms (welding joint);

QCB - query(request,order) for cable bundles;

CHCF - characteristics of the cable forms (welding joint);

Functional objects - welding distribution, materials and orders, stripping, cutting (P1), installation (P3);

SIBCB - a storehouse(warehouse) of incoming batches of cable bundles;

SIBCF - storage of the incoming batches cable forms (welding joints).

3. Design of information – control system. Basic functions, input - output connections, modeling and general structure of information – control system

In line with the event-flow model of the P2 defined functions of information - control system in the industry, the need for the submission of summaries towards - high production levels (Head of process, production manager ...) to define this input - output interactions Information system (Fig. 2).

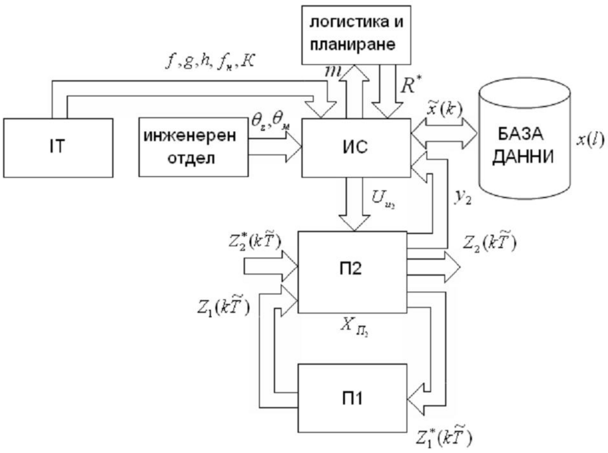

Fig. 2. It presents the structure of Input - Output connections:
*R** – request for summary information;
m – Reference aggregated product

4. Description of space in the state of P2.

The equation of state:

$$X_{P_2}((k+1)\tilde{T}) = f(X(k\tilde{T}), U_{U2}(k\tilde{T}), Z_2^*(k\tilde{T}), \theta_M)\,; \quad (1)$$

the equation of controlled output processes:

$$Z_2(k\tilde{T}) = g(X_{P2}(k\tilde{T}))\,; \quad (2)$$

the equation of measurable outputs:

$$y(k\tilde{T}) = h(X_{P2}(k\tilde{T}))\,, \quad (3)$$

where I – intensity; q - parameters of the event model (evaluations);

z q - parameters of the devices quantitative function (Ratings);

U - managing impacts from IS to P2;

y – bar code reader (scanner);

P2 X – state vector of P2 (a set of current states of the product streams, which completely determines manufacture 2 in a point in time and the next minute under certain selectors and disturbances);

h - operator representation of the relationship of P2 measurable product streams on the state of P2.

5. Control functions of the Control System (CS)

In order to management implementation on the base of assessment of current state in P2 considering the dynamic nature of production management is presented in the state space.

When reporting the presence of feedback, it will be characterized by two subsystems with observer (which evaluates only those of state variables of P2, which have regard to the final production of the cable connection).

The equation of the observer

$$\tilde{x}(k+1) = f_H(\tilde{x}(k), y(k))\,; \quad (4)$$

equation management

$$U_{U_2} = K.\tilde{x}(k)\,, \quad (5)$$

where K – matrix of feedback condition

Defined functions of information - P2 management system are as follows:

1) assessment of the status and parameters of assembly movements and functional objects. Is given by entering information via barcodes and barcode reader (scanner);

2) forming the selectors control actions to P2 (print orders for cable connections, based on assess the condition of assembly movements) with a view realizing the steps of the movements of production flows;

3) the setting of the initial models functional and information processes (objects);

4) introduction of adjustments in the structure of production model in changing the nature of product and production.

Q - a function of the load of process equipment; T – function of stocks.

Z * kT - defining (disturbing, uncontrolled) impact on P2.

It consists of two components and parameters quantity of articles; Z * kT - asking the impact to P1; Z kT - Vector of the controllable output processes (product streams P2), Z kT - starting product stream P1; f - operator for the transition from the old (2) X k P to the new state (1); 2 X k + P to P2.

When reporting management and upcoming (disturbing) current impacts: g - operator responsible for representation of the connection of output product streams P2 from the condition of P2; x (l) - state of the manufacturing process for reporting period (for a certain time interval month, year ......); y - vector of measurable product flows;

6. Methodology for implementation and validation of the draft information system and event model.

Implementation of information system is implemented iteratively. On the basis of the developed project of information system is sequentially carried:

1. The physical database;
2. Applications for a test of the validity, functionality and integrity of developed database;
3. Realization of special projects (applications) for check of validity and functionality developed projects of client applications for realization of measurement and management event-driven flows, summarizing and providing information to logistics and planning department;
4. Implementation and verification of functionality and validity of the application server and general network with client applications;
5. Using in operating conditions of information system. Evaluation and validation of information system for development event management.

Simulation implementation, testing and validation of event-flow model. Realization of event-flow model. On the basis of the instrumental toolbox of Matlab and SimEvents and developed EVENT flow model of the P2 hierarchical model Simulink was implemented.

7. Study and validation of the model. Features in P2 assembly movements.

On the basis of event requests from P3, P2 management logics generates a request for cable bundles to P1.

When cable bundles are being produced in P1 and the request is loading from P3, working position for splice joints is loading.

Application of P3 is loaded working position US welding.

Requested cable installations from P3 (Fig. 3).

Realized cable bundles P1 (Fig. 4).

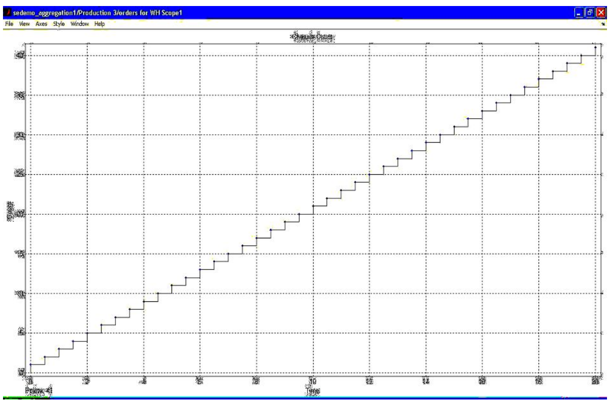

Fig. 3. Shows generation of requests

For a certain operating time given splice (joints) are produced.

Thus produced wire cables are accumulated in the buffer storage.

Until supply of the cable forms to the working positions has a higher frequency than realization of splice joints cable bundles are accumulated in the buffer warehouse.

Staying in P2 buffer storage for following ultrasonic welding (Fig. 5). Produced splice joints – Fig. 6.

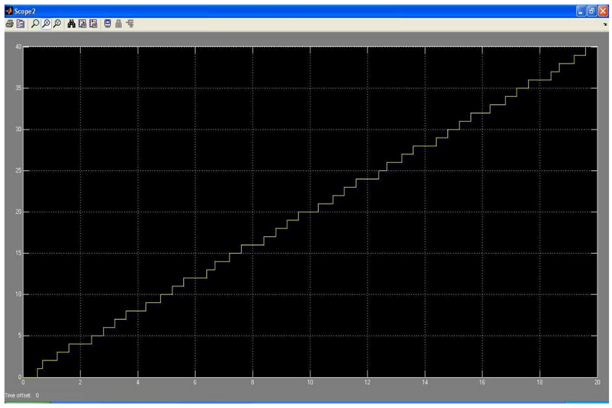

Fig. 4. Shows produced cable bundles.

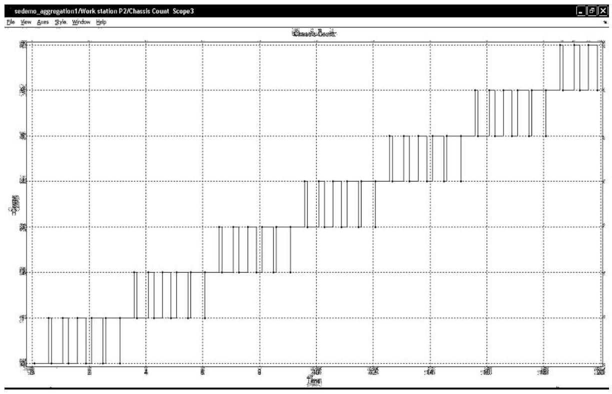

Fig. 5. Shows the temporary buffer storage in P2 – waiting for ultrasonic welding

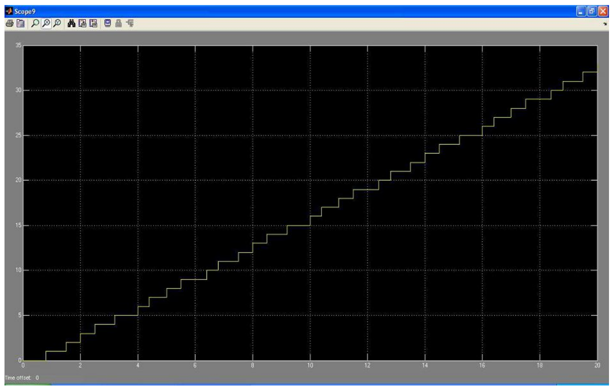

Fig. 6. Shows produced splices - welding joints

Conclusion

In accordance with the principle examined functional stream in P2 at an application time -0,5h and operation time - 0,6h as well as at obtained simulation results from Fig. 3 – 6 follows that we have a valid realization of EVENT flow model.

Since implementation of ultrasonic welding is 0,1h longer than the time of forming application in the internal buffer storage at USW workplace within one shift there will be an asynchronous accumulation of small amounts of cable bundles.

Except this, synchronization of produced cable connections gets also disturbed.

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Моделювання та дослідження процесу програмно-керованого виробництва джгутів з використанням ультразвукового зварювання для з'єднання проводів

М. С. Дімітров

Практичний розвиток завдань загальної теорії управління, організації та управління виробничими системами та процесами, комп'ютерними інформаційними системами і технологіями, інструментальними середовищами і системами розробки вимагає розробки нових моделей, структур і систем управління різних типів виробничих систем та процесів. **Метою даної роботи** є вивчення виробничої системи з метою підвищення ефективності за рахунок розробки нових моделей і структур для управління виробничою системою. **Результати дослідження.** В роботі досліджуються технологічні характеристики виробничого процесу для виробництва кабельних компонентів і представлена модель потоку подій виробничого процесу, зокрема, запропонована модель процесу контролю виробничих структур при з'єднання проводів методом ультразвукового зварювання. При розробці моделі в Matlab використовувався механізм потокових моделей Event-Drive. Крім того, розроблено і реалізовано програмне забезпечення для вивчення і перевірки інформаційної системи і моделі подій за допомогою інструментів Matlab і SimEvents. Реалізація та перевірка модулів здійснюється за допомогою сервісу Paradox інструментального середовища Database Desktop. При моделюванні враховано особливості виробничого процесу для виготовлення кабельних з'єднань, досліджено різні методи по показнику імпорту енергії в зоні зварювання. **Висновки.** В результаті досліджень запропоновано методологію реалізації та перевірки проекту інформаційної системи процесу програмно-керованого виробництва джгутів з використанням ультразвукового зварювання для з'єднання проводів. Для її функціонування необхідно виконати такі етапи: створення фізичної бази даних; створення додатка для перевірки достовірності, функціональності і цілісності розробленої бази даних; реалізувати спеціальні проекти для перевірки достовірності і функціональності розроблених проектів клієнтських застосунків.

Ключові слова: рух потоку; модель потоку подій; ультразвукове зварювання; виробничі системи.

Моделирование и исследование процесса программно-управляемого производства жгутов с использованием ультразвуковой сварки для соединения проводов

М. С. Димитров

Практическое развитие задач общей теории управления, организации и управления производственными системами и процессами, компьютерными информационными системами и технологиями, инструментальными средами и системами разработки требует разработки новых моделей, структур и систем управления различных типов производственных систем и процессов. **Целью данной работы** является изучение производственной системы с целью повышения эффективности за счет разработки новых моделей и структур для управления производственной системой. **Результаты исследования.** В работе исследуются технологические характеристики производственного процесса для производства кабельных компонентов и представлена модель потока событий производственного процесса, в частности, предложена модель процесса контроля производственных структур при соединения проводов методом ультразвуковой сварки. При разработке модели в Matlab использовался механизм потоковых моделей Event-Drive. Кроме того, разработано и реализовано программное обеспечение для изучения и проверки информационной системы и модели событий с помощью инструментов Matlab и SimEvents. Реализация и проверка модулей осуществляется при помощи сервиса Paradox инструментальной среды Database Desktop. При моделировании учтены особенности производственного процесса для изготовления кабельных соединений, исследованы различные методы по показателю импорта энергии в зоне сварки. **Выводы.** В результате исследований предложена методология реализации и проверки проекта информационной системы процесса программно-управляемого производства жгутов с использованием ультразвуковой сварки для соединения проводов. Для ее функционирование необходимо выполнить такие этапы: создание физической базы данных; создание приложения для проверки достоверности, функциональности и целостности разработанной базы данных; реализовать специальные проекты для проверки достоверности и функциональности разработанных проектов клиентских приложений.

Ключевые слова: движение потока; модель потока событий; ультразвуковая сварка; производственные системы.