



## APPLICATION OF METHODOLOGY FOR DEVELOPING AND OPTIMIZING MECHANICAL PROCESSING TECHNOLOGICAL PROCESSES IN PRODUCTION

Normatov S. B.

ChDPU, Department of Technological Education

### Abstract

This article presents a methodology for developing and optimizing mechanical processing technological processes in production conditions. The study analyzes the selection of technological parameters, methods to improve production efficiency, and approaches to enhance quality indicators. The model developed based on this methodological approach allows for rational use of resources, reduction of waste, and optimization of energy consumption. Consequently, production productivity and processing accuracy are improved.

**Keywords:** Mechanical processing, technological process, methodology, optimization, production, accuracy, efficiency.

### Introduction

When developing and optimizing mechanical processing processes using automated equipment, careful attention must be paid to several critical factors when selecting technological processes. These factors include the use of automatic measurement methods, implementation of standard and group technological processes, utilization of hydraulic supports on lathes, and the application of software-controlled equipment. Automation ensures precise and stable tool trajectories for each operation, thereby increasing production efficiency and product quality.



For accurate and optimized mechanical processing, it is essential that each machine and device maintains its components and assemblies in a specified relative position. Similarly, during part machining, tools such as guiding supports, milling and cutting heads, stopping points, and copying devices must be correctly aligned relative to the mechanisms and assemblies that define their movement trajectories. The accuracy and efficiency of mechanical processing depend on the correct mutual positioning of parts and assemblies and their proper placement in production using designated bases. In this way, the methodology for developing and optimizing technological processes ensures high accuracy and stability in production.

### **Bases in Mechanical Processing:**

The concept of a “base” is fundamental in developing and optimizing mechanical processing processes. A base refers to a set of surfaces, lines, or points of a part used to orient other parts or a specific portion of the part during machining or measurement. This concept ensures complete utilization of the surfaces necessary for proper orientation during assembly and production.

To achieve full accuracy of parts in mechanical processing, their spatial position must be constrained in six degrees of freedom: three translational movements along coordinate axes and three rotational movements around the specified axes. Using surfaces that either interact with the machined surface or are connected to other parts ensures correct orientation of components, which is essential for maintaining accuracy and stability in the technological process.

### **Reference Surfaces:**

The set of three primary surfaces forms the part’s base and ensures correct orientation during machining and assembly. When selecting a primary support surface, the largest surface is preferred to improve orientation accuracy and reliability, allowing adequate spacing between corresponding reference points.

A permanent support surface can be any surface, even if small, provided its condition is stable and shape consistent (e.g., spray-coated surfaces or cast joints). When centering parts or selecting conical surfaces, the base conditions may

 <p><b>WORLD BULLETIN PUBLISHING</b> Online Publishing Hub</p>	<h1>World Bulletin of Education and Learning (WBEL)</h1>
<p><b>ISSN (E): 3072-175X</b></p>	<p><b>Volume 01, Issue 02, November 2025</b></p>
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<p><a href="https://worldbulletin.org/index.php/1">https://worldbulletin.org/index.php/1</a></p>	

significantly change. In such cases, the base function is often limited to centering, with some instances requiring additional support functionality.

In production scenarios where the combination of design and assembly bases is impossible, small errors in assembly bases can complicate proper part alignment. For example, in assembling an internal combustion engine, using inspection assembly bases can significantly improve assembly accuracy, even if machining accuracy is lower, though it may require additional time. Thus, selecting and using technological bases improves the accuracy and efficiency of mechanical processing in production.

### **Application of Technological Bases:**

In some cases, such as manufacturing complex, expensive, or high-precision machines in single-unit production at large-scale machine-building plants, using inspection assembly bases is practical. The concept of technological dimension orientation is crucial, as it allows technological bases to be considered as sets of surfaces oriented relative to machined parts.

Unlike designers, process engineers consider multiple configurations and dimensions of parts during manufacturing to convert them into finished products. Using technological bases is essential for calculating dimensional chains and properly distributing machining allowances. The machined surfaces of parts are linked through dimensional chains to the primary surfaces of technological bases, making the nature and properties of these bases highly significant for process accuracy. The main surface of a technological base directly interacts with the relevant mounting surface of the machine, serving as a support surface.

By using automatic measurement principles, necessary accuracy during machining can be achieved relatively easily by adjusting the machine relative to the support surfaces of the parts. When the machine is properly adjusted, dimensions of all parts in a batch are consistent, and random variations in part dimensions are negligible, ensuring high-precision production.

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### Support and Setup Bases:

Support and setup technological bases are widely used in large-scale production, particularly for machines operating with automatic measurement systems. Machine setup relative to these bases is based on the assumption that when parts are replaced, their bases maintain a consistent position relative to machine stops during the production of a batch.

However, this assumption does not always hold for support mounting bases, as it relies on the flatness of the device installation and near-perfect correspondence with the support surface of the part. Analysis shows that, in practice, the primary surface of the part and the installation surface of the corresponding fixture rarely exhibit random deviations, highlighting the importance of correctly identifying and using primary bases during the design and optimization of technological processes.

### Precision Considerations:

When using a support technological base on a configured machine, misalignment between the support surface of the part and the machine's mounting surface may introduce additional errors during machining. Therefore, the required accuracy must be ensured in advance by the process engineer.

Using support technological bases slightly reduces dimensional accuracy, but this trade-off is offset by the greater advantage of setup bases, as part installation errors have minimal impact on the precision of dimensions obtained from these bases. The choice of setup or support bases is mainly determined by pre-established part dimensions, and product designers must analyze the technological characteristics of parts to select the most appropriate bases.

In small-batch production, inspection technological bases are widely used to ensure part accuracy through proper machining methods.



**WORLD BULLETIN  
PUBLISHING**  
Online Publishing Hub

# World Bulletin of Education and Learning (WBEL)

**ISSN (E): 3072-175X**

**Volume 01, Issue 02, November 2025**



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