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RECENT DEVELOPMENTS IN SUSTAINABLE MANUFACTURING OF GEARS: A REVIEW

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ABSTRACT

Most socially aware manufacturers place a premium on awareness. Manufacturers must comply with a variety of stringent environmental criteria in order to remain competitive on a global basis. The manufacturing industry as a whole is working to increase efficiency and quality of products while also keeping the environment pure and sustainable. This could only be done by using environmentally friendly fluids and lubricating techniques when machining, decreasing waste, active waste management, and eliminating energy usage, among other things. The key services providers to other manufacturing and industrial segments, including the gear manufacturing industries, are also working on implementing strategies aimed at improved sustainability. A few more latest developments in gear manufacturing to improve sustainability can be summarized as reducing its use of mineral-based lubricating oil by employing alternate solution lubrication techniques such as least amount lubrication (MQL) and dry machining, material saving, waste reduction, reducing power consumption, and maintaining efficiency by reducing the number of gear manufacturing operations. This study examines and summarizes the present state of technologies for gear manufacture that is environmentally sustainable, as well as suggests strategies to improve productivity and the quality while maintaining environmental sustainability.

KEYWORDS: *Gear Machining, Minimum Quantity, Lubrication, Sustainable Manufacturing.*

1. INTRODUCTION

Since the inception of the SD concept at the first global conference on the environment in Stockholm in 1972, policies and programmes for sustainable development (SD)[1] have experienced substantial shifts in focus. With the prospect of a growing global population, accelerated development, greater resource usage, and the resulting environmental repercussions, the notion of sustainability has evolved beyond simply concern about pollution and biodiversity to resource management [2].The science of resource management entails developing a holistic understanding of the mechanisms that contribute to natural or manmade resource enhancement or degradation. Resource management is a lot easier, especially when you have a lot of them. The use of resources by users may be tracked, and the data can be analyses. Validated and comprehended in a simple manner. The term "information" in resource management refers to basic knowledge about stocks, flows, and processes within the resource system, as well as the human-environment interactions that affect them.[3]The system Local data may be ignored or averaged out in highly aggregated data. Critical for predicting future issues and establishing long-term remedies.

1.1 Sustainable Manufacturing:

Sustainable manufacturing[4] is defined as the creation of manufactured goods that have minimal negative impacts on the environment, preserve natural resources and energy, are safe for workers, community, and consumers, and are financially sustainable. In terms of safer and more efficient production, this article aims to emphasize the sustainable production factors associated to the production of a particular product (gears). It's doesn't, however, address the societal side of sustainable unless it is actually affected by the manufacturing practices and/or concerns the health and safety of the people directly involved in the manufacturing. This review does not cover the direct societal advantages (or lack thereof) associated with gears and gear production.

As a key enabler of these goals, the manufacturing sector can make a significant contribution to sustainable development. As a result, environmental sustainability[5] is becoming increasingly crucial. Achieve a competitive advantage, implying long-term economic viability. To put it another way, in order to be sustainable, products, processes, and services must be able to meet difficulties not just in terms of their functions, performance, and cost, but also in terms of environmental and social concerns. To be considered "sustainable," a process must have a low environmental impact[6], be valuable to society, and be financially viable. As a result, the manufacturing industry must remain proactive in the development of cleaner industrial goods and processes.

1.2. Challenges and opportunities in gear manufacturing

Many industrial areas rely on gears and, as a result, the gear manufacturing[7] business, because gears are one of the most basic mechanical components for transmitting motion and/or power to keep machines, instruments, and equipment running. Every year, billions of gears are produced around the world. Manufacturing processes for metallic gears can be divided into three categories:

(i) Machining techniques including hobbling, milling, shaping, and broaching;

(ii) Forming processes like stamping and extrusion

(iii) Additive manufacturing technologies including die casting and powder metallurgy.

Finishing activities have a big impact on overall sustainability since they normally imply a lot of tool wear, a lot of cutting fluid and energy consumption, and a lot of waste management, including handling, disposal, and recycling.

1.3 The problems associated with manufacturing of gears by conventional processes can be summarized as follows:

i. To create quality gears, all conventional gear manufacturing procedures require finishing processes such as trimming, shaving, grinding, honing, burnishing, and so on.

ii. These following finishing procedures necessitate the fabrication, repair, and maintenance of the finishing tool; they consume a lot of lubricating oil and energy; they make waste handling, recycling, and disposal more difficult; and they increase the total cost.

iii. The failure of standard lubricants and lubrication/cooling systems to provide adequate lubrication causes excessive tool wear during machining, reducing tool life and necessitating the use of re-sharpening facilities and/or new tools.

iv. Providing and pumping large amounts of cutting process to the cutting zone during traditional lubricating and cooling results in increased power consumption and, if the fluid has poisonous qualities, may endanger the operator's safety and health. Handling and disposing of wet chips (metal cutting wastes) and wasted cutting fluid are tough activities that may have an environmental impact.

2. DISCUSSION

2.1 Strategies for sustainable manufacturing of gears.

2.1.1 Environment-friendly lubrication techniques

Large volumes of nutrient lubricating oil may have a negative impact on the environment since they may cause increased ground contamination, increasing power consumption, greater wet chip handling and waste disposal, and significant health and safety hazards.

To overcome these challenges, there has been a steady increase in interest in executing dry or near-dry machining procedures. Although dry machining has the ability to eliminate the need of cutting fluids entirely, it may have a negative impact on other aspects of machining performance, such as lubricity, tool life, and thermal damage to the work piece and tool.As a combination between substantial cutting fluid consumption and dry machining, near-dry machining technologies such as minimal quantity lubrication (MQL)[8], limited amount cooling (MQC), and least quantity cooling and lubrication (MQCL) were developed.MQL is the most widely utilized of the closer machining processes. The MQL technology's multi-performance capabilities in gear machining include heat control, cutting surface lubrication, effective chip removal, environmental friendliness, and energy efficiency.

2.2 Advanced gear manufacturing processes:

2.2.1 Overview

i. All conventional gear manufacturing processes, as explained in section 1.2, have obvious limitations and will almost always require a further finishing operation to achieve fit-for-purpose quality. This finishing method uses more energy, material, and cutting fluids, and so has a detrimental impact on overall sustainability. Potential single-stage gear production using wire electric-discharge machining (WEDM)[9] and gear rolling are two recent inventions that aim to improve energy and resource efficiency while overcoming some of the disadvantages of standard manufacturing procedures. These advanced processes may have significant benefits when compared to the traditional processes.

ii. Materials efficiency is ensured by no chip creation (in gear rolling) and much substantially lower removal (in WEDM).

iii. Reduced setup, cycle, and total process times.

iv. Manufacturing and finishing of gears in a single stage not only brings about a reduction in the process chain, but also increases energy efficiency.

v. Economic efficiency i.e. lower cost due to low consumption of power, material, cutting tool and fluid.

vi. Improved manufacturing quality of gears.

*2.*3Conventional Gear Processing:

2.3.1 Gear rolling

Gear rolling is a cold work manufacturing technique that may be done in one of two ways i.e. flat rolling and round rolling.

i. Cold flat rolling tools[10] travelling in opposing directions mesh with the rolling gear blank symmetric to rotation to perform cold flat rolling. Neugebauer et al., 2007 provide a more extensive description of the technique. The current paper's major focus is on some recent advances in round rolling techniques.

ii. Round rolling[11] of gears is a cost-effective cold-massive forming method that transforms a whole gear into a material. The tiny shaft is fastened in an axial direction in a fixture that allows rotational and axial movement of the drilled gear blank (rotationally symmetric). Compressive loading is used to create the gear teeth using a series of rolling dies (two or three gears with the same profile and geometry).

2. CONCLUSION

This section briefly examines the implementation of a few more essential measures for achieving gear manufacturing sustainability. Strict environmental rules and international competition are compelling industries all over the world to embrace more efficient, cost-effective, and environmentally friendly methods of production. The current article examines the current state of technology and the extent to which engineers and manufacturers are working to develop sustainable gear manufacturing methods. Several ideas and methodologies for achieving gear manufacturing sustainability have been researched and addressed.

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