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Investment calculations and production automation in welding

White paper

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The focus of this paper is on aspects, which should be taken into consideration when handling investment calculations related to production automation, like robotics.

Introduction

Production engineers often get excited about new technical solutions and tend to think that the benefits of new investments are also obvious to everybody else in the company. The surprise might be unpleasant, if enthusiastic engineer has not been prepared to argue his case properly.

How to talk to your treasurer

Production development engineers face typically a question: *What is the payback period of the proposed investment?* Relevant question, but let's start with pointing out that "payback period" does not actually describe the profitability of an investment; it just describes the time needed to "repay" the amount of money used for the investment. In its simplest format, it does not take into account the time value of money, risks involved, opportunity costs etc.

Therefore, the preferred tool for evaluating the profitability of investments is typically the one that utilizes **net present value** (NPV) instead or in addition to the calculation of "payback time". **Internal rate of return** (IRR) or calculations based on annuity can also be used.

From the financial point of view, the NPV formula could look as follows:

$$NVP(i) = \sum_{t=1}^{N} \frac{R_t}{(1+i)^t} + \frac{RV}{(1+i)^N} - C_o$$

NPV(i)	discounted value of the investment
t	time periods (years)
N	total number of periods = depreciation time
i	company set target for internal rate of return
Rt	cash flow during period t
RV	residual value at the end of depreciation time
Co	the total initial investment cost

If, with given restrictions for N and i, the output NPV(i)>0 the investment is in general profitable.

NPV calculations are useful when comparing different kinds of investments with each other, like "paint shop" vs. "welding line" or in simple "apple to apple" situations like *should I purchase welding power source A or B* and when making "make or buy" decisions like *should I produce this part myself or outsource it*.

In these cases, the NPV will show which investment is the most profitable, indicated by the highest NPV value. So, in short: there should be one NPV value for each alternative production concept, continuing with current concept being one.

At this point is good to remember that comparing resulting NPV figures, we see only the relative profitability of different production concepts. Typically, shareholders seek both growth and profitability for their companies. It is essential that compared production concepts are compatible in both categories. All concepts have to offer same capacity so that cost per produced unit can be calculated with the same volumes.

Notes on variables used in formula:

Since **targeted internal rate of return** (i) and **depreciation time** (N) are more dependent on company internal financial rules and local laws than actual manufacturing operations, these factors are not addressed in this paper in detail. They should anyhow be the same for all comparable investments.

While **residual value** (RV) of a non-automated production concept might easily be estimated as zero, the residual value of the automation investment can still be significant after determined **depreciation time** (N). Depending on company policy, the depreciation time can vary a lot, but generally three to seven years should be acceptable. Average technical lifetime for a robot is however 12 to 15 years. Therefore, it is fair to argue that some residual value, at the end of this relative short depreciation time, should be taken into account when making investment calculations for automated production systems.

Initial investment cost (Co) should include the costs of equipment and software purchases as well as training, project management and other internal costs like infrastructure changes etc., caused by the proposed investment. These costs are related time-wise directly to purchasing and commissioning of the automation system.

Cash flow in each period can be calculated as follows:

Rt = earnings – operational costs

Earnings present the end customer value increase, which the investment provides. For example, in the case of a welding robot, it can be the sales value of welded consumable kilos, produced during a **time period** (t). It is easy to see that the feasibility of an automation investment depends heavily on high utilization rate of increased production capacity. In the case of robotic arc welding, one robot could be producing 6000...12 000 kg of weld per year, while one manual welder produces 1500...2000 kg at the same time. If we assume that the customer pays the same amount of money per welded consumable kg in product and the demand is there, the earnings are easy enough to estimate for both concepts.

Defining costs for this part of the formula is the tricky part of this exercise and therefore it is discussed more in details in next chapter.

Why comparing investment cost to direct labor cost of today is not enough in production automation cases?

When estimating the profitability of investments made for production automation, one should be aware of the following points:

- Comparing only direct labor cost [$/h] to proposed investment leads easily to wrong conclusions.
- In order to be able to determine the "Rt" factor in the NPV formula accurately, we must understand the role of manufacturing activities in company as whole.

While most companies know exactly how much hourly wages are today, they are not necessarily aware of how much each actual manufacturing function costs for the company today or in the coming years.

In this paper, the costs are divided in to the three different categories, presenting cost factors that should be determined for all alternatives before any real comparison between choices can be made.

1st cost category:

Each work stage is directly burdened by costs like:

- direct wages,
- cost of the workshop floor area used by each work stage (building and related infrastructure like heating etc.),
- cost of the management and supervision,
- costs of tools and materials, and
- costs for shared utilities like overhead cranes etc.

2nd cost category:

There are also costs that actually burden the work stage, but are harder to define if they have not been systematically traced. They occur, for example, because of the current way operations are done. These could be costs like:

- costs for quality activities (inspection, repair work),
- costs caused by work in progress (WIP),
- costs caused by long/varying lead times (delivery accuracy),
- health and safety related costs,
- overtime / additional working hours in downstream work stages which are needed to manage the variability of manual work in previous stages, and

- overtime / additional working hours from all supporting resources, like supervision and logistics, resulting from above listed issues.

Important note!
Sometimes the cost of reduced WIP alone can justify the investment on automation.

3rd cost category:

Some costs are related to the availability of needed resources over a period of time. They can be pointed out, but typically not accurately calculated, only estimated. A few examples:

- The easiest to understand here are the labor costs for skilled labor, which are increasing because of macro-economic reasons – one individual company has little or no means at all to influence these. Since investments on production automation are made for several years into the future, the labor costs of today cannot be used for the total period of an investment's life time. Instead, the changes in labor costs over a period of 10...15 years should be taken into account. 7..15 % annual rise in these costs is not unheard of.
- The effect of learning curve can be decisive. Each time a new product is introduced to a work phase, the processing time for the 1st product could be for example 50-150 % longer than the calculated optimum target time. It takes several products for workers to learn how to achieve the target throughput time. Automation standardizes production activities, because once set-up, they repeat the same productivity in individual work stages ever after – unlike humans. This can result in dramatic savings in lead times with every new product introduction (NPI).

The last point is not an actual cost factor, but a fundamental fact to be recognized:

Can the job be done in general without automation?

Can the targeted turnover (volume) and profit be reached when considering:

- accuracy,
- quality,
- speed,
- process related hazards, health and safety of workers,
- general availability of skilled workers, and
- limitations on floor and storage space, material flow etc.

If the conclusion is that the job cannot be done without automation, using labor cost as comparison and an element in calculation formula to determine savings is more or less irrelevant.

Don’t forget measuring with Key Performance Indicators

Once the all cost factors are identified, they can be added up and tied with actual products rather than resource hours. At this point simple, relevant Key Performance Indicators (KPI) can be made available for production stages. For example:

- [$/tn] - cost of produced steel tn
- [$/m] - cost of welded meter (or kg)
- [$] - cost of average WIP
- [1/year] - inventory turnover rate
- Etc.

Current KPI figures can be compared with the evaluated KPI figures, which are based on investments. The new production concept with proposed investments should be able to give better results, over the chosen time frame, as visualized by selected KPI’s than the existing system. Similarly, in case of “green field” factories, two or more different concepts can be compared.

Conclusions - avoid comparing apples and oranges

In order to understand the impact of investments on automation in production, a wider perspective should be taken in use. Together with new production equipment also production planning and scheduling must be modified to serve the selected production concept.

Investments on automation should be considered as **a strategic issue** and whole production concepts should be evaluated instead of individual work steps.

Traditional investment calculation tools can be used to evaluate the profitability of automation investments, if a comprehensive and compatible evaluation of alternatives is done. The key question is then which concept provides the best profitability and required production capacity for the company?

What is the cost per produced unit over determined period is a more relevant question than *How much does this one piece of equipment cost, which replaces one of our current functions*.