SHOT PEENING OF GEAR COMPONENTS FOR THE AUTOMOTIVE INDUSTRY

Albert Schlatter1 , and Hans Jörg Stoll1

1 DISA Industrie AG, Solenbergstrasse 5, CH 8207 Schaffhausen, Switzerland

ABSTRACT

Shot peening using blast wheels offers a high level of flexibility and process reliability especially for larger series and larger workpieces. This paper describes shot peening solutions for bevel gears and crown wheels for the automotive industry at BMW, Dingolfing. The significance of shot peening trials to determine the optimum solution is outlined and solutions found - satellite shot peening systems - are presented. The influence of a proper working dust removal plant and separation system on shot peening results are shown, importance and control of process reliability are outlined.

SUBJECT INDEX

1) Shot peening with blast wheels
2) Automotive gear parts
3) The significance of blast trials
4) The machine concepts, automatic handling
5) Dust removal and separation system
6) Process reliability

SHOT PEENING USING BLAST WHEELS

Shot peening by means of the air blasting method is generally known. In the current technology of surface treatment, shot peening with blast wheels has become widely accepted as a reliable and economic processing method. The fields of application are thus accordingly diverse. Blast wheel systems offer a high level of flexibility and process reliability and can be applied for controlled treatment of a wide range of workpieces, especially larger series and parts. Shot peening is principally suitable for parts which are subjected to bending or alternating torsional stress.

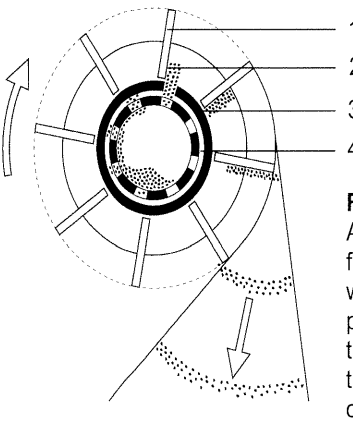


Figure 1, Operating principle blast wheel
A metered amount of abrasive falls through the feed spout onto the blast wheel. The impeller (4) which runs in synchronism with the blast wheel, pre-accelerates the abrasive and delivers it to the throwing blades (1). The desired throwing angle of the abrasive is set by adjusting the position of the outlet slot of the control cage

SHOT PEENING GEAR PARTS FOR THE AUTOMOTIVE INDUSTRY

Shot peening leads to significant improvements of the mechanical properties of work-pieces and serves to extend the stress-load limit of components or permits design of lighter weight parts. At the Dingolfing plant near Munich, BMW is manufacturing all gear components for passenger cars and motorbikes. Production can be both - single and mixed product runs (parts for passenger cars and motor bikes). After hardening and annealing, all gear parts are shot peened to increase vibration strength and resistance against stress cracks and vibration crack corrosion. Requirements are to a certain extent complex: On one hand root and tooth flanks of the parts have to be shot peened, with other areas only requiring descaling or deburring. Following part families are processed:

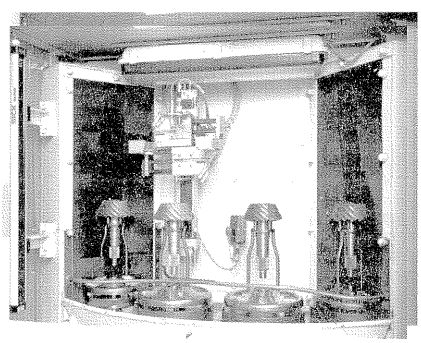
BEVEL GEARS

Dimensions: min. height 160 mm; max. height 220 mm; max. unit weight 3.5 kg
Requirements: Shot peening of the tooth flanks to 0.28 - 0.32 mm Almen A with a coverage of > 98 %, cleaning resp. removal of the cover paste on the thread without impairing the thread function; descaling the remaining parts. An excessive increase in hardness at the shaft must be prevented. For certain types of bevel gears, it is necessary to additionally ensure that the tip surface is not hardened, which means that the tooth flanks also have to be shot peened whereas further areas and the untempered head parts, in particular the centre where the parts are clamped into position for concentricity measurements, must not be shot peened.

CROWN WHEELS

Dimensions: max. diameter 240 mm; max. height 42 mm; max. unit weight 4 kg
Requirements: Shot peening of tooth flanks to 0.28 - 0.32 mm Almen A with a coverage of > 98 % and descaling of the remaining parts.

Further requirements and specifications for both part families are as follows:
Abrasive of the size S230 (hardness 46-52 HRC) is used for all parts. Crown wheels and drive bevel gears have to be shot peened individually (fig. 2), pair-wise (fig. 3), or even in triples, thus making special carrier facilities necessary. Production status: 6,000 pairs/day; plants are working in 3-shift operation.



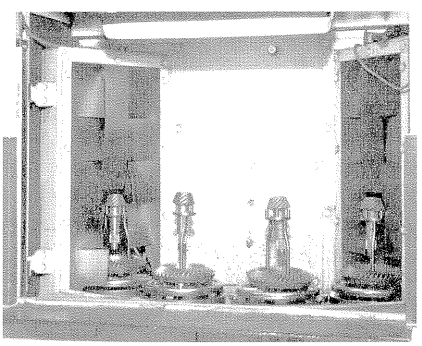


Fig. 2: Parts, shot peened individually ... ... and in pairs. Figure 3

Shot peening is normally the last operation in the production process. In this specific case the tooth parts are lapped and ground after hardening and shot peening. In the following, running characteristics are investigated. It is of prime importance that tole-

rances for Almen values are always complied with to guarantee running smoothness of the gear. If the programmed Almen values are under-run, excessive material is removed during lapping, and if the values are exceeded a reduced amount of material is removed. This would either lead to raised noise emission of the vehicle gearbox or result in an inhomogeneous tooth contact pattern. Running smoothness is evaluated in a special test whereby the tolerance zone is between 7 and 10 on a scale of 10 units. It is therefore essentially important to ensure that the given Almen values are observed explicitly.

THE RELEVANCE OF SHOT PEENING TRIALS

To meet these requirements, extensive shot peening trials were performed on a laboratory machine using the customer's workpieces at the DISA Test Centre in Schaffhausen / Switzerland. In these tests the aim was to determine the position of the blast wheel (angle) as well as blasting intensity, abrasive quantity and blasting time. The shot peening programmes were to be tailored to the specific production process required and the process reliability was to be guaranteed. The information derived from such tests indicates that this task can be optimally solved with a satellite shot peening system. Due to the test results the machine construction was adapted to the customer's requirements and thus to the specific applications.

SATELLITE SHOT PEENING SYSTEMS – UNIVERSAL AND PROVEN

With SRS Shot Peening Systems, bevel gears and crown wheels, wheel hubs, gear shafts and similar components, as well as cup springs and clutch springs are shot peened in cycled rotary operation. In this case 15 speed-controlled satellites, integrated into an indexing turntable carry the workpieces through the system in cycled rotary operation. The turntable is driven by means of an indexing gear and positions the individual satellites with great precision so that they can be loaded and unloaded either manually or using industrial robots, manipulators or automatic modules. The satellites are furnished with a robust bearing with labyrinth seal. In the shot blasting zone they are rotated continuously by a toothed drive belt. The blast wheels are arranged flexibly and adjusted according to the part being processed. The abrasive parameters (quantity, grain distribution, blast wheel and throwing speed, workpiece movements and dwell time) are adjusted according to the part being processed. The system is equipped with two differently positioned DISA Blast Wheel units, each providing an output of 22kW. They are frequency-controlled so that not only the blasting intensity, but also the rotational direction of the wheels and thus the shot peening position can be adapted to the different workpieces. The amount of steel shot is tuned to the pre-selected shot peening program via remote-controlled abrasive dosage facilities.

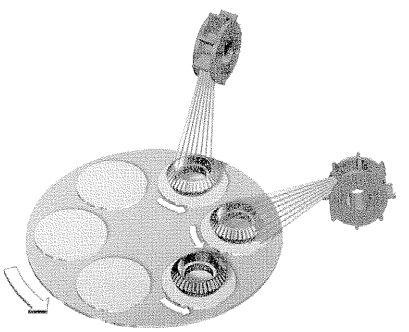


Figure 4: working principle of Rotary Satellite Shot Peening Systems

AUTOMATIC HANDLING

The excellent performance of the first two machines led BMW to investigate the possibility of using a third systems including automatic handling for large-series production runs (monocultures) in fully automatic operation in an autonomous manufacturing cell. In this application (fig 5) robots are responsible for automatic feeding and unloading. The profitability can be additionally enhanced considerably by reducing staff costs and increasing the output. The cell functions are:

- Fully automatic loading and unloading the workpiece pallets
- Shot peening
- Aligning
- Inductive starting (threaded pins)
- Grinding (front surfaces of thread)
- Ball callipers (for surveying the tooth gaps)

Loading procedure: The robot gripper retrieves the workpiece from a pallet, grasping the bevel drive pinion by its shaft, and then swivels to place the component into a central position above the fixture on the satellite table. A further gripper device, activated by a pneumatic cylinder, descends vertically to secure the pinion by its toothed head. The robot then releases and retracts. The gripper subsequently lowers the workpiece into the fixture and then moves upwards, back to its original position.

Unloading then takes place as follows: After the machine table has indexed one position, bringing a processed component into view, the gripper device moves downwards. It grasps the gear drive-pinion and raises it sufficiently for the robot to move in and secure the component. At this point, the gripper releases its grasp, allowing the robot to withdraw the part from the table and place it in a further pallet.

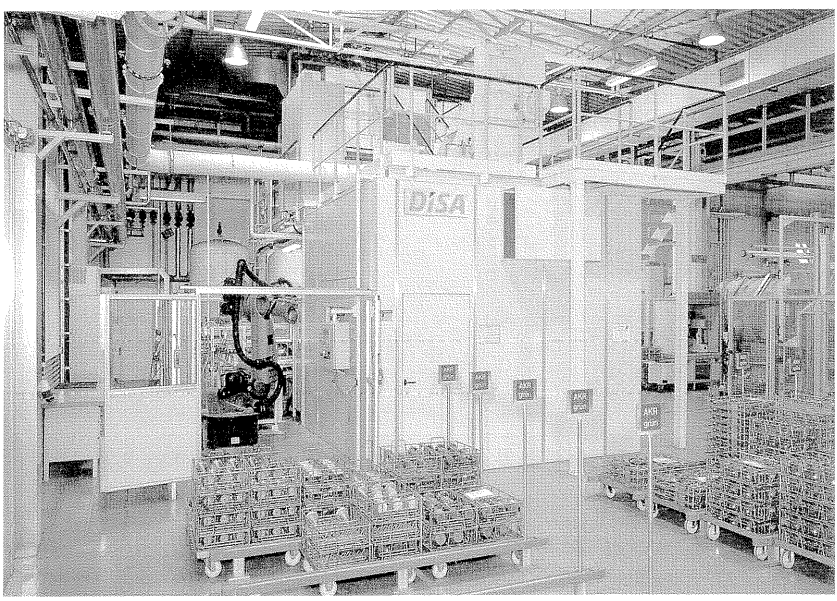


Figure 5: DISA Satellite Shot Peening System integrated in manufacturing cell

Cell solutions require clear interfaces and clearly defined processes to the following functions. The modularity and flexibility of the systems is a further key criterion allowing adaptations to be made at short notice if there is a change in process steps. Cell solutions also permit a drastically improved exploitation of the production area

For all applications, the shot peening programs themselves are assigned to the respective part families, ensuring that the given parameters are used in operation and that process reliability is guaranteed. The individual programs are activated via the appropriate settings at the operator's panel.

DUST REMOVAL AND SHOT RECONDITIONING SYSTEM

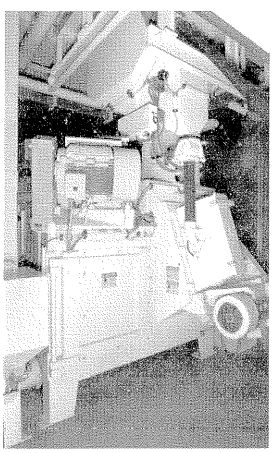
A dust separation system (we principally recommend our customers to use separate filters for each individual shot peening system) with a capacity of 5,000 Nm^3/h is incorporated, allowing the function of the pneumatic separator to be optimally adjusted by suction-cleaning the system. The separator fulfils the following functions:

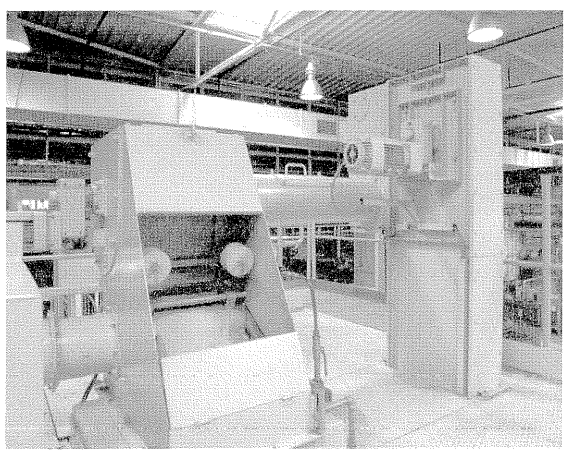
- Separating and discharging scale and dust from the abrasive
- Eliminating abrasive particles which are unfit for the shot peening operation

As the life of the wear parts depends primarily on the degree of purity of the abrasive, the following is applicable:

- The better the separator, the higher its profitability
- The purer the abrasive, the cleaner and more dust-free the workpieces will be.

Besides the wear and tear issue, the abrasive consistency in distribution of grain abrasive size – in particular in shot peening – is the key criterion in terms of quality-oriented manufacturing. Losses in quality or insufficient shot peening results (surface hardening) can thus be excluded. New shot is automatically fed into the cycle via an electronically controlled replenisher.





Arrangement blast wheels (Fig. 6, left) and separation system (Fig. 7, right)

PROCESS RELIABILITY

In shot peening process reliability is the decisive factor. Each part shall undergo a defined treatment. The blasting intensity can be controlled by determining the Almen value and coverage. Due to the fact that all parameters (speed, blasting time, discharge speed, shot sizes and distribution) in SRS satellite shot peening systems are defined exactly, it is possible to adjust and examine the Almen intensity and

coverage. The process reliability is supervised in periodic intervals and must be guaranteed at all times.

CONCLUSION

We would once again like to underline that the requirements in terms of a shot peening solution in comparison with the more familiar blast cleaning applications, e.g. for cleaning workpieces in foundries and in forges, are highly complicated. The machine manufacturer therefore plays a decisive role in designing the system and has to make available the appropriate know-how.