Preface

Expectations on Powder Metallurgy

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The history of modern powder metallurgy is generally said to have begun with the production of ductile platinum by W. H. Wollaston in 1804. Afterwards, W. D. Coolidge developed the production technology for ductile tungsten filaments in 1908. Since then, this year marks the 100th anniversary of this historic achievement.

Powder metallurgy technology has evolved dramatically as a result of innovative progress in materials, processes, and equipment. Recent parts manufactured by sintering processes acquired good shape complexity, acceptable tolerance capability and higher degrees of freedom for material design. However properties of sintered part materials show some differences from those of wrought materials because of microstructure with pores.

We can say, what are the future directions of powder metallurgy? One of the directions is the pursuit for pore-free condition with good shape complexity at low cost, as is already mentioned by Prof. M. R. German in an earlier edition of this Technical Report, Vol. 4, 2005. I would like to propose an additional direction; the challenge to difficult developments which were "hard to solve by powder metallurgy before," as well as the pursuit for developing parts which can "only be achieved by way of powder metallurgy" but not other manufacturing methods.

I would like to explain this proposition by taking a part as an example, which we, DENSO CORPORATION and Hitachi Powdered Metals Co., Ltd., have developed under collaboration and succeeded providing to the auto part market.

The pulley inner hub, which was reported in Vol.4, 2005 for use in car air-conditioner compressors, transmits drive power under normal conditions, but it also has the function of a mechanical fuse which breaks immediately in case of excess load. In other words, required performance on the part is necessary to satisfy both properties; of not breaking under normal conditions, assurance of lower limit of tensile strength, and breaking under excess load, assurance of upper limit of tensile strength. At the same time, it is also necessary to secure reliability, assurance of fatigue strength, under the restriction of securing an appropriate balance of fatigue strength and tensile strength, fatigue limit ratio.

The beginning of the co-development was a proposal of an idea illustrated by auto-part designers, showing at the same time a single graph plotting the fatigue strength and tensile strength of various materials. Immediately followed the discussions; "We want to realize this part with high fatigue limit ratio, and it seems that only sintered material can realize our target value." "It seems to be impossible from the common sense of sintered materials engineers." "But it seems to be very interesting. – OK, let's give it a try."

What are the factors that have made it possible to realize the mechanical element parts with sintered materials in which extremely strict strength assurance is required but is judged to be impossible with wrought materials?

An exceptionally high level control as well as management of the powders, green compacts, sintering conditions, and quality of the sintered parts was set, it is one of the required factors. In addition, the most important key factor, I believe in, that led to success in this development was the steady and vigorous accumulation of a vast amount of data by both Technical and Manufacturing Divisions of both of companies. Such data were compiled and integrated under the light of "science"; such as, the trace investigations on the factors responsible for strength deviations among sintering batches and an understanding of the correlation between pore shape and fatigue strength, and so forth. Intimate investigation, utilizing these data, enabled us to materialize the sintering part with strictly assured upper and lower limits of static strength and fatigue strength as well as with merits of sintering process, which is of great contrast and advantage so far to the common use of sintering part showing large deviations in mechanical strength. This would explain one case in which "only be achieved by way of powder metallurgy" is realized and the challenge to "hard to solve by powder metallurgy before" is performed and overcome.

Powder metallurgy is a field in which both technology and technique: "Takumi" shall coexist in a complex relationship. So it is quite important to study the world of "Takumi" in view of "science" and linking it to engineering of material design and process design. This approach would expand applications of powder metallurgy technology tree and would create higher function of it.

Compilation of experiences in the past might have precluded scientific study. In order to break the stereotype to overcome "hard to solve by powder metallurgy before", researching and developing become an important step. Here in addition, I'd like to stress the key importance resides in the systematic and deeper study of fundamental technologies of powder metallurgy; such as the characterization of powder properties, analysis of the behavior of powders under each process and investigation of the mechanisms of reactions.

For the steady progress of fundamental technologies, the following, among others, are required to be studied and established: (1) analysis and measurement technologies observe true aspects of materials and processes, (2) evaluation technologies to grasp accurately characteristics, physical properties and phenomena, and (3) analytical technology to predict and inspect mechanisms.

On the other hand, from the user side we would like to contribute to achieve the target, i.e., the progress of powder metallurgy, by proposing new applications and concrete target concepts utilizing the powder metallurgy parts, and thus together with powder metallurgy engineers, we are ready to fully investigate the potential for creating parts that can "only be achieved by way of powder metallurgy" and take on the challenge of what is "hard to solve by powder metallurgy before."

To realize this, it is also important for both parties to share information and data, and to carry out material design and process design based on sintered part engineering from an earlier stage of product design.

Looking ahead to the next 10 decades, we would expect that the fundamental technologies of powder metallurgy shall be improved further, and much closer cooperation between sintered part manufacturers and users by sharing of fundamental technologies would develop new approach to materializing new products taking advantage of the distinctive features of powder metallurgy, and thus would make a dramatic advancement.