INFLUENCE OF THE NEW TRENDS IN THE ECONOMICS ON THE ROBOT DESIGN PHILOSOPHY – A CASE STUDY[⊗].

A GAZDASÁG ÚJ TRENDJEINEK HATÁSA A ROBOTTERVEZÉS FILOZÓFIÁJÁRA – ESETTANULMÁNY

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Abstract: *To determine what influences the economics triggered by robot use and design, a large scale of factors can be name*

- *The ever improving technical specification of robot*
- *The direct economic benefit produced by the robot*
- *The indirect economic benefit produced by the robot (often larger than the direct ones)*
- *Local rules and restrictions like RIA (USA), JIS (Japan) and CE (Europe)*
- *Local labor rules, social syndicate agreements*
- *Process and application restrictions*
- *Skills and attitude of labor.*

Keywords: *robotics, new design philosophy, industrial robots.*

Kivonat: *A szerző célja bemutatni, hogy a gazdaság milyen területein hozott változást a robotok alkalmazása, és azok tervezése. Számos ok sorolható fel, amelyek közül a legfontosabbak:*

- *a robotok műszaki paraméretei folyamatosan változnak, és javulnak;*
- *a robotok közvetlen gazdasági előnyt hoznak létre;*
- *a robotok számos közvetett gazdasági előnyt is generálnak;*
- *a robotk számos területen új szabályozók bevezetését indukálják;*
- *megváltozan a munkaszabályok;*
- *a robotizált folyamatok számos területen új korlátozások bevezetését jelentik;*
- *a robotok megváltoztatják az emberek munkához való viszonyát, és új emberi képességekre kell szert tenni.*

Kulcsszavak: robotika, új tervezési filozófia, ipari robotok

I. LITERATURE OVERVIEW

The various labor theories of value are nothing new, and prevail amongst classical economists, including A. Smith and D. Ricardo [1]. Since then, the concept most often associated with Marxian economics, while modern mainstream economics replaces it by the marginal utility approach [2]. Understanding importance of robotics at institutions of higher education FANUC Robotics established formal relationship with Zrínyi Miklós National Defense University signing a Cooperation Agreement 2 February 2009. The joint activity and its main points are outlined in [6]. Szabolcsi and Mies in [7] dealt with historical aspects of the robotics and showed the way to the modern robotics of the present time. In [3] gave mathematical models of the parameter uncertainties and applied them to robust analysis of the control systems being applied in robot systems. In [4] Szabolcsi presented a new example of robust analysis applied to investigate behavior of the aircraft stability augmentation

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system. Szabolcsi in [5] dealt with mathematical modeling of the human operator behavior, gave main transfer functions and state space models, which can be applied to analysis and design of the robot systems including both civilian and military applications. In [8] Szabolcsi laid down method and main steps of the identification process of the air robot system, and gave guideline to prepare a flight plan for test flight to generate flight parameters' time series to identify theirs spatial motion dynamics.

II. NEW ROBOT DESIGN PHILOSOPHY

If we follow the case study of Engineered Machined Products Inc. (EMP), based in Escanaba, Michigan, USA we can demonstrate some these factors and their effects.

EMP is a Tier 1 supplier to major diesel engine manufacturers. Mr. Brian Larche purchased EMP in 1991 and yielded US$6 million in revenue. Larche's target was to make EMP a world-class supplier of automotive components, and maintain his factory in Escanaba USA (the need and availability of skilled labor). In 2009, EMP's revenue has exceeded the US$320 million mark; it employs 800 people, and has an extensive R&D Technology Center, which has over thirty (30) thermal management and oil management related patents.

Like most manufacturers today, EMP faces serious challenges to produce high-quality products and solutions for their customers, stay competitive, and keep their operations in Escanaba. One of their targets was to keep the business in Escanaba, and in order to do that they had to automate. To meet their challenges head on, EMP decided to implement the latest robotic technologies.

EMP purchased its first robot (from FANUC Robotics) in 1999. The cell serviced – load and unload - four CNC lathes and gave them a taste of what automation could do for their company.

In 2000, EMP took on a contract with a major diesel engine manufacturer to provide high-pressure fuel delivery rails. While focusing on their challenges, EMP called upon Makino and FANUC Robotics to develop a solution for the high-volume machining operation. Producing high-pressure fuel delivery rails is complex, because the rails often require several machining processes to manufacture, and cycle times are very long for each process. The team determined that a multiple robot solution would not be an economical decision for this application.

FANUC Robotics' Toploader series of articulated gantry robots were evaluated for EMP's machining operation. Compared to traditional linear gantry robots, Toploaders reduce floor space and ceiling height requirements. A clear factor of where robot design brings new economical benefit to the user, in this case EMP. They also provide six-axis dexterity to perform value-added post-processing operations such as degating, deflashing, labeling, quality assurance, packaging and palletizing. EMP determined that the M-710iB/70T Toploader robot, with a 70kg capacity, and a variety of rail lengths would best suit their needs.

Figure 1. FANUC Toploader Robot.

Two FANUC Toploaders now services eight machine portals (some leading to several machining centers on Makino's MSC system). The cell layout allowed EMP to place the machines in close proximity around the robot rail, minimizing the traditional circle configuration with pedestal-mount robots. This two-robot line would have required over four people per shift to handle the heavy parts, not to mention the ergonomic issues surrounding repetitive loading and unloading motion. Robots just made sense: the 70kg robots are able to handle two parts at once and since each robot performs the same process and operates independently, EMP can shut down one side if necessary while maintaining production capabilities on the other side. Each robot services two operations per cell, OP10 and OP20.

The robot starts by removing two parts from the movable machine fixture on the Makino MSC system in OP20 and places them on a four-position asynchronous pallet conveyor to be transported on to post machining and cleaning processes.

1. The robot then removes two parts from the OP10 machine and places them on a re-grip station where the parts are turned over for machining in the OP20 machines.
2. Next, the robot loads the parts onto the OP20 machine fixture and returns to the infeed conveyor.
3. Finally, the robot acquires two raw parts from the infeed conveyor, loads the OP10 machine, and the process is repeated.

The robot's flexibility allows it to service any OP10 and/or OP20 combination in situations when a machine is undergoing service or tool changes. Since this cell's inception in 2001, it has undergone a re-tooling to accommodate revisions to the fuel rail. Because the system was designed to easily handle customer modifications, machining processes and automation changes were minimal, and only required new machine fixtures and robot end-of-arm tooling (EOAT).

EMP has automated additional machining applications and now has eleven FANUC Toploader robots in operation**.** The company is currently the primary source for high-pressure fuel delivery rails for two major diesel engine manufacturers. The automation focus on complex precision machining has allowed expanding into areas that a typical machine shop would not be able to do.A second design factor that contributes to the increased economic benefits based on robot design is robots with vision: in addition to machining operations using Toploader robots, EMP has incorporated other types of FANUC robots at their facility. For example, the FANUC R2000iA/165F robot is used in several smaller machining cells throughout EMP's factories. The smaller systems are not only economical, but enable EMP to easily change product runs with minimal to no physical component changes.

FANUC's V-500iA/2DV_vision system combined with DTS America's flat-belt conveyors allow for a variety of parts (fitting within the parameters of the system) to be conveyed into the cell and located by the vision system. For example, a machining cell that processes water pump impellers contains two R-2000iA robots and two over/under flat-belt conveyors along with two FANUC 2D Vision systems. A single Industrial PC controls the two cameras; the frame-grabber will allow up to eight cameras on a single PC. Communications between the PC and the robots is furnished via Ethernet; all FANUC robots are equipped with Ethernet on R-J3 and newer controller platforms.

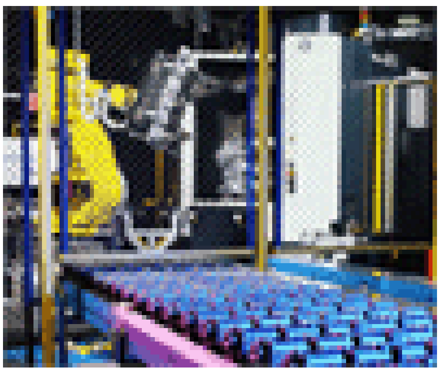

Figure 2. FANUC Robot in Service.

Currently the system handles nine variations of impellers with simple changeover on the robots. Due to multiple-sized parts that are run on the system, the parts are placed on pucks that ride on the flat-belt conveyors.

1. When a part is removed from the puck, the robot picks up the puck and places it on the outfeed conveyor.
2. The finished part is then placed on the puck for transportation out of the cell.
3. During a product change the cell enters a cleanout mode initiated by the operator via the SNPX-interface HMI connected directly to the robot controller.
4. The robot completes the cleanout process, aborts, and a new part number is entered on the HMI.
5. The operator changes out the gripper fingers and quick-change-tooling on the machine tool, presses 'cycle start', and the robot is able to make the next product.

The robot is equipped with a tool changer if EMP elects to incorporate automatic product change to meet future demands. EMP also has robots doing assembly work at all three of its plant locations (Escanaba, Michigan, Indianapolis and Greenfield, Indiana) These assembly processes have several small parts (sub-assemblies) that are incorporated into the final assembled product - all accomplished by robots - minimizing human intervention and inconsistencies, while assuring delivery of a quality product. While many competitor companies downsize and send their work overseas, EMP has achieved in 2010 to have a successful manufacturing operation in Michigan. A large part of our automation has allowed employing over 160 new hires in 2009.

The EMP example shows that the choice of new design robots, 6 axis on a linear track and added vision systems bring direct and indirect economic benefit. Labor value in terms of humans has been reduced whilst the needed productivity of its machining centers has increased. It is this indirect benefit that is the success factor.

Relating the EMP case to the theory we need to look at the labor theories of value (LTV). Popular belief defines these as economic theories of value according to which the values of commodities are related to the labor needed to produce them; basically the classical supply and demand curves in terms of labor value.

The Labor Theory of Value states that the market value of a commodity is ultimately determined by the total amount of socially necessary labor time that went into its production and delivery.

In this line of thinking it can be argued that if you have a factory that is completely robotic, it has created wealth without the use of labor. The EMP example is certainly well underway of reaching this level.

In reality it doesn't really matter if there is only one person left minding the shop and supervising the robots, or even nobody at all. The final product still embodies labor power from other parts of the overall process including the production and transport of raw materials and energy. Yes, there may even be some human accounting, management and marketing tasks which prove to be socially necessary to make the product worth bringing to market, or maybe not. The newly equipped robot powered shop of EMP has only a temporary opportunity to make super profits. As soon as competitors discover the same thing, the market price of their products will be determined by the price of your raw materials plus the amount of labor required designing, manufacturing, operating and maintaining the robots.

We can also differentiate between the one-off efforts involved in design and manufacture of the robots, and the ongoing requirement for some labor to operate, power and maintain these machine tools. As far as the value of the items produced by this newly automated labor-efficient factory is concerned, the initial investment will sooner or later be disregarded, and both the perceived and actual value of the items once brought to market will drop to match the lower amount of human labor power involved in the production process. At EMP labor need was reduced by introducing automation, but is also generated new fields of labor within EMP, robot programming, maintenance etc.

Machine running hours (the CNC centers and robots in the EMP case) can be considered in the same way as or perhaps on a par with human labor hours. The robots are consuming a certain amount of energy for each hour of production, and will require a scheduled maintenance after certain fixed periods which could be divided into the hourly rate.

The question arises whether there is a fundamental difference between machine hours and human hours.

Humans have certain needs which if not fulfilled will not make them very useful workers. Sleep for example! In order for your worker to be able to work at making profits for you on a regular basis, she also needs to be able to take a minimal amount of time off for rest and everything else necessary to keep body and soul together, as they say. Of course we all need to eat, just as the robots consume energy, so the provision of food, shelter, warmth and even the production of future generations of workers need to be factored into the total labor costs of buying each human labor hour.

Driving down the cost of labor is what profitability is all about, the EMP case makes that all too clear, which is why corporations will sometimes invest millions in order to lay off just a handful of workers. As long as it reduces the total wages bill, the profitability will be seen to have increased, thus pushing up the stocks value which can then be used to borrow and invest in yet more labor reduction, as long as things are going well. Classical economist David Ricardo's labor theory of value holds that the value of a good (how much of another good or service it exchanges for in the market) is proportional to how much labor was required to produce it, including the labor required to produce the raw materials and machinery used in the process. David Ricardo stated it as, "The value of a commodity, or the quantity of any other commodity for which it will exchange, depends on the relative quantity of labor which is necessary for its production, and not as the greater or less compensation which is paid for that labor" (Ricardo 1817). While robots and the new trends in robotics as seen above are not a panacea to get completely rid of the human labor part, it does raises questions about the limits of robotic automation. If there is one.

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