

A Case Study of Combining SPC and EPC in Multistage Manufacturing Processes

Y.D. Zhu¹, X. Zhang² and J.M. Seuntjens²

¹ Department of Mechanical Engineering, National University of Singapore ² Kulicke & Soffa (S.E.A.) PTE LTD

Introduction:

Bonding wire (Fig.1) fabrication is a typical multistage manufacturing process including casting, wire drawing, annealing, and spooling (Fig.2). In ensuring the wire quality, the process parameters of one or different stages present a great challenge for process modeling, optimization, and fault diagnosis. In industry practice, critical wire properties, such as elongation (EL) and breaking load (BL), are monitored with statistical process control (SPC) tools, e.g. control charts, process capability values and so on. However, such applications have limited diagnostic capability [1], and impact on the yield and productivity. Since some in-process variables can be manipulated in order to get the product properties onto target, engineering process control (EPC) was introduced in this work and combined with the application of SPC.

Combining SPC & EPC:

Fig. 3 shows the framework of integrated SPC and EPC in wire manufacturing. EL and BL of spool_T are monitored by x-bar and R charts. EL and BL of spool_{T+1} are forecasted by EWMA using $\lambda=0.2$. EL can be on-target value by manipulating annealing time and temperature. BL can be on-target value by controlling drawing speed and die sizing. The specific relationship between wire properties and the in-process variable are achieved through empirical studies. Consequently, adjustment can be made upon forecasted out-of-control signal so that corresponding spool_{T+1} properties will be on the target.

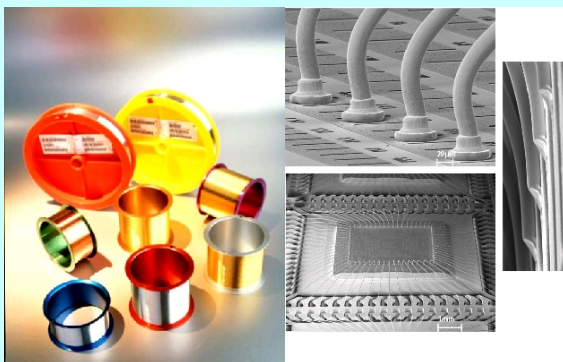


Fig.1 The gold, alumina, and copper bonding wire products

Process Name	In-process Parameters	Product Properties
Casting	Temperature Speed	Chemical composition
Drawing	Speed	
Annealing	Time Temperature	Hardness
Drawing	Speed Sizing	Diameter
Annealing	Temperature Time (Speed)	Elongation Breaking load
Spooling	Speed	Diameter

Fig. 2 Wire fabrication and crucial manipulated in-process variables

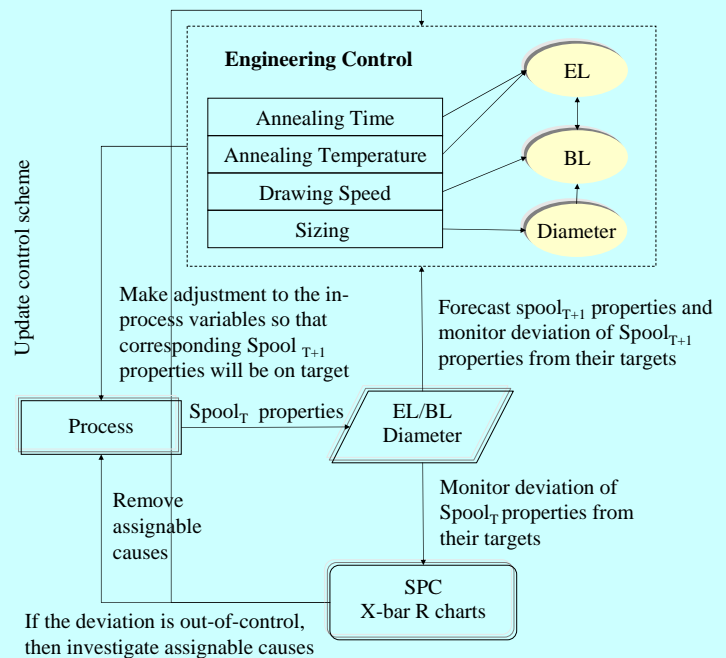


Fig. 3 Combining SPC & EPC

Results:

Since the combined SPC and EPC scheme was applied in Kulick & Soffa PTE, LTD, the performance of boning wire fabrication process has improved according to 3 months close monitoring[2]. In summary, average deviation of EL and BL of 6 alloys from the target value has decreased from 0.08% and 2.1gm to 0.056% and 1.57gm respectively. The Cpk values of EL has improved about 52% and BL 37%. In addition, due to the application of forecast and feedback control, wire scrap has decreased 26% for none confirming mechanical properties. As the bonding wire materials are expensive metals, such as 99.99% gold, the cost reduction is significant. Hence, industry practice has demonstrated the effectiveness of such a combined scheme.

Reference:

- [1] D. C., Montgomery, *introduction to statistical quality control*, 4th edition, John Wiley, 2003.
- [2] J. A. Seuntjens, *Bonding wire division 2005 fiscal year quality, yield, and productivity report*, Kulicke & Soffac PTE LTD, 2006