ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering, Volume VII (XVII), 2008

RETTROFITTING – A TECHNICAL SOLUTION ADAPTED TO SUSTAINABLE DEVELOPMENT PRINCIPLES

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Key words: retrofitting, sustainable development, environmental footprint, machine tools

Abstract: The paper aims at presenting a synthesis of retrofitting operations applied to machines and to underline its benefic effects upon environmental protection. It starts from the basics of sustainable development and those principles which require such shifts in the human activity that are able to make it more and more „environmentally friendly". Then it moves towards machine industry, proving how the procedure of retrofitting can reduce its impact upon the environment and create, in the long run, a more sustainable approach towards machine building.

1. PRINCIPLES OF SUSTAINABLE DEVELOPMENT AND THE REDUCTION OF HUMAN IMPACT UPON THE ENVIRONMENT

1.1. Aspects regarding sustainable development and environmental impact

The most well-known framework for sustainable development has been created from a global perspective by the World Commission on Environment and Development (also known as The Brundtland Commission), starting with the report it presented to The United Nations organization in 1987. The forming of the Commission and the elaboration of the report were the firs initiatives taken, at a global level, as a result of the awareness about the severe degradation of the natural and human environments on Earth, caused by negligent human activity. The Commission put forward the concept of *sustainable development*, which [implies meeting the needs of the present without compromising the ability of future generations to meet their own needs]. In time, this became the easiest and most common definition of the concept. Moreover, in order to really contribute to the ceasing and prevention of environmental destruction, sustainable development was to become [a central guiding principle of the United Nations, Governments and private institutions, organizations and enterprises].

The most popular approach until the 1960s-70s considered development a simple growth of production that had to lead to economic growth (result of the postwar economic boom) – Fig.1.1. After 1970s, we have been witnessing a paradigm shift, a series of attempts at re-defining development. It being one of these attempts, sustainable development urges us to consider not only economic growth, but also social and environmental aspects. Thus, human activity must ensure that a balance is achieved between economy, society and environment – Fig.1.2.

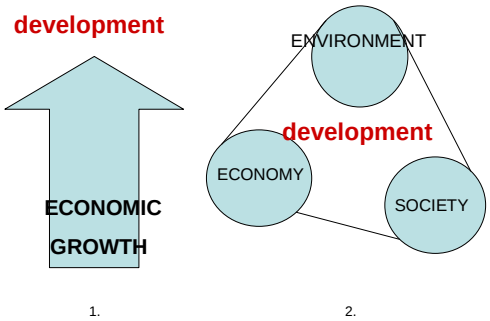

Fig. 1. Comparison between two approaches to development – 1. the "classical" one, 2. "sustainable development"

When speaking about or working towards sustainable development, we always aim at making our activity less harmful to the environment. "Environmental impact" is generally defined as the impact of human activity upon the human and ecological health, as well as the environmental changes that the specific activity may cause.

The "environmental footprint" is another concept in direct relation with that of environmental impact. The footprint is an instrument that helps us determine if our lifestyle and our activities are sustainable. It is based on a calculus of the land surface we need for our nourishment, lodging, transportation, goods and services. All types of human consume is "translated" into surfaces of productive land that are needed for their resources and for absorbing the waste resulting from our activity.

According to a measurement done in 2004, the environmental footprint of humanity surpassed the sustainability limit in 1970 and it stayed so since. Until the year 2000, the global environmental deficit was of almost 1 acre per person. That is why humanity needs to find and apply ways in which its environmental footprint could drop. On an industrial level, this implies adapting technological processes to a series of environmental principles that can lead to results such as lower energy consumption and the production of a minimal quantity of waste in every phase of production and use of tools and machines.

The Rio Declaration on Environment and Development (1992) formulated 18 basic principles of sustainable development, of which we select those that may guide us along our activity of production or technical-scientific research:

- Current development must not endanger the developmental and environmental needs of present and future generations;
- Nations have the right to exploit their own resources, but without provoking environmental problems outside their borders;
- Nations will cooperate towards the conservation, protection and re-establishment of the global ecosystems. Developed countries accept their responsibility towards this process, considering that they produce a higher environmental impact and they own better technologies and more financial resources;
- Nations must reduce and eliminate unsustainable production and consumption habits.
- Nations will develop effective environmental legislation and will evaluate the environmental impact of certain activities.
- Nations must cooperate to promote an open economic system, which may lead to sustainable economic growth and development in all countries;
- The polluter pays.

- Sustainable development requires a deep understanding of issues, which makes it necessary that countries exchange technologies and knowledge in this respect.

Among others, the 1992 UN Conference on Environment and Development proposed: the finding of alternative energy sources, a change in production and consumption patterns of nations, the development of environmentally friendly technologies.

1.2. Methods of reducing the human impact upon the environment

In order to reduce our impact in the environment by direct action upon the waste produced by human activities, an option is to follow 3 related concepts: *Reduce, Reuse, Recycle*.

Reducing is about changing our consumption patterns so that we consume less. This implies buying less objects and implicitly causing less waste. This is the most "environmentally friendly" human behaviour.

Reusing the objects we already have is essential in order to prevent waste production, as well. This is better than recycling, as it does not require additional energy consumption to process the objects. Moreover, there are un-recyclable materials.

If we were not able to reduce our consumption or reuse our objects, we must at least recycle. This will help the environment, but still not as much as the first two actions. However, recycling is very positive, because it provides recycled materials that are much more "environmentally friendly" than newly-produced ones.

Although these concepts were born in relation to waste, we believe that they may be applied to almost all fields of human activity and they may become a guide for people and enterprises along the path of reducing their environmental impact and increasing the sustainability of their activities.

2. ASPECTS REGARDING THE IMPROVEMENT OF MACHINE TOOLS IN THE SENSE OF REDUCING THEIR ENVIRONMENTAL IMPACT

Following the principles presented above, we consider the improvement of functional parameters and the precision of machine tools, thus adapting a facet of the machine industry to the principles of sustainable development.

After a certain number of functioning hours, the moving parts of machine tools start to wear and so they need to be re-built, to be brought back to designed parameters, therefore to be renewed. This may imply either repairing the existing machine or replacing it with a new one. Renewal may also be applied to morally worn-out machines as well. These machines have components that are not worth renewing, for they may be behind the times. That is why they are replaced with modern-day components, which perform much better. It is thus necessary to modernize those elements of the machines that come in contact with these new components, too.

If we choose the first type of renewal – the one with a more reduced environmental impact – we have three options to bring the machines back to their parameters: A. Rebuilding the machine; B. Remanufacturing the machine; C. Retrofitting the machine

A. Rebuilding means repairing broken elements, even replacing them by disassembling the machine and reassembling it. This brings it to at least the initial parameters, if not better ones. Some operations are done in collaboration, such as the correction of commands. This is usually about the mechanical rebuilding of the machine.

B. Remanufacturing is about building a new machine on the framework of an existing one. The parameters of the new machine will be better than those of the old one. The costs of such an operation are very high, reaching 70-75% of the price for a new machine. Remanufacturing also includes the refitting of smaller elements and may need re-designing some subassemblies. In some cases, the numerical commands of these machines are replaced, which may take up to one year. Some numerical commands may be replaced with better ones.
C. Retrofitting means an improvement of controlled elements, main drives, advance and accessory drives, such as ball screws, their drives, measurement elements (rulers, converters etc.), electrical and electronic commands connected to the newest CNC equipment. Retrofitting is done on the location where the machine is found, so the machine subassemblies do not need to be moved. Its duration and costs are much lower than for the previous two methods.

3. POSITIVE IMPACTS UPON THE ENVIRONMENT

We shall further on present the results obtain when retrofitting a TOS WHN 130 Borwerk, which was equipped with a numerical command of the type Haidenhain T320, having 4 axes under command, the spinning of the table (B) being indexed to 90 degrees, as in Figure 2. The four axes are X, Y, Z, W.

Figure 2. CNC milling-machine, retrofitting, HAIDENHAIN equipment

Table 1 shows the positive impacts of this operation:

Tab.1

No.	Retrofitted sub-assembly	Operation	Positive impact Sustainable result (SR)	Obs.
1	Chassis	Touching up conductors + rebuilding of the table	Cost reduction for making a new chassis; *SR:*	Positive impact

		setting surface	- reduction in energy consumption (necessary for the chassis casting) and saving ferrous material;	
2	Automation on the axes: X,Y,Z,W	Replacing classical feed-screws with ball screws and screws with adjustable nut	Increase in productivity and quality (higher processing speeds); *SR:* - decrease of energy consumption and material consumption, by reducing the add-ons;	Positive impact
3	Electrical commands	Rebuilding of the electrical cabinets, using command elements of high performance	Increase in productivity and quality; *SR:* - increase in the service period; - the machine is not damaged so often; - more safety in exploitation;	Positive impact
4	CNC command	Replacing numerical command (NC) with the newest CNC	Increased precision, productivity and quality; *SR:* - fewer possibilities of damage, usage of performance elements;	Positive impact
5	Introducing closed loops (negative reaction loops) in the machine drives	Systems with self-diagnose of MUCN, by automatically adjusted circuits that use: moving transducers, pressure transducers, temperature detectors, rotary transducers.	Improvement of the processing accuracy at high chipping speeds. The traditional method of increasing the stiffness is solved, from a constructive point of view, by an increase in the chassis mass or hydraulic compensation. *SR:* - reducing the weight of the machine, which is necessary for an adequate stiffness to work for mechanical processing, therefore determining a lower material consumption.	

The reduction of the consumption of material used for the building of the machine creates sustainable effects in the machine industry, starting from: ore extraction (negative impact upon the underground resources), melting ore to obtain steel or crude iron (energy consumption), casting or iron (energy consumption), mechanical processing upon the chassis or the composing elements (energy consumption), transport to beneficiary (energy consumption).

Increasing the processing accuracy (quality) has effects in reducing environmental impact and creating a more sustainable industry by diminishing waste (additional consumption of energy, of materials) both for the producer and for the beneficiary.

The increase in productivity determines sustainable effects such as the reduction of the number of machines that are necessary for production (material consumption).

Last but not least, a higher exploitation safety and the fact that the operator's work becomes easier also contribute to a more sustainable result.

4. CONCLUSIONS

The concept of sustainable development, as well as its relating concepts of environmental impact reduction, can and need to be applied in industry just like in other fields of human activity. In this paper, we have tried to show how the field of machine tool industry can become more sustainable, by using simple methods.

If we compare the three methods by which a machine may be brought to its parameters, we find retrofitting as the best one, in terms of improving the functioning and precision of the machine tool. From a technical point of view, the method is short and makes the machine tool work better, while decreasing the environmental impact of the industry.

One can save between 30 and 60 percent over buying an equivalent new machine tool. When retrofitting, the costs are much smaller than when rebuilding a machine or when remanufacturing it. Some indirect cost savings from reworking a machine can be realized by reusing existing foundations, fixtures and tools.

The machine will not stay off for too long, as it can go back to work within a short while.

The operator can easily learn the use of the new numerical command. The programming of the machine is user friendly. The reduced consumption patterns ensure a reduced environmental impact. The very approach of this procedure helps build a different perspective on machine tool building and promotes more sustainable ways of industry development, starting from the principles of sustainable development.

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