

變「箱」超人
Speed Joint

團隊背景 Background of the Team



小組名稱 Team name	電能之星 PSBG Excellence
成立日期 Date of formation	2003年1月 January 2003
所屬部門 Composition	輸電及供電業務部 Power Systems Business Group
促進員 Team facilitator	何兆光 S.K. HO
隊長 Team leader	梁國健 K.K. LEUNG
小組成員 Team members	葉志源、梁仲賢、梁浩為、鄺志明、劉永泰、羅家健、黃家明、潘沛鴻 C. Y. IP, C. Y. LEUNG, Howard LEUNG, Ray KWONG, W. T. LAU, K. K. LO, Brian WONG, P. H. PUN

背景 Background

中電擁有13,000公里高壓電纜(11,000V-132,000V)，為全港240萬用戶供電。不可避免地，如此長的電纜須由接駁箱連接。由於高壓電纜接駁箱在性能上要求很高，市場現有接駁箱結構複雜，體積笨重，花費高昂(中電：6,000萬/年)，安裝/復電耗時，對環境亦有影響。

常言道，高品質需成本的付出，但我們堅信憑創意提升品質能夠降低整體成本。因此我們自發提出並成功完成這看似不可能的任務——快速高壓接駁箱。

Background

In CLP, there are over 13,000km of High Voltage (HV, 11,000V-132,000V) cables supplying electricity to 2.4M customers. Unavoidably, the cables need to be connected together by HV Cable Joints. For high technical requirements of HV operation, market-available cable joints were complicated and bulky, and hence costly (CLP spends HK\$60M/year), time-consuming to install / restore electricity and unfriendly to environment.

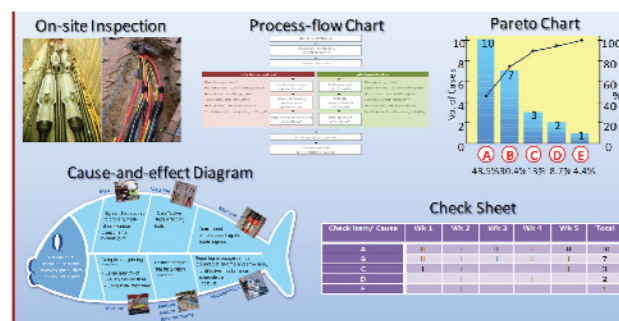
With unshakable conviction "Quality Pays and Innovation Helps" from each member, we actively proposed a seemingly impossible mission of developing HV "Speed" joints. Not by miracle but innovation, we successfully developed our HV Speed Joints, creating multi-dimensional benefits to the society and CLP.

問題原因 / 主要分析及驗證

- 在不同模式的工作坊，與前線人員、工程師、顧客及承建商通過思維衝擊，歸納問題成因和項目方向。
- 透過以下工具分析流程及數據：
實地考察(五週)、流程圖、因果圖、查檢表及柏拉圖(圖一)
- 根據以上分析，市面上的高壓電纜接駁箱由三大關鍵元件組成，以達致高壓絕緣、電場控制、防水及長期耐熱等高性能要求，所以難免結構複雜、組件繁多，從而導致成本高昂，工序繁複，復電耗時。

Causes / Root Causes Analysis and Validation

- Collecting advices from stakeholders including frontline, engineers, customers, contractors, etc. through a number of "Brainstorming and Consensus Workshops" of different formats.
- Analysing process and data through powerful quality tools – 1) 5-week Onsite Inspection, 2) Process Flow Chart, 3) Cause-and-Effect Diagram, 4) Check Sheet and 5) Pareto Chart (Fig.1)
- With the above analysis, we found that the market-available HV joints composed of 3 different key components for "electrical insulation," "stress control," "water blocking" and "long-term thermal performance" were costly and ineffective, resulting from "Complicated Jointing Process" and "Large Quantity of Joint Components."



圖一 成因問題分析工具
Fig.1 Root Cause and Problem Identification by Proper Analytical Tools



解決方案 Solutions

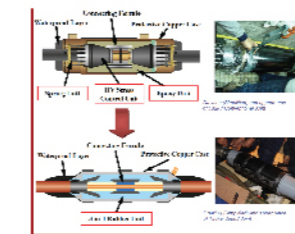
- 我們堅持信念，勇於挑戰現狀。我們利用獨特的研究方法：問題樹形圖、思維衝擊(共25個構思)、構思合理化工坊、矩陣-數據分析優選法、電氣理論應用、工程學會專家會議、生產可行性研討、控制圖監測法與國際標準測試和現場試驗來驗證理念(圖二)。
- 我們首創並成功先將理念應用於11千伏電纜快速接駁箱，通過設計、技術及選材的創新，以減少組件及簡化工序。例如，利用現代多層聚合物的製造技術將關鍵元件三合一。
- 我們用力場分析、差距分析和風險評估模型，確定流程、人員技術及資金的阻力和改善之處，並通過變更管理、工序設計標準化、技術培訓與交流和廿四小時技術支援全面解決它們。
- 此次成功帶來極具影響的漣漪效應。在第二個PDCA循環中，我們以最少資源，最短時間，將此發展模式應用於更困難的情況——「132千伏電纜快速接駁箱」(圖三)。

Solutions

- Not compromise our conviction, we challenged the status quo in the market. To devise the solution systematically, we made use of our unique and stringent approach consisting of "Problem Tree Diagram," "Brainstorming for totally 25 Ideas," "Idea Rationalizing Session," "Matrix-Data Analysis for Solution Ranking," "Application of Proper Electrical Theories," "Expert Meetings with Learned Society," "Checking Production Feasibility with Manufacturers," "Concept Verification by International Laboratory Testing and Field Trial" and "Control Chart Monitoring Implementation Effectiveness" (Fig.2).
- We first succeeded in transforming some concepts into our own 11kV Speed Joint with numerous innovations in technical design, material selection and production process for reducing cable joint components and simplifying jointing process. For instance, the three key components can be combined into one single component utilising modern multi-layer polymer manufacturing techniques.
- We adopted "Force Field Analysis," "Gap Analysis" and "Risk Assessment Model" to identify the restraining forces and gaps in process, staffing & skills and resources & budgets, and get them resolved through a comprehensive package of "Management of Change," "Procedures and Design Standardisation," "Skill-transfer Training & Communication" and "Round-the-Clock Technical Support Arrangement".
- That success created influencing ripple effect that the development model was easily applied in the 2nd PDCA cycle for an even more difficult case "Development of 132kV Speed Joint" with minimal additional resources and much shorter timeframe (Fig.3).



圖二 方案發掘模式
Fig.2 Solution-generating Approach



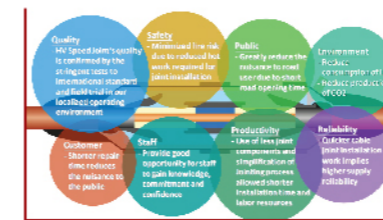
圖三 132千伏傳統及快速接駁箱比較
Fig.3 Comparison of 132kV Conventional and Speed Joints

成果及效益 Achievements & Benefits

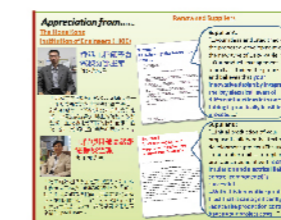
- 有形得益：由於在中電全面實施及標準化，專案在減省工程造价(↓\$21M/年)、安裝時間(↓1,267日/年)以及二氧化碳排放(↓3.1噸/年)方面取得卓越成效。不但覆蓋了專案前期投入，甚至遠超管理層和團隊預期目標。隊員的知識、承擔、信心、信任、興趣和團隊精神都有明顯上升。
- 無形得益和環保：為客戶，公眾，環保團體，行業從業人員和中電創建了各種無形得益(圖四)。
- 持久有效性：此設計已成為中電高壓電纜接駁箱的規範，並且中電已與兩家廠商簽訂了長達5至6年的長期合約。
- 知行合一：隨著生產力的提升和成本的降低，所有相關的部門在日常營運中全心投入實施，並通過實地考察和用戶增值回饋會議來達至知行合一。
- 持份者及業內人士讚譽：因創新和對行業的重大貢獻得到香港工程師學會——電機分部和知名供應商的高度讚賞(圖五)。

Achievements & Benefits

- Tangible Benefits: Due to successful full implementation and standardization in CLP, the realised saving in project cost (↓\$21M/yr), installation time (↓1,267day/yr) and CO2 emission (↓3.1ton/yr) are huge, which even far exceeded our effort spent as well as the high targets pre-defined by Management and the Team. Survey has also shown team members' knowledge, commitment, confidence, team work spirit & trust and interest are uplifted significantly.
- Intangible Benefits and Environmental Protection: Speed Joint also created numerous intangible benefits to various stakeholders such as customers, the public, green group, industry practitioners and CLP (Fig.4).
- Long-lasting Validity: Speed Joint design has become CLP's norm for its huge tangible and intangible benefits to various stakeholders. In order to secure and sustain the benefits so created by Speed Joint, long-term partnership contracts lasting for 5 and 6 years were established with two capable cable joint manufacturers.
- Walking-the-Talk: With the improved productivity and reduced costs, all related business units supported in whole-hearted devotion to the implementation in their daily operations and walked the talk by involving themselves in site visits and User-Value-Added feedback session for further improvements.
- Stakeholders' and Industry Practitioners' Appreciation: We got high appreciation from the HKIE – Electrical Division, renowned suppliers for the innovations and the huge contribution to electricity industry (Fig.5).



圖四 對持份者多層面的無形效益
Fig.4 Multi-dimensional Benefits to Various Stakeholders



圖五 持份者及業內人士的讚譽
Fig.5 High Appreciation from External and Internal Stakeholders