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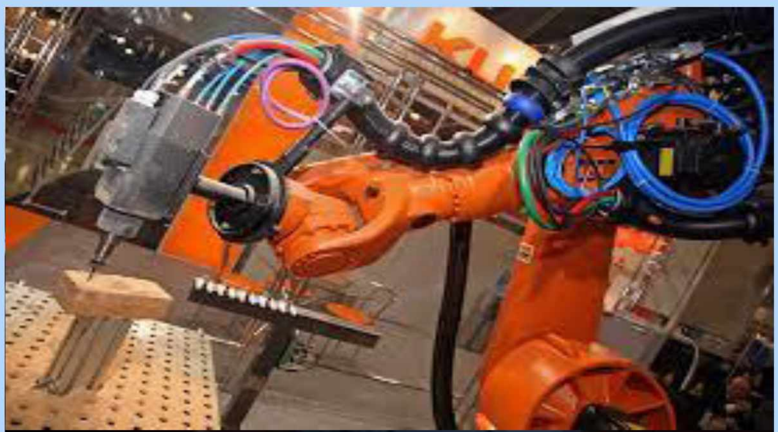

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COMPUTER INTEGRATED MANUFACTURING: OVERVIEW OF MODERN STANDARDS

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Abstract
The article deals with modern international standards ISA-95 and ISA-88 on the development of computer inegreted manufacturing. It is shown scope of standards in the context of a hierarchical model of the enterprise. Article is built in such a way to describe the essence of the standards in the light of the basic descriptive models: product definition, resources, schedules and actual performance of industrial activity. Description of the product definition is given by hierarchical presentation of products at various levels of management. Much attention is given to describe this type of resources like equipment, which is logical chain to all these standards. For example, the standard batch process control shows the relationship between the definition of product and equipment on which it is made. The article shows the hierarchy of planning ERP-MES / MOM-SCADA (in terms of standard ISA-95), which traces the decomposition of common production plans of enterprises for specific works at APCS. We consider the appointment of the actual performance of production at MES / MOM considering KPI. Generalized picture of operational activity on a level MES / MOM is shown via general circuit diagrams of the relationship of activities and information flows between the functions. The article is finished by a substantiation of necessity of distribution, approval and development of standards ISA-88 and ISA-95 in Ukraine. The article is an overview and can be useful to specialists in computer-integrated systems control and management of industrial enterprises, system integrators and suppliers.

Keywords
ISA-88, ISA-95, Manufacturing Operations Management, MES

The role of standards in the development of integrated automated control systems.

World practice of implementation of integrated control systems of manufacturing enterprise shows a significant increase in their efficiency by reducing energy consumption, production downtime, optimal allocation of material and energy flows, the use of hidden reserves, increment of observability and controllability of object [1]. Over the past 20 years, humanity has advanced considerably in the direction of the partial automation of technological, organizational and economic processes to create a single integrated production, implementing the best practices in management and innovative information technologies. The results of these activities have been approved in a number of international standards and described in a large number of articles and textbooks [2-5]. Nonprofit organization MESA International [5], whose members are manufacturers of specialized software, integrators, manufacturers and individuals including the academic community, made great contribution to this work. Organization ISA (International Society of Automation) has approved the most advanced standards [6]. The availability of world standards says about a successful use of approved technologies they contain, and the availability of textbooks - existing training schools.

In contrast to such a large quantity of educational content in the world, in Ukraine, unfortunately, these standards and approaches, which are set out therein, practically unknown to the community of control engineers. Information about these standards and their appointment only recently begun to appear in the Ukrainian resources [7], and their elucidation is almost non-existent. This means that Ukrainian system integrators practically not ready for the development of computer integrated manufacturing (CIM) even in the domestic manufacturing enterprises. We consider that it is necessary to analyze and popularize the world standards with further localization for the successful development of the field of automation in Ukraine. This article is intended to review the basic ideas laid down in standards ISA-88, ISA-95 and ISA-106 committee which are the most important for the development of CIM.

Among the most important standards, which systematize the best practices of developing CIM are an American standard ANSI / ISA-95 [8-10] and their world analogues IEC-62264 that essentially are adaptations of ISA. In Ukraine, unfortunately, these standards have not been adopted at the state level, despite an orientation on harmonization of Ukrainian and European standards. For comparison, in Russia these standards have been adopted and localized as GOST R IEC 62264-1 [11] since 2010, making their usage more priority over the corporative.

To understand the place of modern standards in an integrated manufacturing, they should be considered in the context of a functional structure that is shown in the first part of the ISA-95 (see Figure 1). According to this standard the hierarchy of management a manufacturing enterprise is described with 4 levels: 1st and 2nd levels are designed for process control, 3rd - Manufacturing Operations Management (MOM), 4 - for business planning and logistics. It should be noted that this structure integrated manufacturing does not impose specific requirements for implementation functions. For example, some world famous software products encompass the functions of each of the levels, but do not realize all the listed functionality. For the same reasons Level 3 accepted to name MOM (Manufacturing Operations Management) as opposed to MES (Manufacturing Execution System), as well as MOM includes more functions than declared by MESA model. For example, MOM includes several functions operational management of services for physical assets of manufacture, which are not foreseen by MES model.

Performing the function of 4th level is usually covered by systems such as ERP (Enterprise Resource Planning). The first and second parts of the ISA-95 standard, which were approved primarily, just intended for solving problems of integration of ERP and MOM systems. That is, they are directed to the description of (model) data presentation, which will be exchanged by those systems and to some extent the rules of the exchange. It should be noted that the standards do not have requirements for the internal structure of these systems and the implementation of specific functions, but they have requirements for their interaction (data description) at various levels of management that will integrate different, even the existing, implementations making some changes to their interface parts.

The third and fourth part of the standard (ISA-95.03 and ISA-95.04) focuses on the interaction between functions in the middle of MOM, and with the second level of functional model. To some extent this standard describes the model of the functions in terms of interaction between them. As in the first parts, these parts describe the structure of data, which is exchanged between functions, and not a software interface.

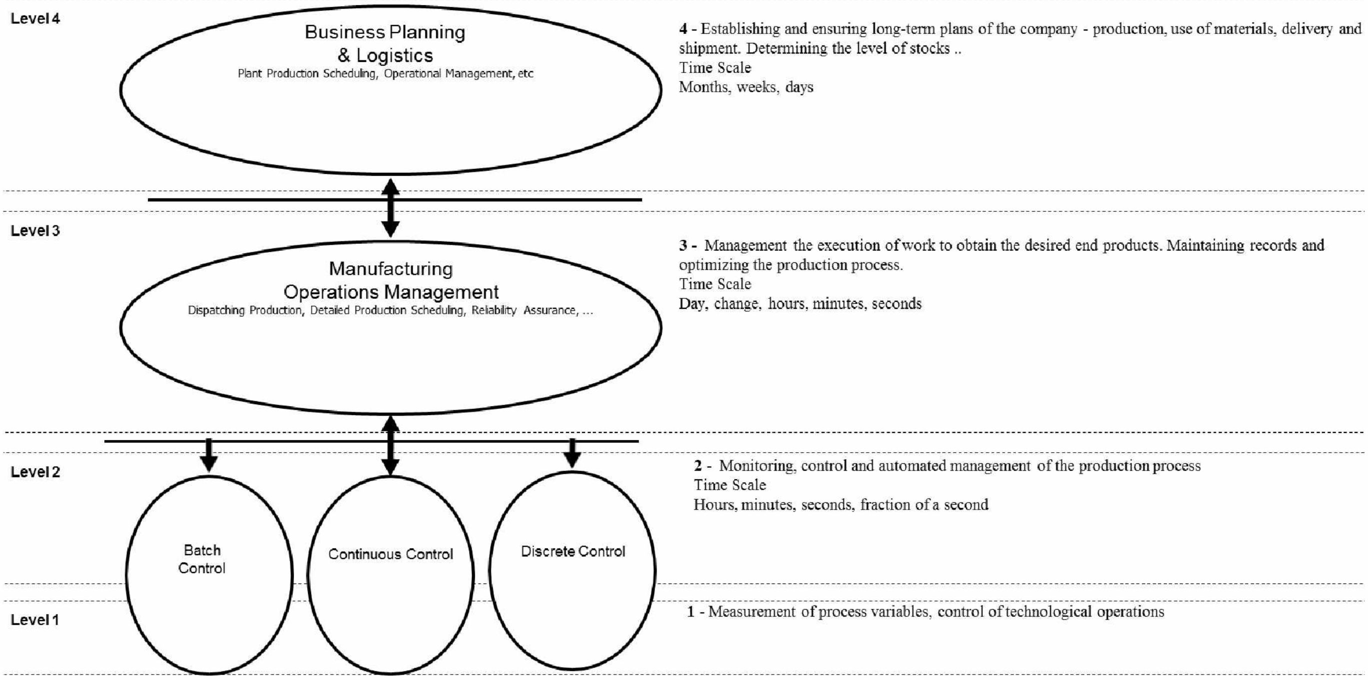

Figure.1. Functional hierarchical structure of management of manufacturing enterprise according to the ISA-95 (IEC 62264)

Implementation of the first and second level under the reduced models is covered by the automatic process control systems (APCS), which are not covered by the standard. However, this model has adopted the division between types of productions:

1. Batch Control – periodic (batch, small-lot) production management;
2. continuous Control – continuous production management;
3. Discrete Control – discrete production management.

This division is caused by defined production features that are known to impose its trace on the management of production processes. For integration of these levels in the general system of production management they must be previously prepared. First, management of production enterprise requires presentation of resources and activities of these levels in the form of models which differ for different types of industries. Second, control algorithms of level 2 should take into account necessity of realization of bilateral integration on the principle: down - planning, up - the actual state. For this, Batch Control has used ISA-88 standard for a long time. To some extent adaptation of the standard is also made for discrete industries. There are also some adaptations of ISA-88 standard for continuous production, however, is about ten years are working on a standard ISA-106, which is designed specifically for such facilities. Now the work on standards are still running and preliminary results are given in the technical report (ISA-TR106). Following rules of construction manufacture control systems that provide for their integration into a single CIM are laid in the standards ISA-88 and ISA-106 and built according to the standard ISA-95.

Thus, today the group ISA standard includes almost all activities managerial of 3 lower levels of the hierarchy management production enterprise:

1. ISA 95.01 and ISA 95.02 – data model in an exchange between the 3rd (MOM) and 4th (ERP) level
2. ISA 95.03 and ISA 95.04 – data model in an exchange between the functions of 3rd level (MOM) and to some extent exchanging with 2nd
3. ISA 95.05 – high-level protocol for data exchange of 3rd (MOM) and 4th (ERP) level
4. ISA 88.01, ISA 88.02, ISA 88.03, ISA 88.04, ISA-88.05 – standards for the Batch Control
5. ISA TR88.02 – adaptation of standards ISA-88 for packing problems (discrete processes)
6. ISA TR88-95.00.01 – technical report about the compatible use of ISA-88 and ISA-95
7. ISA TR106 – technical report on the development of standards for continuous production management.

The above are just standard ISA, although most of them have analogs IEC, mainly adopted by simple adoption. Taking into account certain inertia (not less than three years) in the process of approval of European analogues, below we will focus on a review of just original American versions.

The basic ideas of manufacturing enterprise management.

Assets and activities of the production enterprise must be described by a set of interrelated models for the possibility of analysis its fluid state and management. The key idea of the standards is definition of models at different levels of management and in various industrial fields. The standards give clear guidance on the presentation of industrial enterprise resources, their condition, potential and actual usage on decomposition of the general monitoring functions and control of production processes on planning issue of products and flexible forming a new type of product. These recommendations have been repeatedly proven in production, that are the best practices. Therefore, even in the case of construction management systems without reference to these standards as normative, their use gives a fairly complete representation of categories that can describe any enterprise.

In general, industrial control operations can be described by a set of interrelated models:

- definition of product that is from what (materials) and how (the necessary work and equipment requirements) to produce the product;
- available resources, that is what available (materials, equipment and other resources) for the manufacture of the product;
- a production plan, that is when and with what available resources is planed to produce product;
- actual production figures, that is how passes the production of the product

In the new version of the standard ISA-95, similar models are used not only to describe Production Operations Management, but to describe such activities as Maintenance Operations Management, Quality Operations Management and Inventory Operations Management. Such presentation expands the scope of the standard ISA-95 on all the features of MOM level of industrial enterprise and not just on manufacturing. However, the standard ISA-88 and ISA-106 is aimed at the production functions, therefore we will focus more on them below.

Product Definition.

The first developed standard of the above was the ISA-88, that laid a very important fundamental principles of production management. Perhaps the most innovative concept was the division of control activities into two different categories: process control and basic control. Such division allows the use of one and the same equipment to produce various products that is a principal in the manufacture of multiassortment products for variable technological requirements. Required materials (type, amount, requirements), expected products (amount, parameters), equipment requirements, requirements for additional resources, required operations for management the process - all this is described in the definition of the product.

In terms of the ISA-88, a product definition is written in the Recipe, and in the ISA-95 - in Product definition model. It should be noted that sequence of manufacturing operations, allowing "programming" manufacturing process for a particular product is specified in the product definition. This is a fundamentally new approach that allows to produce newly created products without changes in the structure and program of control system. However, this approach requires its support at all levels of management involved in this function. In terms of the ISA-88 such technological programs, that are written in the recipe, operate with technological terms such as "heated to 80 ° C", "mix for 30 minutes," and called Procedural Control. Program in recipes (recipe management) cannot be performed without equipment, so expected that it will be implemented using equipment control, which is implemented in the control system of specific equipment.

In ISA-88 general product definition for a particular technological cell is described by Master Recipe. The technological program in the master recipe can be done on different equipment. Own copy of the master recipe with a unique identifier (batch number), in which it has specific equipment that will be involved in the process, is created for each batch of product. This copy is called Control Recipe and it can change in the preparation of the party , including: process parameters, equipment and technology program. In addition, control recipe is the object, which focuses all archived information on the passage of the preparation of the product party , it allows to carry its genealogy.

In ISA-95 definition of the product is described by the model Product Definition, which in turn is a partial case of model Operation Definition. We recall that the new version of the standard ISA-95 provides versatile Operation model, because list of functions includes not only productive activities (ie work with the product), and the maintenance and organization of work on quality assurance and logistical support. Although the description of models may seem quite difficult (all models in the standards are given in notation UML), by and large, they are described on the same principle as in the ISA-88.

Resources.

Resources, that according to the standards are described as a set of models, are needed to produce the required product. Equipment, which provides production solutions, is separately allocated resource in ISA-88 and ISA-106. All other resources (necessary materials, energy resources, staff) are included as parameters of equipment control, but the ISA-95 envisages for them individual models. Equipment models overlap in all of the above standards and are their "common denominator" (Figure 2).

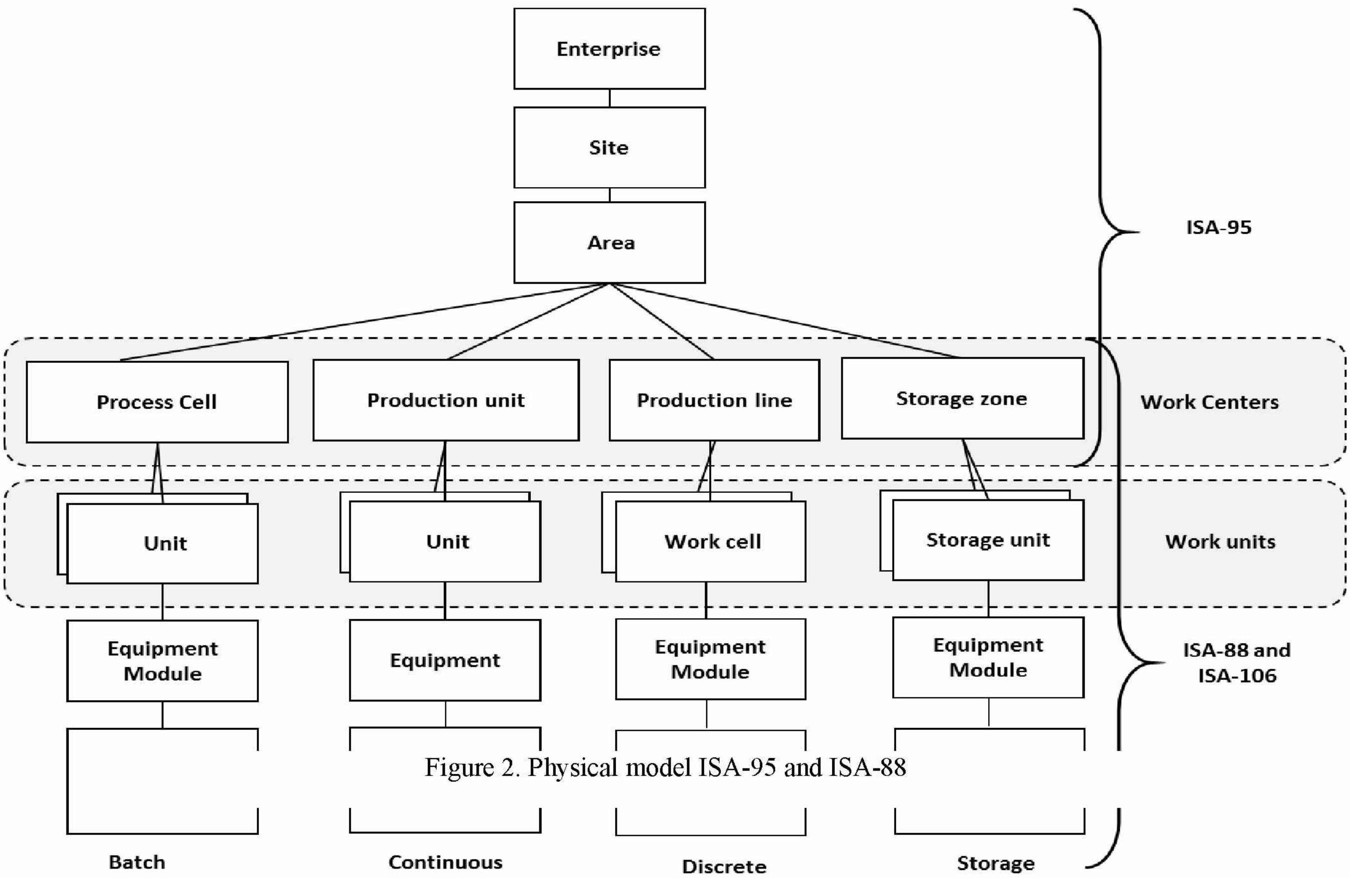

Figure 2. Physical model ISA-95 and ISA-88

ISA-95 standard covers the activity of the upper four levels of physical models:

1. Enterprise – is a production complex, which is responsible for a nomenclature of products which are produced, Site on which they are produced and methods of production. For example, it may be agro industrial company with several sugar factories located in different places.

products without changes in the structure and program of control system. However, this approach requires its support at all levels of management involved in this function. In terms of the ISA-88 such technological programs, that are written in the recipe, operate with technological terms such as "heated to 80 ° C", "mix for 30 minutes," and called Procedural Control. Program in recipes (recipe management) cannot be performed without equipment, so expected that it will be implemented using equipment control, which is implemented in the control system of specific equipment.

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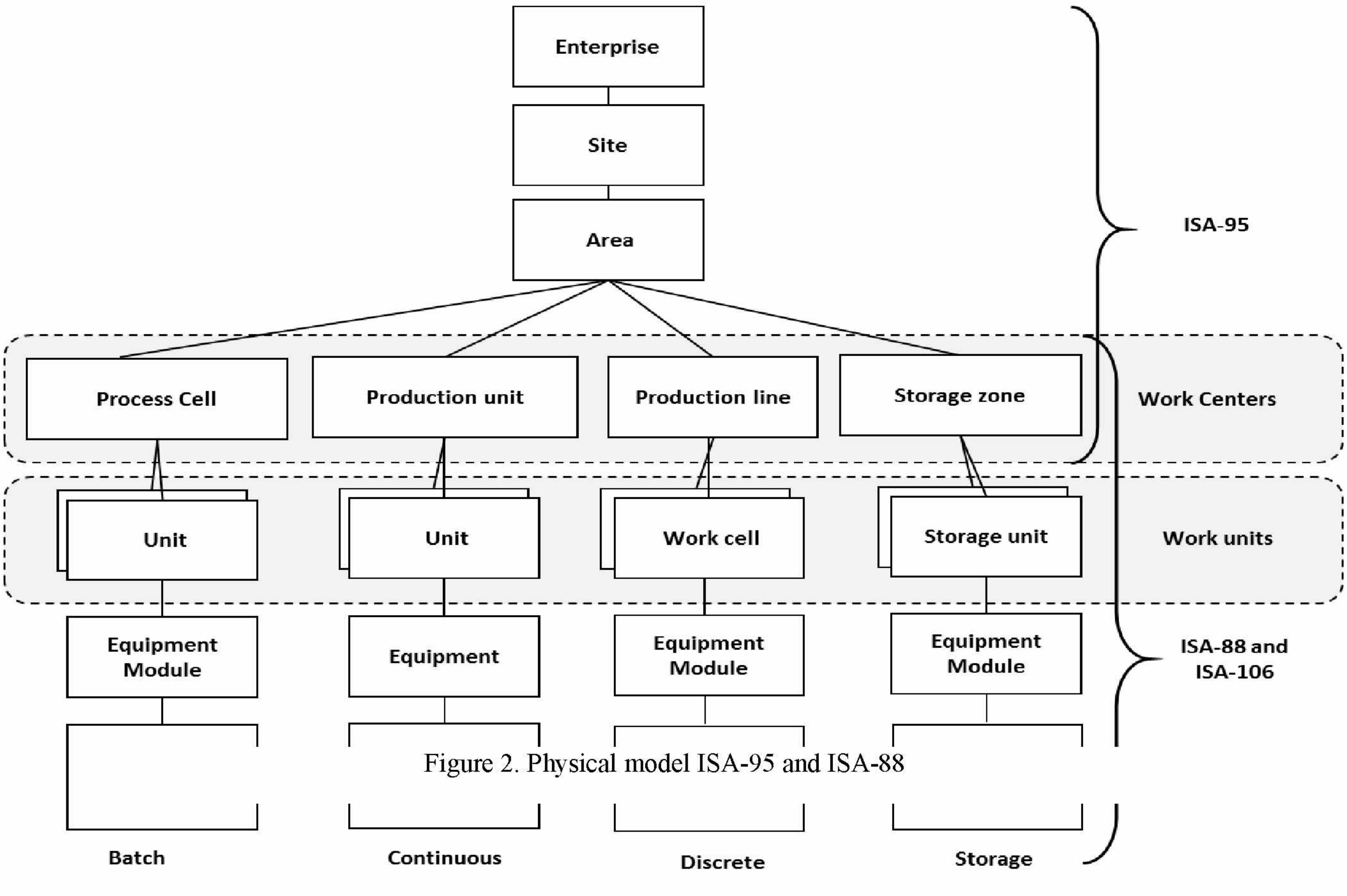

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ISA-95 standard covers the activity of the upper four levels of physical models:

1. Enterprise – is a production complex, which is responsible for a nomenclature of products which are produced, Site on which they are produced and methods of production. For example, it may be agro industrial company with several sugar factories located in different places.

2. Site - is a group of integrated objects that provide manufacturing, according to the schedule. For example, it can be factory;
3. Area (Area) – is a group of objects in site that provides producing according to production capacity. For example, for a sugar factory it can be production line of sugar, for dairy - cheese or butter departments:
4. Work center – is a Process Cell for batch processes, Production Unit for continuous and Production Line for discrete.
    - Presentation of process cell model is described in the ISA-88. For example, process cell for milk production may be line of preparation of integrally-dairy products, or part of it;
    - Presentation of the production unit model is described in the ISA-106 technical reports [22, 23]. Examples of production units for sugar production are all departments with continuous processes, including tract feeding and washing of beet, diffusion department, cleaning department etc;
    - Presentation of production line model for discrete industries can be described as analogous to the ISA-TR88.00.02 [16]. This, for example, can be assembly line production of household appliances.

Also the fourth level is described by standards ISA-88 or ISA-106 together with the lower three.

In this model, the term "equipment" refers to a particular entity, which has a role in production operations and includes control features that automate them. Such a combination of physical hardware and control functions under ISA-88 is called Equipment Entity. It has basic control features that are designed to perform certain operations with specific equipment. Besides basic equipment control, equipment entity should support procedural control that performs operations that were "programmed" and indicated in the recipe by technologist. According to the ISA-88 recipe and equipment entity interact in this way that allows realizing equipment control separately from the realization of process control algorithms, and then connecting them. An example of this connection is shown in Figure 3. For example, phases like "heat to ...", "mix for ...", "dial..." are implemented in procedural and equipment entity, which are connected by information flows to transfer commands, parameters and receiving current values.

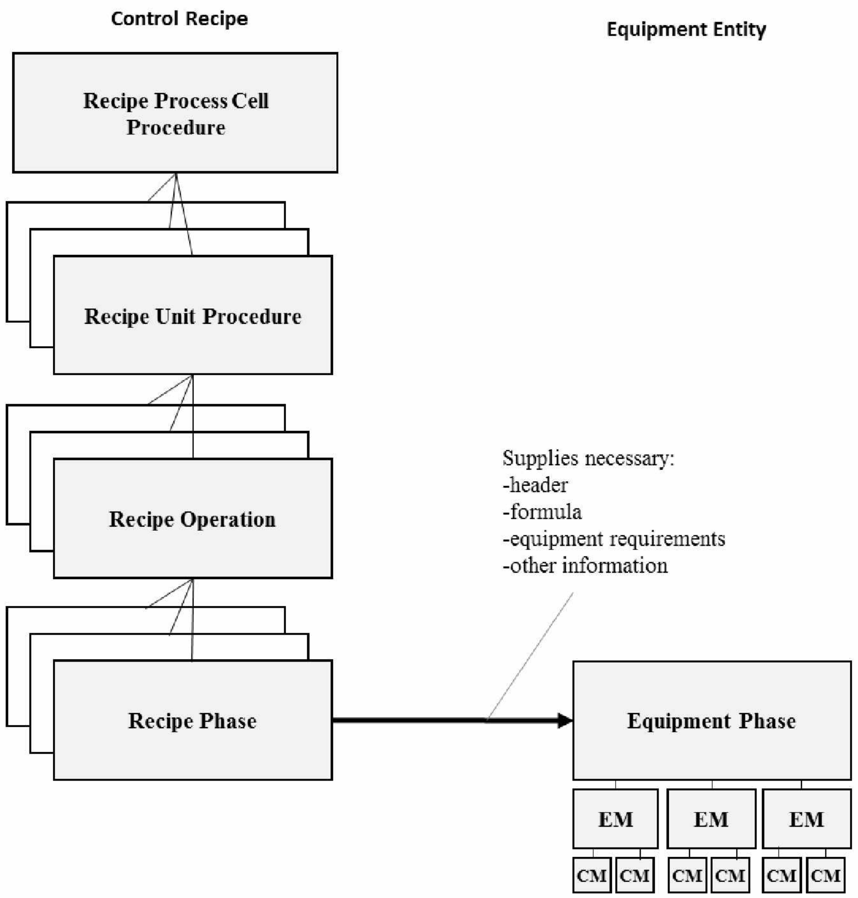

Figure.3. Communication recipe with equipment entity according to the ISA-88

Similarly, interact the upper levels where necessary product definitions "come down" from the top levels of management hierarchy to the level of work centers (Work Center).

Resource models are described according to the ISA-95, give an opportunity to request currently available equipment, personnel, materials and other resources that may be or already involved in production. Given that all models are interconnected, the resource can be specified as a reference element in the definition of the product, manufacturing plan and the actual performance of production.

Production schedules and production requirements.

The rules of forming production schedules are not described in these standards, as it is highly dependent on control object and approaches to production processes. However, it is assumed that subsystem, which will deal with the formation and control of the production schedule, will operate as described in the standard model. In particular, it will focus on the required plan of making products, which is transmitted from the upper levels, the definition of product and available at the right moment resources, those are specified therein. According to ISA-95 general Production Schedule (Production Schedule) on issue of products (see. Figure 4), which is defined at the level of organizational and economic control, goes to the functions of Detailed Production Scheduling, which form the Work Schedule. Formation is performed according to the definition of foods that is necessary to develop and available resources (equipment, personnel and materials). Below we consider this process using a Gantt chart.

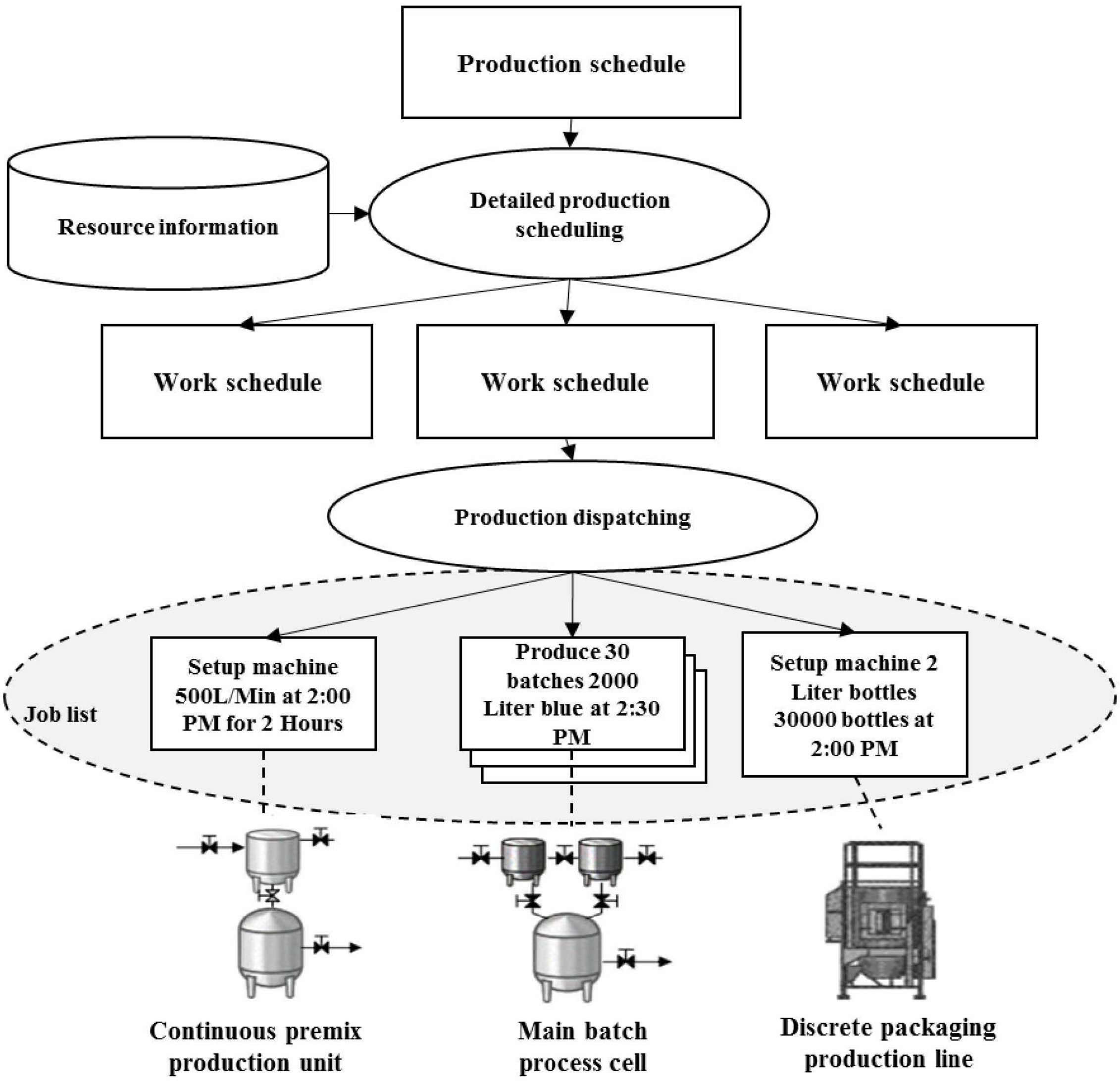

Figure 4. Hierarchy of planning.

Fig. 5 shows an example of making six items of (large parties) products in a Gantt chart. Horizontal lines represent the Work Centers, located on the 4th level of the equipment hierarchy (see. Figure 2). In this example, for the manufacture of items is necessary to use several work centers, each of which in turn participates in the production sequence of different items of products. Work on the planned producing items in the production schedule is called Work Request. Робота виконується в рамках кожного робочого місця для виробництва проміжного продукту. Кожна партія проміжного продукту виробляється на модулі роботи, це найменша частина обладнання, яке може управлятися за допомогою MES-рівня / MOM відповідно до ISA-95 (див. Рис. 2). Thus, Resource Schedule is created for each work center and at each time Job List is formed for the production area. Most jobs are performed under a definite Work Master of Job Order.

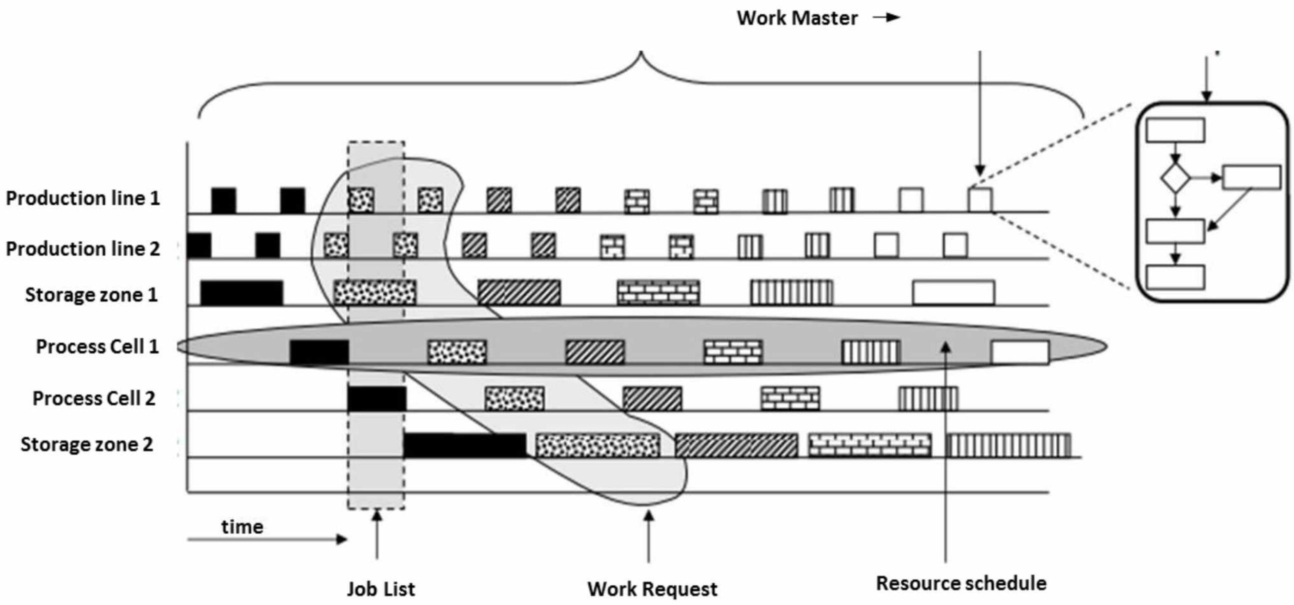

Figure 5. Example of working schedule in a Gantt chart.

According to ISA-88, planning and production schedules are one of the types of control activities required to manage batch process. Production schedule of parties determines which apparatus will be used to develop a particular product party at given moment. Let us consider communications of planning in the light of all levels of the enterprise (see. Figure 5, Figure 6). Production schedule (we remind that producing is one of the types of operational activity of enterprise) as a result of Detailed Scheduling is divided between work centers in the form of Work Schedules. The Dispatching function in real time forms and monitors execution of the list of jobs at particular work center (process cell). Management and control of process cell is performed in accordance with the definition a product that according to ISA-88 for each party is given by the Control Recipe.

It should be noted that the consistent "lowering" of schedules is made only after the planning function, which in turn requests the lower levels of available resources. That is such decision is taken as a result of permanent bilateral exchange between different levels of management. Figure 6 shows that organizational and economic level gets MES / MOM information about Production Capability. It is appropriate to note that the ISA-95 has series of models that integrate different types of information (various resources, activities) and are called segments (process segment, product segment). Production capabilities are provided to the upper level through process segment.

According to Figure 5 and 6 can be traced hierarchy of product definition: Product (Operation) Definition (level ERP) -> Work Master (level MES / MOM) -> Master Recipe (APCS level). Whereas the definition of the product provides for use on different equipment, for a specific lot and party will be created their unique copies in accordance with Work-Directive and Work Recipe, which will also serve as a marker for the producing history of the party and the lot. It should again be noted that the party in this case will be part of the lot.

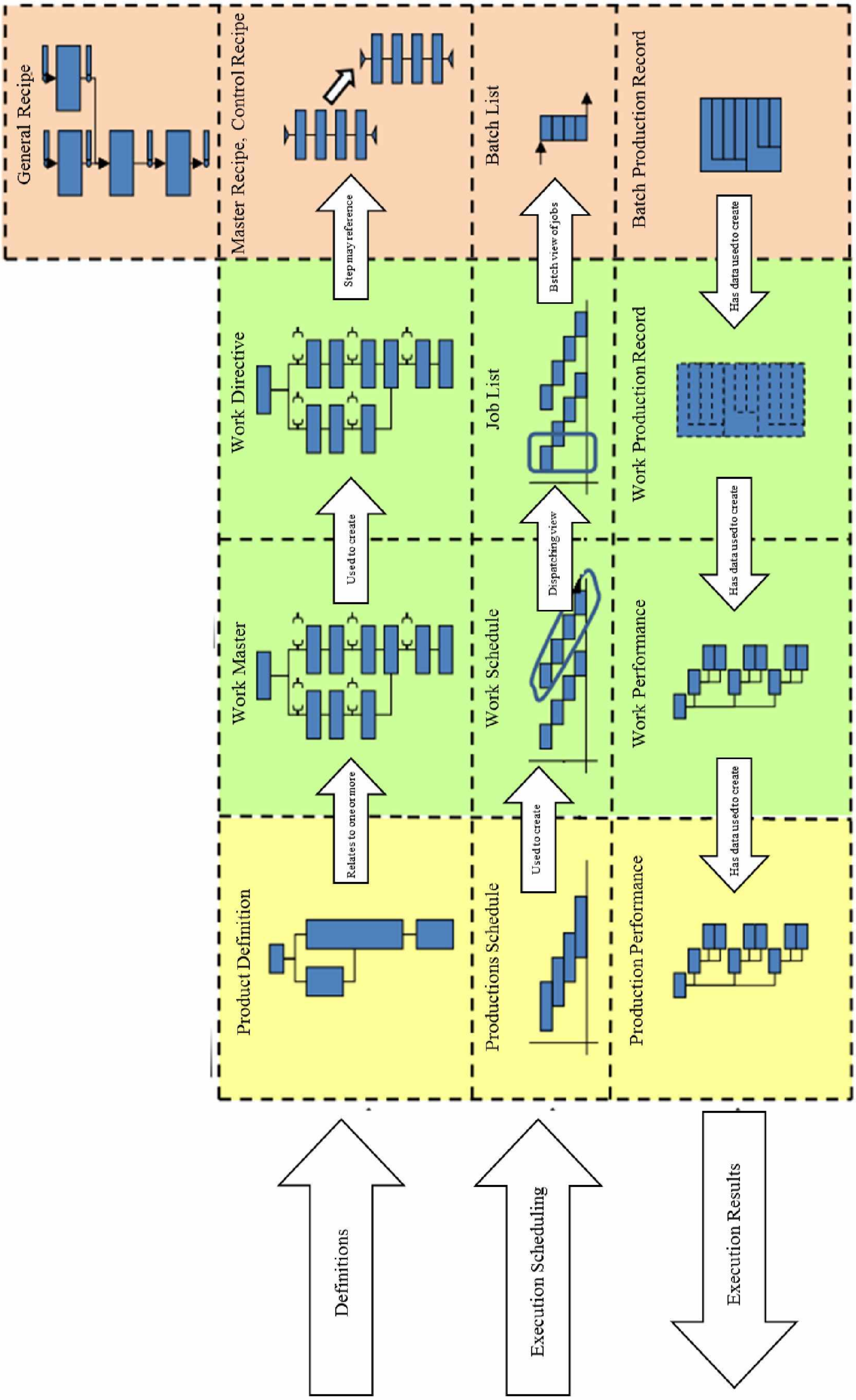

Figure 6. Diagram of the relationship described in the ISA-95 and ISA-88

A closer study of the standards can be seen that the planning function that is defined in ISA-88 and ISA-95 can not only be a part of a unified hierarchy but also overlap. This is true for other control functions. For example according to the standard ISA-88 Batch can be as fully ready to use product and inters (intermediate production). This is primarily due to the versatility of the model since MES / MOM operates not only in the batch production. In addition, not all control systems implement full functionality of ISA-88. On the other hand, software products that implement all the functionality of ISA-88 can be used at MES / MOM.

Actual production performance.

System should provide information on the status of the object and processes to monitor the implementation of production schedules, production analysis in real-time and historical data. number of models and combinations thereof are defined to describe this information. Consider the following data flows through the actual production performance through the management hierarchy (see. Figure 6). Data on the process coming to level MES / MOM through the function of Data Collection. In addition to collecting and providing real-time data to other functions, this function also provides data archiving and their subsequent viewing. The collected data in "raw" form are not required by manufacturing personnel MES / MOM and ERP, so they must be processed first to maximize information content. That is the collected data is usually checked for finding within the normative values (Alert) and displayed as key performance indicators (KPI). The latter can also undergo inspection for the formation of a real-time warning (Work Alert) of not enough good job of apparatus, process or machine through functions of Performance Analysis. Considering the importance of KPI calculation methods in production, standard ISO 22400 has been developed recently, the second part of which describes a typical set of performance indicators and their calculation algorithms [24].

An important function of MES / MOM is Tracking or also known as genealogy that allows to identify the history of making specific lot or batch of product: set and actual technological parameters under which the product was manufactured; qualitative and quantitative indicators of raw materials and product; product definition, and so on. According to ISA-88 for batch processes, tracking is provided by analysis of archival of Batch Production Record on its lot number.

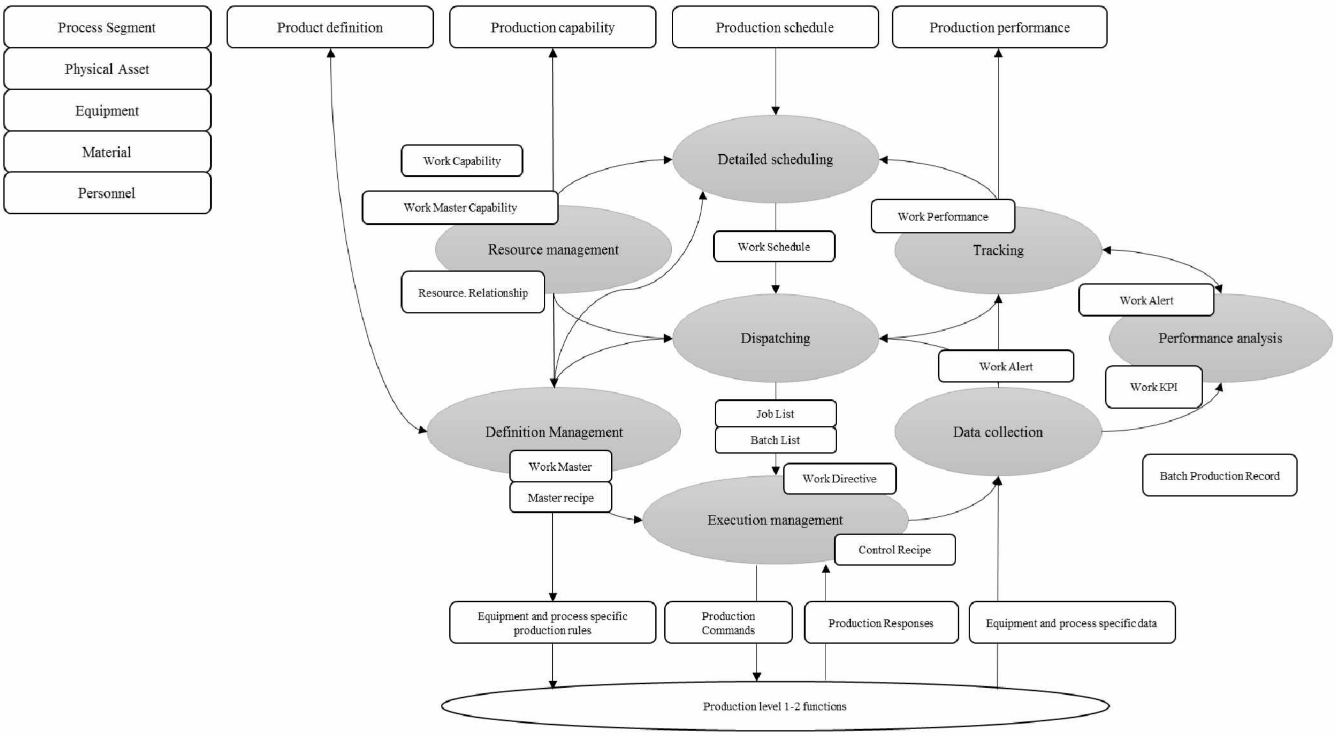

Figure 7. Information flows between the functions of MES / MOM and other under ISA-95

Summing the description of the main ideas of management systems of enterprise, we will give by thesis their functionality. ISA-95 is a standard which describes the organization of functioning integrated manufacturing and give data models that are exchanged between functionality parts of computer inegreted manufacturing. I.e. ISA-95 is a standard of integration ERP with MOM, MOM with APCS and MES / MOM components together.

ISA-88 is a standard for batch management processes. Like ISA-95, the standard is based on the principles of product definition (the recipe) and resource definition of equipment, on which is performed by this recipe. All other resources (staff, materials, energy) are included in the recipe as a formula or additional requirements. In addition to the recipe formula also includes procedure - technology program of product manufacturing. Recipe, including the procedure, is created by technologists without changing the control system. This is the main advantage of systems based on ISA-88 over classic monolithic control systems, because new products can be created without upgrading the existing system. Note that the parameters of the recipe may include emergency limits and exceptions processing algorithms that depend on product technology.

Each batch of the produced product is controlled on base of a unique control recipe, which is stored in the archive together with the value of process variables in which the party was produced. This approach makes it possible to trace the history of producing batch by its identifier. This is another great achievement of this standard. Technologies of standard facilitate planning and make more flexible use of equipment

The need and perspectives of the implementation of standards in Ukraine

As we said at the beginning, despite the proven effectiveness all over the world these standards in Ukraine are had known. Polls in social networks, communication with production personnel, representatives of international brands and integrators in Ukraine showed very poor knowledge of even the existence of these standards, their purpose and especially use. This shows the poor state of preparation of Ukrainian engineers in automation of production level. Below we look to what it can bring and what improvements can be made in the direction of development.

Several productions with dominant batch processes (e.g. pharmaceutical) at the level of obligatory for the implementation of international standards require the use of ISA-88. The absence of functional, based on the recipe control, makes it impossible to create new recipes and conduct genealogy of the product, not to mention the operational planning. It's witty that some control engineers used tools based on ISA-88 without the knowledge of the principles of their functioning. At that engineers simply followed existing implementation, figuring it themselves by trial and error. In most cases, the required functionality is invented independently, that significantly delay the project life cycle and greatly complicates the integration of subsystems into a unified system.

Works on ISA-106 standard, though not completed, with the basic concepts and the results of its application is available online. As Dave Emerson [25] noticed in his article, automation of procedures start, stop and exit from emergency situations and switch to another product make it possible to significantly protect technological process from accidents and reduce the time and energy loss. Such approaches are not new, particularly they are known as a subsystem of decision support. However, most continuous production control systems traditionally based solely on regulation.

As for the ISA-95 standards and their application in instrumental tools is not total. The majority of implementations do not lean on this standard and made using their own approaches and difficult to integrate with other subsystems. However, all of these implementations are often found general flaws that come with unpreparedness of lower control levels. For example, repeatedly determined lack of control reliability of data that prevents reliable calculation of balances and KPI on the upper levels. This requires the development of lower levels of enterprise management considering their integration in the computer integrated manufacturing. The only model of equipment ISA-95, ISA-88, ISA-106 allows software development, for example, for PLC and SCADA / HMI, taking into account their subsequent integration with the upper level.

We select what we think it is necessary to consider these standards for as guides in manufacture automation and integration of control systems, as they clearly define the necessary functions and their interaction. The standards present principles of classical decomposition and aggregating of CIM functions, which in itself is a great achievement. One of the basic concepts of standards - is a state-oriented management, which is an integral component of all models. She has shown its advantages that should be an argument for taking this approach into service by all programmers APCS. To date, there is no analogue to the above standards; they collected the results of the leading organizations in the field of automation and research.

We believe that the promotion and development of these standards even in Ukraine is possible and necessary. Ukrainian system integration owns strong and promising personnel, but continued targeting Eastern markets, made them bear service. We call for joint promotion and development of professional standards through the community, through the creation of Ukrainian books. The department IACS National University of Food Technologies (NUFT) has already made the first steps in this direction. During the last 2 years a group of teachers and undergraduates works on the translation of standards, technical reports and articles. To promote data standards is created a website that outlines all the major materials [26]. NUFT is a member of industrial control engineers of Ukraine that promotes these standards in Ukraine. In addition to educational activities, the department IACS within the research developed software framework to the PLC that is fully compliant with standards listed above. We provide to higher education institutions and other community members of control engineers to join this movement, which significantly advance the development in Ukraine.

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AUTOMATION NEWS

How Automation Can Measurably Boost U.S. Industry

There’s rarely a shortage of ideas about how to boost industrial growth and innovation. Most such discussions, however, typically spring from a personal, anecdotal, or industry-vertical point of view. To get a broader perspective and determine the most beneficial areas of focus for specific, quantifiable improvement, the National Institute of Standards and Technology (NIST) analyzed data collected through extensive interviews and surveys with researchers, developers, manufacturers and other stakeholders.

The studies also estimate the positive economic impacts of eliminating those obstacles—which NIST says would total more than $100 billion in annual savings.

It’s not surprising that three of these four studies focus on technologies covered regularly by Automation World due to their relevance across the discrete, process and batch manufacturing industries. These three technology areas are additive manufacturing, advanced robotics and automation, and smart manufacturing. The fourth area addressed by the NIST study focuses on roll-to-roll manufacturing—the fabrication of electronic devices on a roll of flexible plastic or metal.

The largest predicted cost savings across the studies are tied to smart manufacturing (defined by NIST as processes in which all manufacturing data from design to finished product is electronically exchanged and processed) and advanced robotics and automation. NIST suggests that smart manufacturing could reap $57.4 billion in annual saving to industry and advanced robotics and automation could save another $40.1 billion.

Despite its relatively recent entry into the manufacturing space, additive manufacturing/3D printing could save industry another $4 billion annually, according to NIST.

Across all these areas of focus, NIST’s analysis determined that U.S. industry must address currently unmet needs for measurement science and proof-of-concept demonstrations for emerging technologies. “Gaps in the technology infrastructure—including the lack of reliable measurement and test methods, scientifically based standards, and other formal knowledge and tools—limit advanced manufacturing’s further development and adoption,” says NIST economist Gary Anderson, coordinator of the studies.

Because the studies only considered the benefits directly attributable to closing the identified technical gaps in each sector, NIST says the impacts noted in the research estimates are conservative. “If we consider the larger-scale outcomes brought about by meeting these needs—such as new and improved products, increased production quality, long-term industry growth and job creation—the impacts would be significantly higher,” Anderson says.

https://www.automationworld.com/how-automation-can-measurably-boost-us-industry