

## **OPPORTUNITIES TO IMPROVE PRODUCTION USING ACTIVE MAGNETIC BEARING SYSTEMS**

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### **ABSTRACT**

*The paper is based on the presentation of active magnetic bearings (AMB) which, in the world of technology, more and more overtake a leading position. AMB are increasingly used in all areas in which we have a rotation of one element in relation to others. Special emphasis is placed on integrating AMB in the production process, primarily the possibility of using these bearings on assembly lines and machine tools. Various manufacturing processes require very high accuracy and almost minimal vibration during transportation of products at production line. The automotive industry is such an example. Anywhere welding is performed, such as, during transportation of a car at assembly line, AMB can contribute to increase accuracy, reduce maintenance costs and increase lifetime of bearings. AMB have almost unlimited lifetime, which would mean that the manufacturing process can work almost without stopping. We know that we must stop the production when replacing the classic rotating bearings. From the main spindle bearings of machine tools is required less tolerance and vibration, but for classic roller bearings today is very difficult to fulfill that requirements. Therefore, designers are increasingly deciding to use AMB.*

**Keywords:** Active magnetic bearings (AMB), machine tools, assembly lines.

### **1. INTRODUCTION**

From today's production process we are increasingly seeking better precision during production, especially when we have machining in the production lines. To obtain greater accuracy, it is necessary to minimize vibration. The most important role in reducing and eliminating vibration of moving elements in the production process, represent the supporters of these elements in relation to the fixed elements. These supporters are usually bearings, and they must eliminate the above mentioned vibration, and on that way significantly affect the accuracy of production. The same bearings are expected to be long lasting, and to have low demand for their replacement, in order to prevent great losses. Because all of the above, today we have integration of AMB in places where we usually use classic bearings. This integration brings many advantages to production line, but also, AMB have some disadvantages. In this paper, we will show the advantages and disadvantages of integration of AMB in the manufacturing process. The first part of this paper will refer to the principles of the AMB's work.

## 2. ACTIVE MAGNETIC BEARINGS

AMBs can completely support a body by magnetic forces without any mechanical contact. Of technical interest are, in a first place, the ferromagnetic forces, which can be generated by permanent magnets or by actively controlled electromagnets. It has been known for a long time, however, that stable contact-free suspension in all degrees of freedom (DOFs) cannot be achieved by permanent magnets only, at least one active element is always necessary for stabilization of such a system. Magnetic bearings based on permanent magnets are passive elements unable to control rotor vibration actively. Thanks to their physical principle, magnetic bearings have some unique and very interesting properties.

- Magnetic bearings work without any mechanical contact. Therefore, the bearings will have a long life with much reduced maintenance and with low bearing losses. Since no lubrication is required, processes will not be contaminated, which constitutes another important advantage over conventional bearing technologies. AMB systems can also work in harsh environments or in a vacuum.
- The reduced maintenance and the possibility for omission of the complete lubrication system lead to considerable cost reductions.
- The rotational speed is only limited by the strength of the rotor material (centrifugal forces). Peripheral speeds of 300 m/s are a standard in state-of-the-art AMB applications, a value not reachable by most other bearings.
- The electromagnetic bearing is an active element which enables accurate shaft positioning and which makes its integration into process control very easy. The vibrations of a rotor can be actively damped. It is also possible to let the rotor rotate about its principal axis of inertia to cancel the dynamic forces caused by the unbalance.
- Due to their built-in sensors and actuators AMB systems are perfectly suited for not only positioning and levitation of a rotor but also for serving additional purposes such as monitoring, preventive maintenance or system identification. These important features are possible without the need for any additional instrumentation.

## 3. THE FUNCTIONAL PRINCIPLE OF AMB

The basic functional principle of an AMB can be briefly described as follows (Figure 1). The system itself is inherently unstable. This instability is caused by the attractive forces of the electromagnets. Therefore, active control of the magnets is necessary. For this, a sensor measures the displacement  $x$  of the supported rotor. A controller, nowadays most often a digital controller on the basis of a signal processor or microprocessor, uses the sensor information to derive an appropriate control signal  $u$ . This control signal is amplified by a power amplifier to drive the control current in the coil. The coil current together with the ferromagnetic material in the path of the coil causes a magnetic force to act on the rotor. The electromagnetic force has to be calculated by the controller in such a way, that the rotor remains in its predefined and stable hovering position. Basically, the control operates in such a way that, when the rotor moves down, the sensor produces a displacement signal which leads to an increase in the control current. The increasing electromagnetic force then pulls the rotor back to its nominal position.

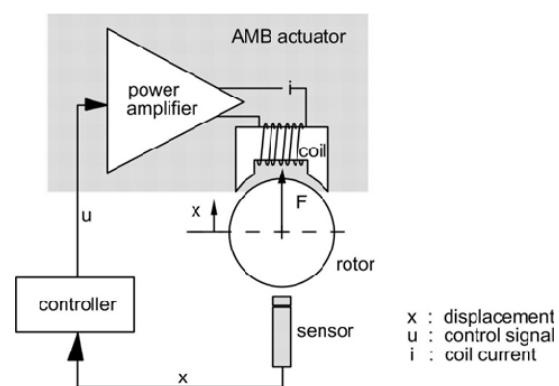


Figure 1: Basic principle of an active magnetic bearing (AMB)

Of course, during the technical realization is always necessary to use multiple AMB for the control of a shaft. It is important to emphasize that we do not need one controller and one power amplifier for each bearing separately.

It is possible to maintain control over multiple bearings with only one controller and one power amplifier. In technical sense, this represents a system of active magnetic bearings (AMBs).

#### **4. OPPERTUNITIES TO IMPROVE PRODUCTION USING ACTIVE MAGNETIC BEARING SYSTEMS**

AMBs can bring the biggest advantages by using them in machine tools and assembly line. By using AMBs in machine tools we can get much less vibration of main tool and because of that we can make more precise machine elements.

##### **4.1. Integration of AMB in machine tools**

Computer controlled machine tools (CNC machines) have several rotating elements in their construction, from which largely depends the quality of machining. Also, the tool holder is constructed in a structure which enables all six degrees of its freedom. There are rotation of the workpiece carries, rotation of tool carriers and movement of the tool carrier along with a tool. Moving tool carriers is sometimes done with threaded spindles. This threaded spindles are usually supported with bearings.

Because of the large number of moving parts that are supported by a large number of bearings in machine tools, and because of the need to achieve high-precision production, nowadays conventional bearings are being replaced with AMB. AMB can be used for supporting the tool carriers, support carriers of the workpiece, and for supporting the threaded spindle.

Because of the advantages of AMB, which we have mentioned in section 2, by using them in machine tools we will achieve the following:

- Accuracy of machining would no longer depend on the quality of bearings used for supporting rotating elements. If we use conventional roller bearings we can have deviation of the machining quality because friction in the bearings increases deviation over time.
- Rotation of the workpiece and the tool would be isolated from external influences, most important external influence is vibration created during machining.
- We will achieve higher productivity, because we would not have to shut down the machine to replace the bearings.

The biggest disadvantages of AMB, their prices, because of expensive electronic components, could be avoided by using one controller and one power amplifier for several machine tools in production line.

##### **4.2. Integration of AMB in production lines**

As we have stated earlier, the manufacturing process, at the present time, demands more and more precision. We want to minimize vibration during the production on production lines, and to make production more efficient and productive. All these requirements can be fulfilled using AMB. However, AMB brings their biggest flaw, the need for energy and constant computer control. Because of this problem, using AMB is payable in the production area only if we can use one controller and one power amplifier to control multiple AMB, as it is shown in Figure 2.

Figure 2 shows basic principle of AMB usage on the production line. The same principle could be used simultaneously on multiple production line and with that we can control multiple bearings with only one controller and one power amplifier. This significantly reduces the price of bearings, because it is not necessary to buy a controller and power amplifier for each bearing separately. This is how we can eliminate the biggest disadvantages of AMB.

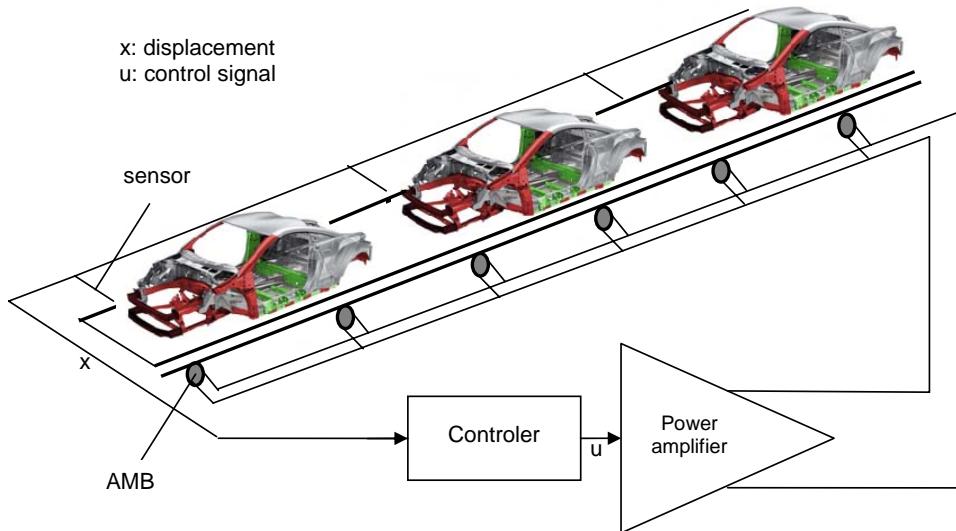


Figure 2: Basic principle of an active magnetic bearing systems (AMBs) integrate in production lines

## 5. CONCLUSION

All the aforementioned leads to conclusion that the AMB offers interesting opportunities to improve productivity and precision of production, through the installation in machine tools and production lines. Because of development and improvement of AMB, reducing their size and increasing load capacity, engineer more often substitute conventional bearings with AMB. Soon we can expect machine tool with AMB inside, and therefore the need for their studying and including in a college literature is more than obvious.

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