Cost Oriented Robots for Kosovo

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Received January 7, 2009

Abstract - *The cost of developing and operating control and automation systems is a crucial factor of productivity and competitiveness for a number of applications in manufacturing plants, quality control systems and robotics.*
This paper has been focused on practical use of technologies that provided significant cost reduction in operating automated systems for a variety of industrial applications and buildings/facilities operations in Kosovo.
Topics that have been discussed were as following: key technologies reducing cost of automation systems; industrial applications of variety technologies, such as smart devices, wireless sensors and control systems, field robots, etc.; cost reducing engineering strategies as well as simulation of manufacturing systems and processes form cost estimation.

Key words: *Robots at SMEs, Manufacturing Automation, Cost Oriented Automation*

1 Introduction

The importance of automation in the process industries has increased dramatically in recent years. In the highly industrialized countries, process automation serves to enhance product quality, master the whole range of products, improve process safety and plant availability, utilizes efficiently resources and lower emissions.

The greatest demand for process automation, in general is in the chemical industry, power generating industry, and petrochemical industry; the fastest growing demand for hardware, standard software and services of process automation is in the pharmaceutical industry.

The starting points in assessing the future needs for automation are, on the one hand, global development and economic trends, and, on the other, the way in which they are reflected in the development of society and the economy (Sirkka-Liisa, Jämsä-Jounela., 2007).

Cost Oriented Automation promotes cost effective reference architectures and development approaches for production and transportation that properly integrates human skill and technical solutions, includes shop floor production support and decentralized process control strategies, addresses automation integrated with information processing as well as automation of non-sophisticated and easily handled operations for productive maintenance.

Cost Oriented Automation opposes the rising cost of sophisticated automation and propagates the use of innovative and intelligent solutions at affordable cost. The concept can be regarded as a collection of methodologies aiming at exploiting tolerance for imprecision or uncertainties to achieve tractability, robustness and in the end Cost Oriented solutions.

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Cost Oriented Automation does not mean basic or poor performance control. The design of automation systems considers its life cycle with respect to cost: cost oriented automation. Batch processing in manufacturing with decreasing lots, but increasing part complexity as well as mixed parts to be manufactured, demands for intelligent automation integrated with human capabilities of experience and knowledge regarding shop floor control and maintenance to save cost: cost effective automation (Erbe, H.-H.2003).

Soloman (Soloman, S., 1996) points to shortening product life cycles that need more intelligent, faster and adaptable assembly and manufacturing processes with reduced set-up, reconfiguration and maintenance time. Machine vision, despite partly of costly components, properly applied can reduce manufacturing cost (Lange, F. and Hirzinger, G., 2002). In order to survive in a competitive market it is essential that manufactures have the capability to deploy rapidly affordable automation with minimum downtime. This capability to adapt to a changing manufacturing environment results in cost saving and increased production. The concept of Cost Oriented automation or affordable automation is the provision of the human mind (Soloman, S., 1996).

Within the last years so called shop floor (micro workshop) oriented technologies got developed (Erbe, H.-H., 1996) and achieved success at least but not only in Small and Medium sized Enterprises (SMEs). They are focused to agile manufacturing that means to use an intelligent automation combined with human skills and experiences at the shop floor.

Shop floor control, Fig. 1, is the link between the planning and administrative section of an enterprise and the actual manufacturing process at the shop floor and is the information backbone to the entire production process. What at least Small and Medium Sized Enterprises (SMEs) need are Cost Oriented shop floor control devices, not only to avoid more or less complicated and expensive technology, but to effectively use the skill and experience of the workforce. Recent achievements for manufacturing are:

- Cost Oriented numerical controls for machine tools and manufacturing systems (so called job-shop controls).
- Programmable Logic Controller (PLC) shifting from PLC´s to general purpose Personal Computers. PC´s can easily perform many of the functions originally built into a PLC.
- Life Cycle Assessment of manufacturing systems: design, production, implementation, maintenance, qualifying operators (human skill), refitting, recycling/disassembling with respect to costs.
- Information-/Communication-Technology integrated in manufacturing system components to foster an agile automation in networked manufacturing enterprises and their extension to virtual enterprises.

Cost Oriented Automation is also related to:

- Organizational change and implemented information technology in Small and Medium Sized Enterprises for cost effective use of automation/control systems;
- Total Productive Maintenance with Tele-diagnostic via Internet to reduce costs for specialists;
- The internet protocol; it can be used for networking of controls, sensors and actuators;

- Shop floor control and maintenance with decision support based on automatic generated proposals by multi agents.

Robots, as a module of automation processing, can be divided in three classes (Whittaker, W.L.,1993):

1. Programmed robots perform predictable, invariant tasks according to preprogrammed instructions. They are the backbone of manufacturing, mostly preprogrammed off-line with a

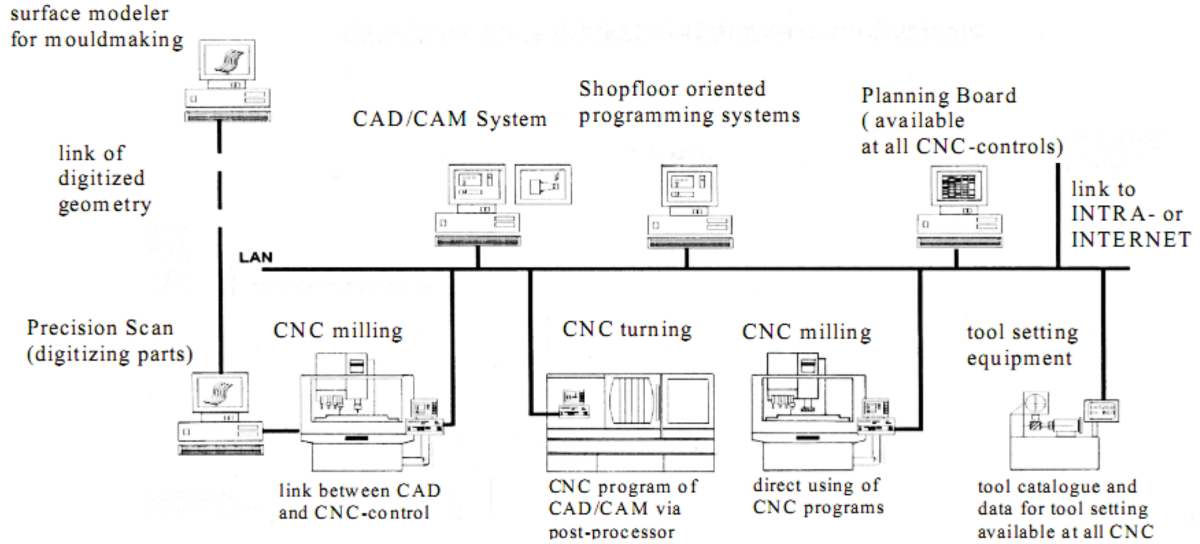

Fig. 1 Modules of a Shop Floor Network (Erbe, H.-H., 1996)

simulation of the programmed tasks before loaded to the robots at the shop floor (for a so called realistic robot simulation).

2. Tele-operated robots include machines where all planning, perception and manipulation is controlled by humans. Also called manipulators, they are served in real-time by operators. Tele-operation over great distances is one of the challenges for these kinds of robots (in minimal invasive surgery and distributed manufacturing).

3. Cognitive robots sense, model, plan and act to achieve goals without intervention by human supervisors. They serve themselves to real-time goals and conditions in the manner of Tele-operators but without human intervention. These are called Field Robots or autonomous robots.

As robot technology is mostly regarded as costly, one can see today an application not only in mass-production (automobile industry) but also in small and medium sized enterprises (SMEs), manufacturing small lots of complex parts. The rising product variety and customer pressure for short delivery times put robots in the focus. Hybrid forms of tele-operated and programmed robots are therefore attractive. The stationary application of such robots are not very useful due to the always changing needs in SMEs and specialists for installing and programming are expensive and hardly to find in SMEs.

An important point respecting the cost of robot technology in SMEs is the role of the human operators. Future tele-operators will combine robotic and manually controlled functions, with the degree of automation depending on the success of artificial intelligence research.

2 Cost oriented robots

Robots have become a normal feature of the industrial landscape.

In the last 30-40 years, large enterprises in high-volume markets have managed to remain competitive and maintain qualified jobs by increasing their productivity, through, among others, the incremental adoption and use of advanced ICT and robotics technologies. In the 70s, robots have been introduced for the automation of a wide spectrum of tasks such as: assembly of cars, white goods, electronic devices, machining of metal and plastic parts, and handling of work pieces and objects of all kinds. Robotics has thus soon become a synonym for competitive manufacturing and a key contributing technology for strengthening the economic base of Europe.

So far, the automotive and electronics industries and their supply chains are the main users of robot systems and are accounting for more than 60% of the total annual robot sales. Robotic technologies have thus mainly been driven by the needs of these high-volume market industries. In these global key markets where relatively few robot manufacturers can compete, European robot manufacturers face today a fierce competition.

To remain competitive in the global arena, future manufacturing scenarios throughout all industrial branches will have to combine highest productivity and flexibility with minimal lifecycle- cost of manufacturing equipment. This is particularly valid for today's small and medium sized productions as these are particularly prone to relocation due to high labor costs. In order to face these challenges and respond to ever changing customer demands, paradigms of knowledgebase manufacturing have been formulated during the Lisbon Summit in the year 2000 by concentrating on high-added value products, skilled work force and superior manufacturing technology.

2.1 A design case of a robot cell

Due to their flexibility and programmability, industrial robots play a central role in manufacturing, tightly integrated with its surrounding equipment to accomplish the needed productivity. The evolution of industrial devices like PLC's, cameras, intelligent sensors, etc., with their special programming environments/languages/features for configurability and reuse of those devices, forms a bottleneck for system integration. Therefore, programming a manufacturing cell usually requires specific knowledge about different devices making it a work for trained specialists or multi-disciplinary teams.

An example of a robotic cell (Veiga G., Pires JN, Nilsson K., 2007) is given in Fig. 2, composed of an ABB IRB 140 robot, equipped with the new IRC5 controller, a conveyor controlled by a PLC (Siemens S7-200) and a web camera. Basically, the conveyor transports sample pieces over the machine vision system, which calculates the number and position of the pieces. The results are sent to the robot controller to command the robot to pick them from the conveyor and place them into a box. A detailed description of this setup is available at (Pires, J. N., Godinho T. and Araújo R., 2006), where the author used an alternative solution based on a general client-server application developed using TCP/IP socket based communications. Since only the robot has built-in support for sockets communications, the several PC based applications were to distribute services over the network. They also developed two different clients to operate the cell: PC based GHMI (Graphical Human Machine Interface), and a PDA interface operates the cell: PC based GHMI (Graphical Human Machine Interface), and a PDA interface.

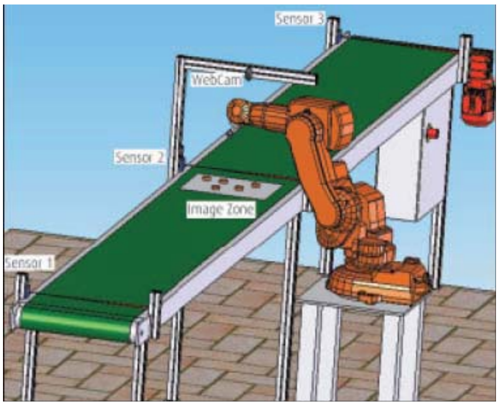

Fig. 2 General view of a robot cell (European Robotics Network, 2005)

2.2 Current and Future Trends in Industrial Robot Technology

There are numerous new fields of applications in which robot technology is not widespread today due to its lack of flexibility and high costs involved when dealing with varying lot sizes and variable product geometries. New robotic applications will soon emerge from new industries and from SMEs, which cannot use today's inflexible robot technology or which still require a lot of manual operations under strenuous, unhealthy and hazardous conditions.

Relieving people from bad working conditions (e.g., operation of hazardous machines, handling poisonous or heavy material, working in dangerous or unpleasant environments) leads to many new opportunities for applying robotics technology. Examples of bad working conditions can be found in foundries or the metal working industry.

If sensor information can be reliably used for robot control and if robot instruction schemes may be intuitive (e.g., by using more intuitive interaction mechanisms, built-in process knowledge and automatic motion generation), many other applications where present robot technology has failed can be envisioned (European Robotics Network, 2005):
Assembly and disassembly (vehicles, airplanes, refrigerators, washing machines, consumer goods). Obviously challenges address cost-effective robot systems which are able to cope with a wide range of processes, tasks and objects. In many cases fully automatic task execution by robots is impossible. Cooperative robots should support the worker in terms of force augmentation, parallelization or sharing of tasks. Cost-effectiveness can only be reached by drastically reducing the health hazards for the worker or increasing the productivity of the manual workplace by typically 50 – 100 %.
Aerospace industry currently uses customized NC machines for machining, drilling, assembly, quality testing operations on structural parts. In assembly and quality testing, the automation level is still low due to the variability of configurations and insufficient precision of available robots. Identified requirements for future robots call for higher accuracy, adaptivity towards work-piece tolerances, flexibility to cover different product ranges, and safe cooperation with operators.
SME manufacturing: Cutting, fettling, deflashing, drilling, deburring, milling, grinding and polishing of products made of metal, glass, ceramics, plastics, rubber and wood.
Food and consumer good industries: Processing, assembly, filling, handling and packaging of food and consumer goods.

Construction: Cutting, drilling, grinding and welding of large beams and other construction elements for buildings, bridges, ships, trains, power stations, wind mills etc. In most of these applications robots would have to cope with products having big variations in geometry and material properties and often produced in small batches.

Generally new types of robot systems which will have to deal with the range of applications described above will have to fulfill one or more of the following requirements:
Portable or mobile, to be used with minimum installation, calibration and programming effort.
-Allowing safe interaction (human augmentation)
-High forces, payloads when needed without any safety risk
-Interactive instruction and problem handling instead of programming
-Cost Oriented (1/2 of today's robot price)
-Force control in processes (machining, assembly) and 3D vision to adapt to variability in part geometry
-Stand severe environment.

3 SMEs in Kosovo

In market economies, small and medium enterprises (SME) are a dynamic and active sector where much capital is invested. As a result, they contribute to employment growth and productivity improvement. Now days, the SME sector is the main source of new job generation and income growth. Therefore, the private sector is a major force for growth and transformation in all market economies, including the countries in the region.

In Kosovo, SMEs employ the largest overall number of workers having a significant impact on the aggregate increase of domestic products, services and budget income etc. SMEs are the drivers of a market economy, which presented by the fact that make up over 99% of the total number of enterprises.

In 2004 at 39,257 SMEs were employed about 93,260 employees, mainly at trade sector 36%; at production sector about 15.57%; sector of energy suppliers 9.97%; transportation 8.78%; hotels and tourism 7.85%; construction 7.54% etc ((Observatory of SMEs, 2006).

Historically Kosovo's economy was concentrated in extractive industry, production of non-final materials, semi-final agricultural products. There are 43 metal working SOEs under an ongoing process of privatization (Potential Analyses in line with Metalworking Sector in Kosovo, 2007).
As by December 2006, the portfolio of Kosovo Chamber of Commerce consists of 87 metalworking businesses.

In a today's highly competitive market, Kosovo metalworking manufacturers face the challenge of reducing manufacturing cycle time, delivery lead-time, stable supply of raw materials and inventory reduction. However, every organization (company) has its own objectives and its own way of decision-making processes. Due to the conflictions among the objectives of each organization and non-integrated decision making processes, there might be difficult organizing a supply chain management among these companies and finding out a mechanism which help to resolve those conflictions and to integrate processes.

The majority of SMEs have started to formulate and implement structured development plans covering periods of between 3-5 years taking into consideration circumstances and developments in Kosovo, also are highly dependent upon external funding, especially loans from Diaspora or international financial markets.

There is still a significant negative difference between imports and exports and extremely heavy reliance on imported raw material and final products. The problems/barriers identified that SME's face during their activities/production/manufacture include centralized management, poor-quality materials, unfavorable loan terms, no information of market trends, no quality insurance, inability to meet export market, lack of product diversification, high cost of imported materials, etc.

4. Case studies

SMEs are considered as a key component in the rebuilding and future economic development of Kosovo.

In order to have clear picture about the current situation of the possible implementation of robot into automation manufacturing, two companies in Kosovo who have expressed interest to be involved in case studies.

First the visit of SME called "Rugova" in Peja which is bolting the source water took place. Technology equipment for bottling was from Italy consists as following:

1. Uniblock 12/12/1 – model Oceanic-G with 12 valves with capacity of 1.500 – 2.500 plastic bottles/hour for different shapes of bottles of 200 until 2.000 ml,
2. Automation labeling line model M3000,
3. Semi-automation rotation Uniblock model CP-1. The base of the pallets is 1.000 x 1.200 mm, while in one pallet can be placed:

- 2.980 plastic of 500 ml
- 1.183 plastic bottles of 1500 ml

Height of the pallet is 2.350 mm for both types of bottles.

4.1 Production capacities

One package of filled bottles along with labels contains 6 pieces of 1500 ml plastic bottles or 12 pieces of 500 ml plastic bottles. The palletizing is done manually into the pallet of 800 x 1200 mm.
Thee workers are in charge with palletizing process, while one worker is in charge to feed the Uniblock 12/12/1 for filling with water (see the below pictures).

We have been informed in details about the overall producing process from the technical staff, who explained us about the technology in use, production problems they are dealing with as well as they have shown the interest to automation some of the operation where they considered the bottleneck of the production.

Fig. 3 Two possible working places needed to be automated at “Rugova” in Peja

The second factory we visited was “Gorenje - Elektromotori” in Gjakova. This factory is out of production for more than ten years, due to the difficulties with identifying the owner of the factory. GE produced various types of engineered motors designed specifically for products of identified customers, assorted in three production programs.

According to the company’s mission and objectives, it is with significant importance starting reengineering production program with new types of motors dedicated for household appliances, focusing on those for washing machines. Having in consideration that motors for washing machines are inconsumable products and designed specifically for identified customers, the company’s approach for analyzing market needs was making direct contacts with these identified customers/manufacturers of washing machines from previously served market niches in Italy and Slovenia.

Fig. 4 Machines to be served by manipulation robot at “Gorenje Elektromotori” in Gjakova

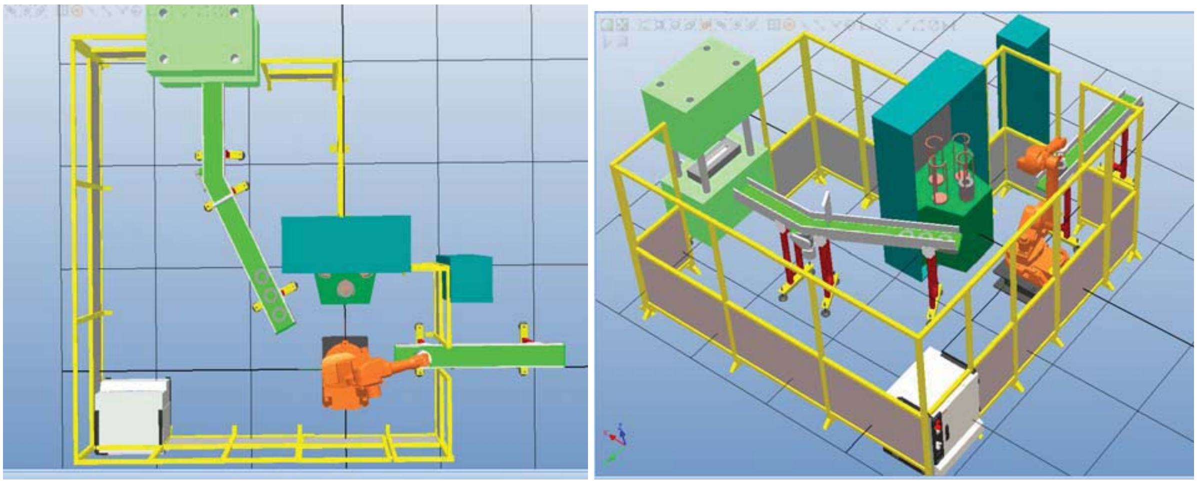

Fig. 5 Layouts of robotized working cell at “Gorenje Elektromotori” in Gjakova

In the Laboratory of Robotics of the Faculty of Mechanical Engineering (FEM), the University of Prishtina is being finalized the pick-and-place industrial robot. The robot has three axes about which motion ca occur: rotation in a clockwise direction on the unit on its base, arm extension or contraction and arm up or down; also the gripper can open or close. These movements are actuated by the use of pneumatic cylinders by solenoid controlled valves. The gripper can be opened or closed by the piston in a linear cylinder extending or retracting, showing a basic mechanism that could be used. PLC has been used to control the solenoid valves and hence the movements of the robot unit.

The first tests have been performed showing the advantages in technology and cost aspects of robots that would be designed, developed and constructed by FEM Staff in connection with partners from industry.

This robot cell is expected to be employed in new SMEs who will express interest to have production lines with automation processes.

Fig. 6 Pick-and-place industrial robot

Robotics research in Kosovo is also done at UBT in Prishtina (Dermaku,A. and E. Hajrizi, 2009)

5 Conclusions

In a today's highly competitive market, Kosovo companies in general face the challenge of reducing manufacturing cycle time, delivery lead-time, stable supply of raw materials and inventory reduction.

The majority of SMEs have started to formulate and implement structured development plans covering periods of between 3-5 years taking into consideration circumstances and developments in Kosovo, also are highly dependent upon external funding, especially loans from Diaspora or international financial markets.

SMEs are considered as a key component in the rebuilding and future economic development of Kosovo therefore applying process automation needs to be main motivation.

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7 Aknowledgement

This work was supported by the “ Austrian Science and Research Liason Office – ASO” under Contract Number K-21-2008.