In 1957, grinding was named as an unintentional heat treatment method. Recently the idea was taken up and fundamental investigations were carried out to develop suitable strategies of process control for well-aimed modifications of surface layer (Komanduri 1993).

In finishing operation of engineering components, grinding processes found a great dissemination because they allow the machining of hard and brittle material to a good surface finish with high dimensional and shape accuracies (Hahn 1962).

In general, engineering components have to be subjected to a hardening heat treatment process at the surface layer to increase fatigue strength and wear resistance properties. Highly loaded components are often surface hardened using a variety of processes based on thermal or thermo-chemical impact, e.g., Induction or Case hardening. Such heat treatment processes restricted to the surface layer are connected with some typical advantages compared to full hardening heat treatments. In industry different heat treatment methods are used for the production of required surface layer properties. The problem is that these processes cannot simply be integrated into the production line causing economical disadvantages.
A classification of the surface hardening methods is based upon three main effective mechanisms, viz., mechanical, thermal and thermo-chemical alteration of surface layers.

The systematical listing of surface layer hardening methods in Figure 5.1 shows that there is no establishment processes based upon thermo-mechanical properties. With the exception of some investigations into friction hardening a gap exists in the development and use of thermo-mechanical impacts for surface layer hardening, particularly in the area of surface layer hardening by machining.

Based on the specific chip removal and chip formation mechanisms, a substantial part of cutting energy in grinding is transformed into thermal energy. Depending on the grinding conditions, the heat flux mainly takes part via the work-
piece and leads to a large thermal loading by high temperatures in the surface layer was first described by Snoeys and Maris (1978). This thermal load is superimposed by a mechanical load, which in first approximation, is characterized by the Hertzian stress between the abrasive grains and the surface of the work-piece. When grinding hardened steels, this thermo-mechanical load is able to cause undesired alterations in the surface layer cracks, tempered zones or white etching areas (WEA) these effects were investigated and discussed by Field and Kahles (1971).

The process parameters and the thermo-physical properties of the work and abrasive materials principally influence the effective work surface temperature. If the material in the surface layer is heated above the characteristic temperature ($91^\circ\text{C}$) during grinding, diffusion and phase transformation takes place. So most of the observations suggest that the mechanical and metallurgical characteristics of abrasively machined surfaces can be controlled by controlling the effective work surface temperature.

In any case, generated heat quantities in grinding are considered as a restricting factor that necessitates the use of coolants and the selection of moderate grinding conditions. By concluding today’s experience in heat treatment and grinding, 

Four important limitations can be identified.

1. There are many heat treatment processes for surface hardening, but they are very difficult to integrate into a production line causing economical disadvantages.
2. These processes are not suitable for small-scale production since the cost of the equipment is very high.
3. These processes cannot be done perfectly in the case of irregular and contour shaped objects and
4. Subsequent to heat treatment, structural parts are subjected to grinding, in the course of which impairment of hardened materials can arise because of the thermo-mechanical influences of the grinding processes.

The above said problems cause one to investigate, how this process generated heat energy can be effectively controlled and utilized to improve the surface hardness and quality improvement and also prevent damages. To attain this, a new heat treatment process called "Grind Hardening" is attempted and the mathematical model is also developed to predict the temperature at the work surface. For the attainment of grind hardening effect a standard alumina grinding wheel is employed and rough grinding conditions are selected.

In the grind-hardening process, the grinding wheel is equivalent to the moving heat source, similar to the induction hardening process. In doing so the heat transition takes place through the contact area between width and contact length, which is decisively influenced by the wheel diameter and the depth of cut. The heat treatment duration (HTD) referring to a fictitious point in the new surface corresponds to the period, in which the grinding wheel passes through the entire distance.

Consequently, the heat treatment duration depends directly on the depth of cut and the feed. The generated heat quantity, the heating rate and the austenizing temperature are also depends on the grinding parameters.

In this experiment, the formation of a heat-treated zone (HTZ) beneath the surface is characterized by a significant hardness increase. This heat treated zone is composed of two different boundary layers directly at the surface upto a few micrometer thick white etching area with an extremely high hardness is generated, followed by a hardened structure consisting of martensite and carbides. Surface cracks were not observed in any of the grind hardened parts.
In addition to hardness measurement, the generated structure was also analyzed with respect to residual stresses. It was found out that compressive residual stresses are existing in the white etching areas (WEA) and also continue up to the area of etchable martensite.

Based on the investigations, the possible effective range in grind hardening (Figure 5.2) can be estimated and also be compared to other surface strengthening processes like nitriding, laser hardening and induction hardening.

![Figure 5.2 Comparison of effective range of different surface strengthening processes](image-url)