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# Implementation Patterns of CNC Machine in Assorted Applications and Use Cases

*Azhar Ahmed Kamies*
*Petroleum Training Institute, Baghdad.Ministry of Oil*
*Bachelor of Mechanical Engineering. General Mechanic.Work for the Degree of Chief Engineer In Engineering Examination*
*Iraq Oil Ministry*
*Petroleum Training Institute*
*Engineering Inspection, Safety, Maintenance and Oil Projects*

**Abstract**

CNC machines are used in practically every sector throughout the globe to produce components. There are several hard materials that they use to make things like plastics, metals, Aluminium, and wood. CNC stands for Computer Numerical Control, however most people just refer to it as CNC these days. So, what is a CNC machine, exactly? A command function, a drive/motion system, and a feedback system are the three most important parts of any automated motion control equipment. Custom-made from solid material, CNC machining involves the use of a computer-controlled machine tool to create the desired form. Software like SolidWorks or MasterCAM, which is used to create CAM or CAD files, is often used to create the digital instructions used by CNC machines. G-code is written by the software and sent to the CNC machine's controller. Workpieces, cutting tools, and/or workpieces are moved on various axes by computer software on controller that understands design. Manual tool and workpiece movement, which is

Accomplished using levers and gears on older equipment, is slower and less precise thanthe automated cutting process. Modern CNC machines can accommodate a variety of cutting tools and perform a wide range of operations. The complexity of the workpiece aCNC can produce is determined by the number and kinds of axes (planes of movement) and tools that the machine can automatically access throughout the cutting process. DNC or MDC software may include machine monitoring software, or it may be bought separately. To get a better sense of how tasks are running, machine monitoring tools capture data such as setup, runtime, and downtime and integrate it with human data likereason codes. Adapters allow even out-of-date equipment to offer useful data. In the past several years, CNC machine monitoring has become popular, and new software solutions are constantly being developed. Carbon steel is the most widely used commercial steel alloy in the world. Hardness and toughness are enhanced, as is harden ability, when carbon content is raised. However, the propensity of carbon to generate marten site increases brittleness and lowers weld ability. This implies that, when it comes to commercial steel, carbon content may be both a gift and a problem. Steels with up to 2%carbon content do exist, although they are the exception rather than the rule. Carbon content in most steel is less than 0.35 percent. To put it in perspective, consider that it represents a fraction of a percent of the whole population.

*Keywords : CNC Machine, CNC and Key Impact, Iron Carbon Metal*

**Introduction**

Steel and Aluminum are often used in high-performance, long-lasting components in industries such as automotive, aerospace, and robotics, among others. Steel and Aluminum, on the other hand, have significantly diverse physical properties and pricing ranges, making it critical to figure out which is preferable for a certain item.

Data from modern CNC machines may be used by everyone from the shop floor to the top level, thanks to machine monitoring software. There are companies like Memex that provide software (Tempus) for CNC machine data that can be used to create useful graphs and charts. Most machine monitoring systems employ MTConnect as a data standard, which has gained popularity in the United States. This data format is now standard on a large number of new CNC machines.

CNC machining is a common production technology in many fields, and it plays a significant role in cost. There are numerous important reasons why steel may be a better material option than Aluminium for machining a metal product. Steel is significantly stronger than Aluminium, despite the former's lighter weight. Aluminum, on the other hand, is more costly.

Aluminum and steel aren't the only options available. Steel is essentially a family of materials, and when making a material choice, it's critical to carefully weigh the pros and disadvantages of the many steels. For product development teams, it's important to understand four of the most typically machined steel kinds and what makes each one unique.

Many sectors employ 4140 steel because of its excellent fatigue strength, as well as its general toughness and resistance to wear and impact. As a result of the 4140's unique chemical make up, it is very durable and resistant to corrosion. Chromium and molybdenum, as well as manganese and carbon, all aid in corrosion resistance, harden ability, and deoxidization. As a result of its versatility and ease of machining, it may be utilized for a wide variety of steel items.

When working with 4140 steel, you'll need to use a lot more effort to get a good shape. When working with high-carbon steels like 4140, annealing is particularly critical. 4140, while being often quench-hardened, is not readily welded and requires pre- and post-weld thermal treatment to minimise cracking, as well as careful consideration of employing a filler material that is suitable.

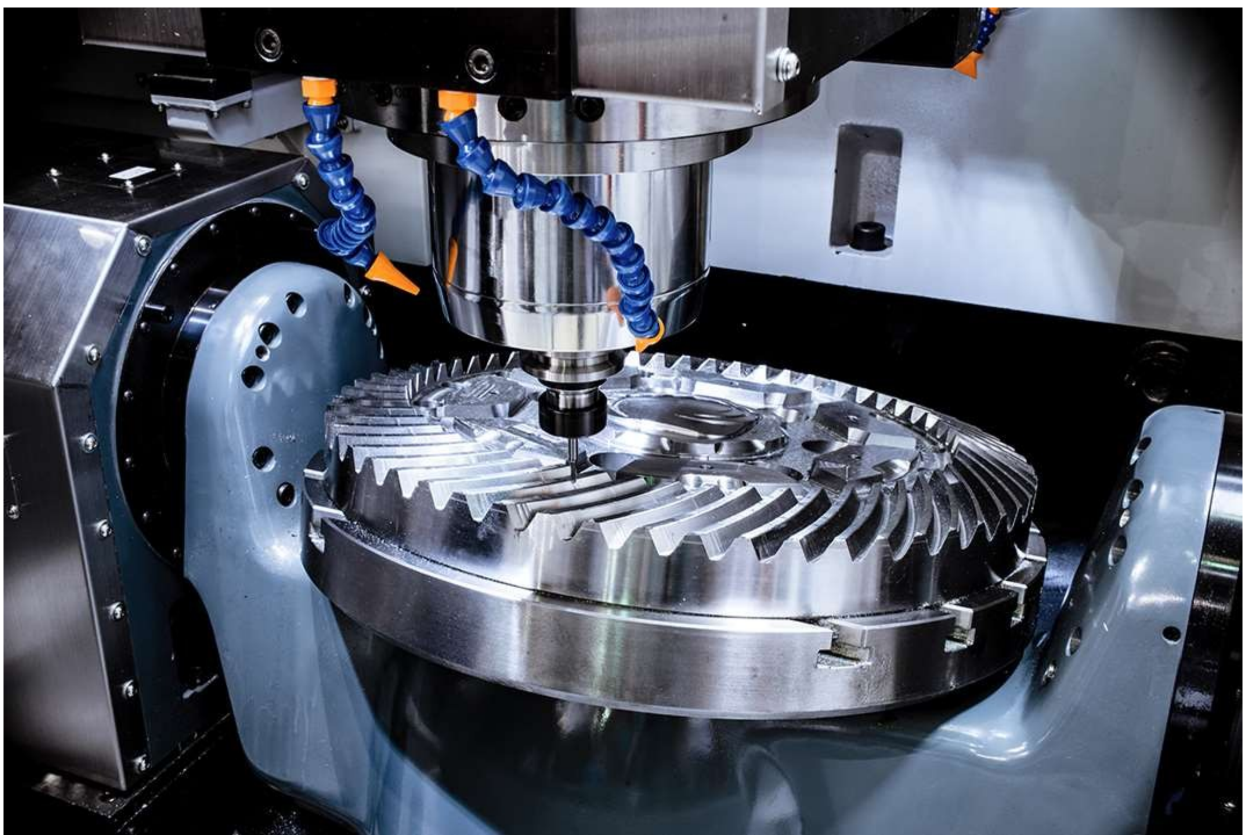


Figure 1 : CNC Machine

In comparison to non-alloy, pure carbon steel, 4140 has a little higher material cost but also a much higher machining cost. However, due to its great strength and long-term

Usefulness, it is regarded as an excellent value. Steel made from 1018 is a carbon steel that is often used for a wide range of applications. The weld ability of 1018 steel is outstanding, although it's not as hard as certain other types of metal.

The ease with which 1018 steel may be shaped is one of the key advantages of this material. As a result, it's well-suited for components that need complex bends or other fine details, such as those requiring forming, forging, welding, or hot working. Therefore, 1018 steel is often utilised in applications such as spindles, pins, and rods. Parts that have been carburized might also benefit from this alloy.

Carbonitrided and carburized 1018 steels may be welded, however it's not advised. When dealing with 1018 steel, production teams should be aware of this constraint. Finishing might be challenging as well due to the material's very delicate nature.

With its machinability, strength, and preciseness, 1018 steel comes at a price. Because of its superior suitability for CNC machining over other equivalent steels, it's more costly.

Relative strength and impact resistance make 1045 a popular choice for applications where these characteristics are critical. The Izod impact test for 1045 steel yields a score of 54. Unlike high carbon or high alloy steels, it can be machined and welded more readily in the cold-drawn or normalized form.

As a medium tensile and medium harden ability steel, 1045 is unsuitable for applicationsrequiring an extremely high level of strength. 1045 may be a viable choice for applications requiring greater strength and wear resistance than mild steels but less strength than thetoughest steels.

In both the rolled and normalized states, 1045 steel may be hardened by either flame or induction. In contrast, nitriding does not work well with this material because it lacks the necessary alloying components.

More costly than 1018 steel, 1045 steel has better strength but is less weldable and machinable, which contributes to its higher price.

Iron, carbon, chromium, manganese, molybdenum, phosphorus, silicon, and sulphur combine to form 4130 steel, a low carbon steel. As a high-strength steel, 4130 has a comparatively low heat-treating temperature and a high level of workability.

When it comes to steel, 4130 steel has the highest modulus of elasticity among its peers, making it capable of withstanding significant pressures. As a structural steel, 4130 steel is particularly well-suited for usage in a wide range of building projects because of its property. Using 4130 in industrial equipment, rock crushing machines, and resistance welding items is common because of these reasons. Many different heat treatment procedures may be performed on the 4130 steel.

The 4130 steel is very heat-resistant, although welding it might be difficult. It's difficult to find a filler metal that has the same level of hardenability as it does. This steel can only be properly welded if the qualities of 4130 and any filler metal used are well understood and appreciated.

In terms of raw material and minimizing costs, 4130 steel is a pretty inexpensive option. Many product teams are interested in using it because of its equivalent physical qualities to aircraft-grade stainless steel, but at a far cheaper cost.

A heat-quench-temper cycle may now be used to harden any steel with a carbon content of 0.35 to 1.86 percent. There are three basic types of commercial steel: low, medium, and high carbon.

Steels with a low content of alloying elements

- Forged high-alloy steel
- Steels made of carbon

Iron with less than 1% carbon and trace quantities of manganese, phosphorus, sulphur, and silicon are the most common constituents of these steels. Alloying and residual elements have a slight impact on these steels' weldability and other properties. However, carbon content is the primary determinant.

A further breakdown of plain carbon steels may be found in the following four categories:

Lowest of the lows. Low-carbon steels, often known as mild steels, contain less than 0.30% carbon and are the most widely used kind. Higher carbon steels can't match their ductility or machine ability when using these alloys.

Carbon content ranges from 30 to 45 percent in medium-carbon steels. Carbon increases hardness and tensile strength, decreases ductility, and makes machining more difficult.

High carbon steel. These steels, which have a carbon content ranging from 0.45 to 0.75 percent, maybe difficult to weld. There is a need for preheating, postheating (to manage the cool-downrate), and even heating during welding to ensure satisfactory welds and to control the mechanical characteristics of the steel.

Table 1 : Fiber and Associated Aspects

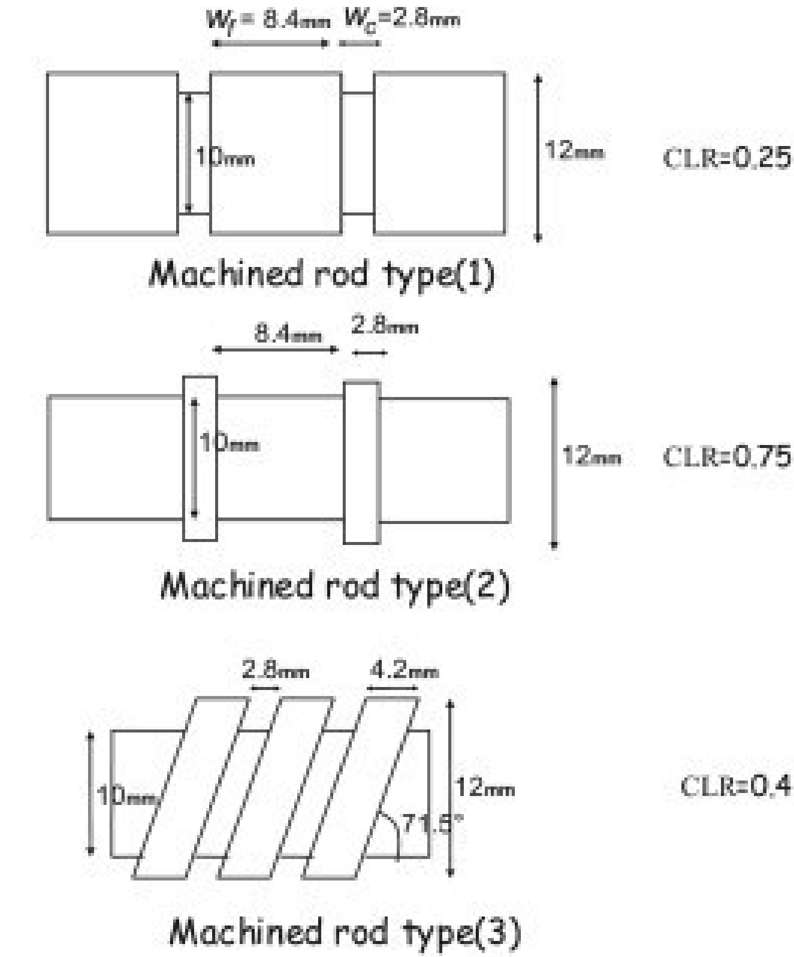
| **Fiber** | **Carbon Fiber** | **CFRP, CRP, CFRTP** |
|---|---|---|
| Metal | Aluminum – 1050 | AL 1050 |
| Metal | Aluminum – 1060 | AL 1060 |
| Metal | Aluminum – 2024 | AL 2024 |
| Metal | Aluminum – 5052-H11 | AL 5052-H11 |
| Metal | Aluminum – 5083 | AL 5083 |
| Metal | Aluminum – 6061 | AL 6061 |
| Metal | Aluminum – 6082 | AL 6082 |
| Metal | Aluminum – 7075 | AL 7075 |
| Metal | Aluminum – bronze | AL + Br |
| Metal | Aluminum – MIC-6 | AL – MIC-6 |
| Metal | Aluminum – QC-10 | AL QC-10 |
| Metal | Brass | Cu + Zn |
| Metal | Copper | Cu |
| Metal | Copper – beryllium | Cu + Be |
| Metal | Copper – chrome | Cu +Cr |
| Metal | Copper – tungsten | Cu + W |
| Metal | Magnesium | Mg |
| Metal | Magnesium alloy | |
| Metal | Phosphor bronze | Cu + Sn + P |

| | | |
|---|---|---|
| Metal | Steel – Stainless 303 | SS 303 |
| Metal | Steel – Stainless 304 | SS 304 |
| Metal | Steel – Stainless 316 | SS 316 |
| Metal | Steel – Stainless 410 | SS 410 |
| Metal | Steel – Stainless 431 | SS 431 |
| Metal | Steel – Stainless 440 | SS 440 |
| Metal | Steel – Stainless 630 | SS 630 |
| Metal | Steel 1040 | SS 1040 |
| Metal | Steel 45 | SS 45 |
| Metal | Steel D2 | SS D2 |
| Metal | Tin bronze | |
| Metal | Titanium | Ti |
| Metal | Titanium alloy | |
| Metal | Zinc | Zn |
| Plastic | Acrylonitrile butadiene styrene | ABS |
| Plastic | Acrylonitrile butadiene styrene | ABS – high temp |
| Plastic | Acrylonitrile butadiene styrene | ABS – anti static |
| Plastic | Acrylonitrile butadiene styrene + Polycarbonate | ABS + PC |
| Plastic | High-density polyethylene | HDPE, PEHD |
| Plastic | Nylon 6 | PA6 |
| Plastic | Nylon 6 + 30% Glass Fill | PA6 + 30% GF |
| Plastic | Nylon 6-6 + 30% Glass Fill | PA66 + 30% GF |
| Plastic | Nylon 6-6 Polyamide | PA66 |
| Plastic | Polybutylene terephthalate | PBT |

| | | |
|---|---|---|
| Plastic | Polycarbonate | PC |
| Plastic | Polycarbonate – Glass fill | PC + GF |
| Plastic | Polycarbonate + 30% Glass fill | PC + 30 % GF |
| Plastic | Polyether ether ketone | PEEK |
| Plastic | Polyetherimide | PEI |
| Plastic | Polyetherimide + 30% Glass Fill | Ultem 1000 + 30% GF |
| Plastic | Polyetherimide + Ultem 1000 | PEI + Ultem 1000 |
| Plastic | Polyethylene | PE |
| Plastic | Polyethylene terephthalate | PET |
| Plastic | Polymethyl methacrylate – acrylic | PMMA – Acrylic |
| Plastic | Polyoxybenzylmethylenglycolanhydride | Bakelite |
| Plastic | Polyoxymethylene | POM |
| Plastic | Polyphenylene sulfide | PPS |
| Plastic | Polyphenylene sulfide + Glass Fill | PPS + GF |
| Plastic | Polyphenylsulfone | PPSU |
| Plastic | Polypropylene | PP |
| Plastic | Polytetrafluoroethylene | PTFE |
| Plastic | Polyvinyl chloride | PVC |
| Plastic | Polyvinyl chloride + White/Grey | PVC – White/Gray |
| Plastic | Polyvinylidene fluoride | PVDF |
| Superalloy | Waspaloy | Waspalloy |

The bar has been raised to an extremely high standard. Metal cutting tools and truck springs both employ extremely high-carbon steels, which have a carbon content of up to

1.50 percent. High-carbon steels need heat treatment before, during, and after welding to retain mechanical properties.




$$\textit{Concrete Lugs Ratio}\ (\mathrm{CLR}) = \frac{\textit{concrete width}}{(\textit{concrete} + \textit{CFRP})\ \textit{width}} = \frac{w_c}{w_c + w_f}$$

**Nonalloy Steels**

Most of these steels have carbon contents below 0.25 percent, and some even as low as 0.15 percent, making them ideal for welding. These alloys comprise nickel, chromium molybdenum manganese and silicon, which enhance strength at normal temperature and improve notch toughness at low temperatures.

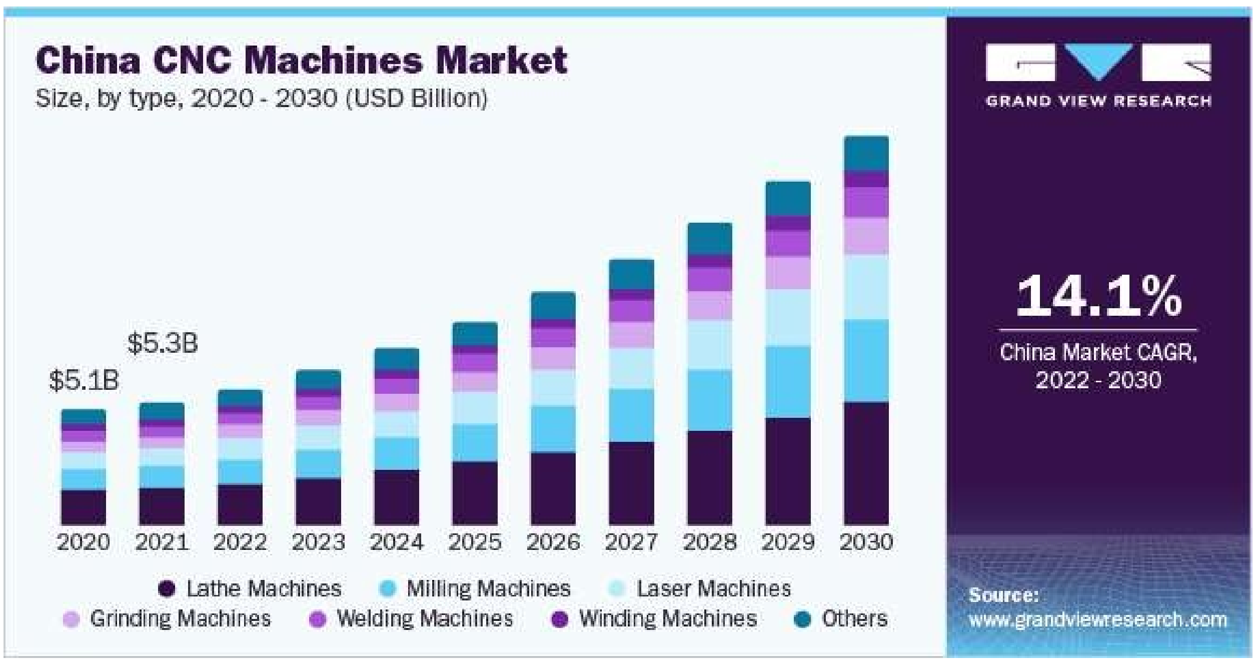



Figure 2 : Plot for Data Analytics on CN Machines

Combinations of these alloys may enhance corrosion resistance and affect the steel's heat treatment reaction. Adding alloys may have a detrimental impact on fracture susceptibility, hence low-hydrogen welding methods should be used in conjunction with them. In certain cases, preheating may also be required. The carbon equivalent formula, which we'll go over in more detail in a future issue, may be used to establish this.

**High-alloy steels**

Stainless steel, the most significant commercial high-alloy steel, is what we're mostly discussing here. In most stainless steels, there is at least 12 percent chromium. Stainless steel comes in three primary forms:

Cutlery is often made from martensitic stainless steel. In order to minimise cracking in the heat-affected zone, they need pre- and postheating while welding due to their low chromium content and high hardenability (HAZ).

Small levels of austenite-forming alloys are present in ferritic stainless steels with a chromium content ranging from 12 to 27 percent by weight.

However, austenite is not a stable material at room temperature and is not weldable. As a result, austenite must be stabilised using particular alloys. Nickel is the most significant austenite stabiliser, although carbon, manganese, and nitrogen are all essential.

Austenitic stainless steels may be given additional qualities including corrosion resistance, oxidation resistance, and high temperature strength by alloying them with chromium, nickel, molybdenum, nitrogen, titanium, and columbium. At high temperatures, carbon may increase strength while decreasing corrosion resistance because to a compound it forms with chromium. Austenitic alloys can't be toughened by heat treatment, thus this is something to keep in mind. That implies that they don't harden in the weld hazard area.

Businesses in the green sector are always on the lookout for better ways to produce their products. The use of CNC machining is one method of reducing the carbon footprint of industrial processes. There are several reasons why CNC machining is more environmentally friendly than traditional milling. In order to reduce carbon emissions, customers may submit electronic files directly to the manufacturers, eliminating the need for travel.

Future sustainability will be dependent on CNC machining in 2030. Manufacturing and production in the modern era are evolving at a quick pace. This trend is being aided by the expansion of industries that use the CNC machine. Since its introduction in the 1940s, the CNC (Computer Numerical control) machine has had a profound impact on production. CNC machines allow any manufacturing process to be scaled up without sacrificing quality or precision. CNC machining has become a need in the industrial business as computers have grown more commonplace.

Improved efficiency is one of the advantages of utilizing a CNC machine. CNC machining reduces emissions in part by minimizing transportation and waste, and by speeding up machining.

Computer-Aided Design (CAD) files are used by CNC machines to manufacture prototype components. The whole process is computer-driven, and the end products are extremely technological and mechanized. A high degree of precision may be achieved by using computer programmers to operate ageing industrial equipment like routers, drills, and lathes. This streamlines the whole production process and may be seen in a broad range of sectors.

CNC products have seen a lot of developments during the last several years. The cost of CNC machining is decreasing. Getting into the CNC machining business has never been easier. Prototyping and prototyping machining are currently common services offered by manufacturing businesses. The Internet of Things (IoT) is a system of interconnected computing devices, mechanical and digital equipment that may transport data across a network without the need for human-to-human or human-to-computer contact. This stimulates teamwork, which results in a better product being created. Computers and mobile devices are increasingly now linked to machines. You may now provide designs for injection moulding and quick machining using CAD files that can be transferred online. This sector may benefit from automation, which can provide new positions for technicians and programmers. Tolerances and quality control systems are always being tightened by CNC service providers. Orders may be made in any number, utilising a broad variety of materials at inexpensive rates while maintaining the best possible quality.

## Conclusion

Carbon dioxide emissions from CNC machines have become a hot issue because of their importance in improving cutting operations and thereby cutting down on global carbon dioxide emissions. Although tool wear has a significant impact on processing carbon emissions, present methods for calculating carbon emission levels in the machining process ignore this fact, leading to an erroneous assessment. The production method for these devices has progressed along with technological advancements. Increasingly, firms are opting to employ smaller, more portable CNC machines, rather than large, stationary ones. As the demand for CNC machine-made items rises, so does the necessity for CNC machines to function at their peak performance levels. – The user interface of the equipment will need to be simplified by coders and developers.

## References

[1] Yi, Q., Li, C., Tang, Y., & Chen, X. (2015). Multi-objective parameter optimizationof CNC machining for low carbon manufacturing. Journal of Cleaner Production, 95, 256-264.

[2] Kumar, N. S., Shetty, A., Shetty, A., Ananth, K., & Shetty, H. (2012). Effect of spindle speed and feed rate on surface roughness of carbon steels in CNC turning.Procedia Engineering, 38, 691-697.

[3] Okokpujie, I. P., Bolu, C. A., Ohunakin, O. S., Akinlabi, E. T., & Adelekan, D. S. (2019). A review of recent application of machining techniques, based on the phenomena of CNC machining operations. Procedia Manufacturing, 35, 1054- 1060.

[4] Ogedengbe, T. S., Abdulkareem, S., & Aweda, J. O. (2018). Effect of coolant temperature on machining characteristics of high carbon steel.

[5] Fysikopoulos, A., T. Alexopoulos, G. Pastras, P. Stavropoulos, and G. Chryssolouris. 2015. "On the Design of a Sustainable Production Line: The MetaCAM Tool." ASME International Mechanical Engineering Congress & Exposition 15: V015T19A015. doi:10.1115/IMECE2015-52960.

[6] Gutowski, T. G., M. S. Branham, J. B. Dahmus, A. J. Jones, A. Thiriez, and D. P. Sekulic. 2009. "Thermodynamic Analysis of Resources Used in Manufacturing Processes." Environmental Science & Technology 43 (5): 1584–1590. doi:10.1021/es8016655. [PubMed],

[7] Hu, L. K., P. Chen, E. Steve, T. Peng, Y. Liu, R. Z. Tang, and A. Tiwari. 2017. "Minimising the Machining Energy Consumption of a Machine Tool by Sequencing the Features of a Part." Energy 121: 292–305. doi:10.1016/j.energy.2017.01.039.

[8] Hu, L. K., Y. Liu, C. Peng, C. J. Wang, R. Z. Tang, and A. Tiwari. 2018a. "Minimising the Energy Consumption of Tool Change and Tool Path of Machining

by Sequencing the Features.” Energy 147: 390–402. doi:10.1016/j.energy.2018.01.046.

[9] Hu, L. K., R. Z. Tang, Y. Liu, Y. L. Cao, and A. Tiwari. 2018b. “Optimising the Machining Time, Deviation and Energy Consumption through a Multi-objective Feature Sequencing Approach.” Energy Conversion and Management 160: 126–140. doi:10.1016/j.enconman.2018.01.005.

[10] Huang, W. J., L. G. Cai, Y. J. Hu, X. L. Wang, and L. Ling. 2009. “Process Planning Optimization Based on Genetic Algorithm and Topological Sort Algorithm for Digraph.” Computer Integrated Manufacturing System 15 (9): 1770–1778. doi:10.1016/j.commatsci.2008.04.030.

[11] Jia, S., Q. H. Yuan, W. Cai, M. Y. Li, and Z. J. Li. 2018. “Energy Modeling Method of Machine-operator System for Sustainable Machining.” Energy Conversion and Management 172: 265–276. doi:10.1016/j.enconman.2018.07.030.

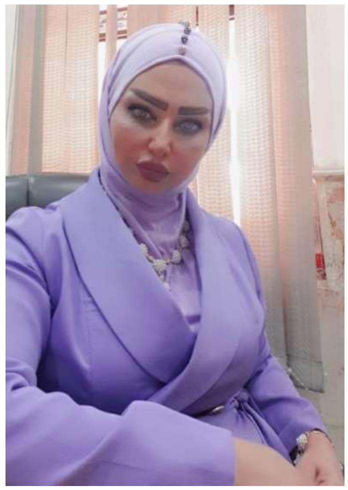
[12] Lee, Y. Z., S. G. Ponnambalam, Y. Zheng, and S. G. Ponnambalam. 2012. “Optimisation of Multipass Turning Operations Using PSO and GA-AIS Algorithms.” International Journal of Production Research 50 (22): 6499–6518. doi:10.1080/00207543.2011.653450. ,

[13] Li, A. P., Z. Y. Gu, J. Zhu, X. M. Liu, N. Xie, and L. S. Yang. 2015. “Optimization of Cutting Parameters for Multi-pass Hole Machining Based on Low Carbon Manufacturing.” Computer Integrated Manufacturing System 21 (6): 1515–1522. doi:10.13196/j.cims.2015.06.013.

[14] Li, L. L., C. B. Li, Y. Tang, and L. Li. 2017. “An Integrated Approach of Process Planning and Cutting Parameter Optimization for Energy-aware CNC Machining.” Journal of Cleaner Production 162: 458–473. doi:10.1016/j.jclepro.2017.06.034.

[15] Li, W. D., S. K. Ong, and A. Y. C. Nee. 2004. “Optimization of Process Plans Using a Constraint-based Tabu Search Approach.” International Journal of Production Research 42 (10): 1955–1985. doi:10.1080/00207540310001652897

**Author**



*Azhar Ahmed Kamies*